DEPARTMENT OF MECHANICAL ENGINEERING

B.Tech. in MECHANICAL ENGINEERING

CURRICULUM & SYLLABUS
2023

VISION AND MISSION OF AMRITA VISHWA VIDYAPEETAM

VISION

Our vision is to be an exemplary institution that thrives on its commitment to the transformative power of value-based education, providing the impetus to develop the expansiveness to harmonize both scientific knowledge and spiritual understanding, so as to utilize knowledge for societal benefit and contribute to a prosperous and sustainable future for all.

MISSION

Education for Life

There are two types of education: education for living and education for life. Studying to become a professional is education for a living, while education for life requires an understanding of the essential human values. At Amrita, we believe that education should also impart a culture of the heart, based on enduring values and inner strength. Amrita's culture of education helps to inculcate in our students the right ethos to be rooted in the values of Dharma (righteousness), Karuna (compassion) and Shraddha (mindfulness). Endowed with qualities of acceptance, patience, self-confidence, perseverance and enthusiasm, the benefit of humanity will become uppermost in the students' thoughts, words and actions. They will then pioneer innovative solutions for the benefit of all humankind, leading to sustainable health and prosperity for all. This resonates with the ancient Sanskrit prayer 'Lokah Samastah Sukhino Bhavantu'. It is a reminder of our deeper connection to the entire world around us, "May our work contribute to the happiness of all beings."

Compassion Driven Research

Our motivation to pursue research is focused on alleviating major global problems related to poverty, starvation, sickness, environmental pollution and contamination. We believe that if we could transform compassion from a mere word into a path of action, we would be able to address most of the world's problems. If we take this step courageously, then our research and its outcomes will have a special impact, spontaneity, and power. This has translated into many latest advancements and innovations that have culminated in greater societal benefit.

Global Impact

At Amrita, we stand united in our mission towards solving globally recognized scientific and societal challenges, including environment, development, and health. Amrita stands at the strategic juncture of two streams of cultures: East and West. It is our vision to bring the two together to bridge the divide through meaningful collaborations with world class universities and innovative approaches that will benefit the entire planet.

GENERAL INFORMATION

ABBREVIATIONS USED IN THE CURRICULUM

Cat - Category

L **-** Lecture

T **-** Tutorial

P **-** Practical

Cr **-** Credits

ENGG - Engineering Sciences (including General, Core and Electives)

HUM **-** Humanities (including languages and others)

SCI **-** Basic Sciences (including mathematics)

PRJ **-** Project Work (including seminars)

AES **-** Aerospace Engineering

AIE **-** Computer Science and Engineering - Artificial Intelligence

BIO **-** Biology

CCE **-** Computer and Communication Engineering

CHE **-** Chemical Engineering

CHY **-** Chemistry

CSE **-** Computer Science and Engineering

CVL **-** Civil Engineering

CUL **-** Cultural Education

EAC **-** Electronics and Computer Engineering

ECE **-** Electronics and Communication Engineering

EEE **-** Electrical and Electronics Engineering

ELC **-** Electrical and Computer Engineering

HUM **-** Humanities

MAT **-** Mathematics

MEE **-** Mechanical Engineering

PHY – Physics

PE – Professional elective

SP - Specialization

Course Outcome (CO) – Statements that describe what students are expected to know and can do at the end of each course. These relate to the skills, knowledge and behaviour that students acquire in their progress through the course.

Program Outcomes (POs) – Program Outcomes are statements that describe what students are expected to know and be able to do upon graduating from the Program. These relate to the skills, knowledge, attitude and behaviour that students acquire through the program. NBA has defined the Program Outcomes for each discipline.

VISION AND MISSION OF THE DEPARTMENT OF MECHANICAL ENGINEERING

Vision

To transform our students into outstanding mechanical engineers with strong domain knowledge and skills, society-centric research intent, and exemplary ethical values, making them the most desired professionals by research institutions, industry, and society.

Mission

- To develop in each student a profound understanding of fundamentals, motivation for continuous learning, and practical problem-solving skills for building a successful career.
- To create and share technical knowledge and collaborate with Industry and Institutions for the betterment of Society.
- To imbibe ethical values, leadership skills and entrepreneurial skills in students.
- To sustain a conducive environment to involve students and faculty in research and development.

PROGRAM EDUCATIONAL OBJECTIVES

PEO1: Apply their Knowledge in Science, Mathematics and Engineering to address Industrial and Societal problems with a strong emphasis on creativity, confidence, ethics, and responsibility

PEO2: Apply latest computational, analytical, simulation tools and techniques to develop and improve products and processes

PEO3: Solve multidisciplinary problems by working in cross functional teams

PEO4: Develop and upgrade technical, intellectual, and emotional skills for life-long learning to compete in a rapidly evolving world

PE05: Nurture entrepreneurial ventures and foster research activities that support sustainable economic development to enhance the quality of life

PROGRAM OUTCOMES FOR ENGINEERING (POs)

PO1 Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2 Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3 Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4 Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5 Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6 The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7 Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8 Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9 Individual and teamwork: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10 Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11 Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12 Life-long learning: Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES (PSOs)

B. TECH – MECHANICAL ENGINEERING

PSO1: Apply knowledge acquired in the field of Design, Manufacturing, Thermal, and Fluid sciences to solve real-world engineering problems using emerging technologies.
PSO2: Extend and implement innovative thinking on product design and development with the aid of modern tools.

PSO3: Apply the Science and Engineering knowledge for advanced materials design and processing for development of sustainable solutions and improvement of products and processes.

PSO4 : Augment the acquired domain knowledge with AI and Computational skills in order be ready with the changing interdisciplinary demands of the industry.

CREDIT STRUCTURE OF THE PROGRAMME

Categories of Courses & Credit Breakup

S.No	CATEGORY	Semester wise Credits									% Share
		S1	S2	S3	S4	S5	S6	S7	S8	Total	
1.	Humanities & Social Science Courses	4	5	1	3	2	2	-	-	17	11
2.	Basic Science Courses (including Mathematics) and General Engineering courses	15	17	5	3	3	-	-	-	43	27
3.	Engineering Core Courses	-	-	17	15	16	16	3	-	67	41
4.	Professional Elective Courses & Open Elective Courses	-	-	-	2	3	6	6	3	20	13
5.	Project work, Seminar, and Internship in Industry or elsewhere	-	-	-	-	-	-	5	8	13	8
6.	Audit Courses [Environmental Sciences, Research Methodology, Indian Constitution]	-	-	ES	IC	-	-	-	-	-	-
Total		**19**	**22**	**23**	**23**	**24**	**24**	**14**	**11**	**160**	**100**

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Department of Mechanical Engineering

Curriculum for B. Tech Mechanical Engineering- 2023 Admission

Semester 1

Category	Code	Course	L T P	Credit
SCI	23MAT121	Calculus and Linear Algebra	3 1 0	4
SCI	23PHY108	Engineering Physics	2 1 0	3
SCI	23PHY188	Engineering Physics Lab	0 0 3	1
ESC	23MEE101	Problem-Solving using C	2 0 3	3
ESC	23MEE102	Engineering Graphics and 3D Modelling	2 0 3	3
ESC	23MEE105	Manufacturing Practice - A	0 0 3	1
HUM	22AVP103	Mastery Over Mind	1 0 2	2
HUM	22ADM101	Foundations of Indian Heritage	2 0 1	2
		Total		19

Semester 2

Category	Code	Course	L T P	Credit
SCI	23MAT129	Differential Equations and Transforms	3 1 0	4
SCI	23CHY116	Engineering Chemistry	2 0 0	2
SCI	23CHY188	Engineering Chemistry Lab	0 0 3	1
ESC	23EEE102	Basic Electrical and Electronics Engineering	3 0 0	3
ESC	23MEE111	Engineering Mechanics	3 1 0	4
ESC	23EEE182	Basic Electrical and Electronics Engineering Lab	0 0 3	1
ESC	23MEE181	Introduction to Python Programming	0 0 3	1
ESC	23MEE182	Manufacturing Practice - B	0 0 3	1
HUM	23ENG101	Technical Communication	2 0 3	3
HUM	22ADM111	Glimpses of Glorious India	2 0 1	2
		Total		**22**

Semester 3

Category	Code	Course	L T P	Credit
SCI	23MAT222	Probability and Complex Variables	3 1 0	4
ENGG	23MEE201	Mechanics of Solids	3 1 0	4
ENGG	23MEE202	Engineering Thermodynamics	3 1 0	4
ENGG	23MEE203	Metallurgy and Materials Science	3 0 0	3
ENGG	23MEE204	Manufacturing Process I	2 0 3	3
ENGG	23MEE205	Machine Drawing	1 0 3	2
ENGG	23MEE281	Material Testing and Metallurgy Laboratory	0 0 3	1
HUM	22ADM201	Strategic lessons from Mahabharata	1 0 0	1
HUM	23ENV300	Environmental Science		P /F
ESC	23MEE282	Design Thinking	0 0 3	1
HUM	23LSE201	Life Skills for Engineers I	1 0 2	P/F
		Total		**23**

Semester 4

Category	Code	Course	L T P	Credit
ENGG	23MEE211	Fluid Mechanics and Machinery	3 1 0	4
ENGG	23MEE212	Manufacturing Process II	2 0 3	4
ENGG	23MEE213	Computational Methods in Engineering	2 0 3	3
ENGG	23MEE214	Thermal Engineering	3 0 0	3
		Free Elective*		2
ESC	23MEE215	Data Science	2 0 3	3
ENGG	23MEE283	Thermal Engineering Laboratory	0 0 3	1
HUM	22ADM211	Leadership Lessons from Ramayana	1 0 0	1
HUM	23LSE211	Life Skills for Engineers II	1 0 2	2
HUM	23LAW300	Indian Constitution		P / F
		Total		**23**

Semester 5

Category	Code	Course	L T P	Credit
ENGG	23MEE301	Kinematics and Dynamics of Machines	3 1 0	4
ENGG	23MEE302	Design of Machine Elements I	3 0 0	3
ENGG	23MEE303	Heat Transfer	3 0 0	3
ENGG	23MEE304	Instrumentation and Control systems	3 0 0	3
ESC	23MEE305	Machine Learning	2 0 3	3
PE / SP	23LIV390***	Professional Elective I**/Live in Labs I***		3
HUM	23LSE301	Life Skills for Engineers III	1 0 2	2
ENGG	23MEE381	Heat transfer and Instrumentation & control system Laboratory	0 0 3	1
ENGG	23MEE382	Kinematics and Dynamics Laboratory	0 0 3	1
ENGG	23MEE383	Fluid Mechanics and Machinery Laboratory	0 0 3	1
		Total		**24**

Semester 6

Category	Code	Course	L T P	Credit
ENGG	23MEE311	Finite Element Methods	3 0 0	3
ENGG	23MEE312	Design of Machine Elements II	2 1 0	3
ENGG	23MEE313	Industrial Automation	3 0 0	3
PE / SP		Professional Elective II **		3
PE / SP		Professional Elective III **		3
ENGG	23MEE384	Industrial Automation Laboratory	0 0 3	1
ENGG	23MEE314	Metrology and Computer Aided Inspection	1 0 3	2
HUM	23LSE311	Life Skills for Engineers IV	1 0 2	2
ENGG	23MEE385	Computer Aided Engineering Laboratory	0 0 3	1
ENGG	23MEE315	Industrial Engineering	3 0 0	3
		Total		**24**

Semester 7

Category	Code	Course	L T P	Credit
ENGG	23MEE401	Operations Research	2 0 3	3
PE / SP		Professional Elective IV**	3 0 0	3
PE / SP		Professional Elective V **	3 0 0	3
PW	23MEE497	Summer Internship	-	1
PW	23MEE498	Project Phase I	-	4
		Total		**14**

Semester 8

Category	Code	Course	L T P	Credit
PE / SP		Professional Elective VI**	3 0 0	3
PW	23MEE499	Project Phase II	-	8
		Total		**11**
		Total credits (Sem 1 to 8)		**160**

* Free Electives will include courses offered by Faculty of Humanities and Social Sciences/ Faculty Arts, Commerce and Media / Faculty of Management/Amrita Darshanam - (International Centre for Spiritual Studies).

**Professional Electives categorised under Engineering, Science, Mathematics, Live-in- Labs, and NPTEL Courses. Student can opt for such electives across departments/campuses. Students with CGPA of 7.0 and above can opt for a maximum of 2 NPTEL courses with the credits not exceeding 8. If one student would like to opt for specialization, the student must take the professional electives from the respective specialization baskets.

***Live-in-Labs - Students undertaking and registering for a Live-in-Labs project, can be exempted from registering for an Elective course in the higher semester

Note: Link for Common Electives

Refer to the intranet page (intranet.cb.amrita.edu) for B.Tech. Programs Common Electives including a) Professional Electives – Sciences b) Free Electives – Management/Humanities/ Social Sciences

https://intranet.cb.amrita.edu/download/DeanEngg/Curriculum_Syllabus/Undergraduate_Programs/B_Tech_01/Engineering_Common_Electives.pdf

COURSE EVALUATION PATTERN

<table>
<tr><th>Course Type</th><th>Int : Ext</th><th colspan="6">Evaluation Scheme</th><th colspan="2">Total (100)</th></tr>
<tr><td colspan="10">Theory, Lab integrated and Pass/Fail (P/F) Courses</td></tr>
<tr><td rowspan="2">L T P</td><td rowspan="6">60 : 40</td><td>CA1</td><td>CA2</td><td>MT</td><td>CA3</td><td>CA4</td><td>ES</td><td>Internal (60)</td><td>External (40)</td></tr>
<tr><td>Q1 / A1</td><td>Q2/A2</td><td>Exam</td><td>Q3/A3</td><td>Q4/A4</td><td>Exam/ Project*</td><td>CA1+CA2+CA3+CA4</td><td>ES</td></tr>
<tr><td>X 0 0</td><td rowspan="4">7.5</td><td rowspan="4">7.5</td><td rowspan="4">30</td><td rowspan="4">7.5</td><td rowspan="4">7.5</td><td rowspan="4">40</td><td rowspan="4">60</td><td rowspan="4">40</td></tr>
<tr><td>X Y 0</td></tr>
<tr><td>X 0 Z</td></tr>
<tr><td>P/F</td></tr>
<tr><td colspan="10">Lab Based Courses</td></tr>
<tr><td rowspan="2">0 0 Z</td><td rowspan="3">60 : 40</td><td colspan="2">6 weeks Task or Exp. (CA1)</td><td rowspan="2">MT</td><td colspan="2">6 weeks Task or Exp. (CA2)</td><td>ES</td><td colspan="2">Total (100)</td></tr>
<tr><td colspan="2">No. of Task based on the course</td><td colspan="2">No. of Task based on the course</td><td>Exam/ Project*</td><td>Internal (60)</td><td>External (40)</td></tr>
<tr><td>1 0 Z</td><td colspan="2">20</td><td>20</td><td colspan="2">20</td><td>40</td><td>CA1+MT+CA2</td><td>ES</td></tr>
<tr><td colspan="10">Project / Internship</td></tr>
<tr><td rowspan="6">PRJ</td><td rowspan="6">60 : 40</td><td colspan="5">CA (60)</td><td>ES (40)</td><td colspan="2">Total (100)</td></tr>
<tr><td colspan="8">Mini Project / Project Phase 1 & Phase 2</td></tr>
<tr><td colspan="5">Based on Review by panel of experts</td><td>External review</td><td colspan="2">CA+ES</td></tr>
<tr><td colspan="8">Internship</td></tr>
<tr><td colspan="5">External report (Industry / Research Organization)</td><td>Presentation & Internship Report</td><td colspan="2">CA+ES</td></tr>
</table>

Nomenclature

L	: Lecture	T	: Tutorial
P	: Practical	Int	: Internal
Ext	: External	CA	: Continuous Assessment
MT	: Mid-Term	ES	: End Semester Examination
Exp.	: Experimental work	X	: No. of Lecture hours per week
Y	: No. of Tutorial hours per week (1)	Z	: No. of practical hours per week
Q	: Quiz	A	: Assignment

* : Project component (in-lieu of end semester examination) only for the selected courses as decided by the department level committee

Department of Mechanical Engineering

Specialization

S.No.	Name of the Specialization
1	Automation & Robotics
2	Computational Mechanics
3	Electric Vehicle Technology
4	Digital Manufacturing

Note:

Students can opt for specializations in lieu of professional electives (S5 to S8) with a minimum of 18 credits. Specialization will be offered only to the students of BTech Mechanical Engineering.

SPECIALIZATION - AUTOMATION AND ROBOTICS

Preamble:

Most industries have adopted Automation and Robotics to enhance productivity with high reliability, which demands a specialized workforce. A specialization in Automation and Robotics is offered to foster Mechanical Engineering graduates at par with the current industry practices and requirements. This specialization encompasses the essential courses necessary to build competence in understanding and solving challenges in Automation and Robotics. The undergraduate curriculum in Mechanical Engineering provides the necessary foundation in mathematics, computer programming, and machine learning, thereby enabling them to pursue the specialization. The comprehensive syllabus of the specialization comprising mechatronic systems, dynamics and control of robotic systems, and Industry 4.0, capture the current trends in the industry, accentuating the need for a skilled and specialized workforce. This specialization offers the necessary background for placement opportunities and pursuing research in Robotics and Automation.

<table>
<tr><th>Code</th><th>Course</th><th>Semesters</th><th>Professional elective</th><th colspan="2">Credits</th></tr>
<tr><td>23MEE450</td><td>Actuators and Drives</td><td>-</td><td>1</td><td>3</td><td rowspan="4">13</td></tr>
<tr><td>23MEE451</td><td>Robot Kinematics and Dynamics</td><td>-</td><td>2</td><td>3</td></tr>
<tr><td>23MEE452</td><td>Microcontrollers and Embedded Systems</td><td>-</td><td>3</td><td>3</td></tr>
<tr><td>23MEE453</td><td>Robotics and Control</td><td>-</td><td>4</td><td>4</td></tr>
<tr><td colspan="6">Any two of the following courses can be selected in addition to above four courses</td></tr>
<tr><td>23MEE454</td><td>E-Noise Vibration & Harshness</td><td>-</td><td rowspan="6">5 & 6</td><td>3</td><td rowspan="6">6</td></tr>
<tr><td>23MEE455</td><td>Industrial Internet of Things</td><td>-</td><td>3</td></tr>
<tr><td>23MEE456</td><td>Industrial Process Automation</td><td>-</td><td>3</td></tr>
<tr><td>23MEE457</td><td>Mobile Robots</td><td>-</td><td>3</td></tr>
<tr><td>23MEE458</td><td>Real Time Operating System</td><td>-</td><td>3</td></tr>
<tr><td>23MEE459</td><td>Drone Technology</td><td>-</td><td>3</td></tr>
<tr><td></td><td></td><td></td><td></td><td>Total</td><td>19</td></tr>
</table>

Note: Specializations offer to B.Tech Mechanical Engineering Students.

* : Mandatory courses

SPECIALIZATION - COMPUTATIONAL MECHANICS

Preamble

Computational mechanics focuses on the development and application of computational methods and tools for analyzing and solving complex engineering problems involving solid mechanics, fluid mechanics, and material science. Computational mechanics is a critical tool for engineers and researchers working on complex mechanical systems, which may not be possible to solve through traditional analytical methods. The specialization is geared towards equipping mechanical engineers with the necessary skills and knowledge to apply numerical methods and computational tools to solve problems related to design, analysis, and optimization of mechanical systems. Upon completion of the specialization, graduates will have the skills and knowledge to design and analyze complex mechanical systems using computational methods. They will be well-equipped to work in industries such as aerospace, automotive, manufacturing, and energy, where there is a growing demand for professionals with expertise in computational mechanics.

Code	Course	Semesters	Professional elective	Credits	
23MEE461	Advanced Fluid Mechanics	-	1	3	13
23MEE462	Advanced Mechanics of Solids	-	2	3	
23MEE463	Computational Fluid Dynamics	-	3	4	
23MEE464	Computational and Experimental Vibration Analysis	-	4	3	
Any two of the following courses can be selected in addition to above four courses					
23MEE465	Computational Fracture Mechanics	-	5 & 6	3	6
23MEE466	Computational Multibody Dynamics			3	
23MEE467	Computational Materials Science			3	
			Total		19

Note: Specializations offer to B.Tech Mechanical Engineering Students;

* : Mandatory courses

SPECIALIZATION - ELECTRIC VEHICLE TECHNOLOGY

Preamble:

Most of the automotive industries are moving towards EV technology due to stringent emission norms and the depletion of fossil fuels. Automotive manufacturers face technology challenges in designing, developing and operating safe, efficient, and reliable EVs. Employment and research opportunities in E-mobility are increasing globally, and engineers should be equipped with the necessary capabilities in EV technologies. B. Tech Mechanical Engineering students aspiring to work in EVs can opt for their specialization in EV Technology offered by the department. Students will be able to acquire skillsets to design, model, analyse and test the functional components of EV sub-systems. The department is equipped with state-of-the-art facilities for testing EV power trains, Battery Management Systems, NVH, Vehicle Dynamics and Automotive Electronics.

<table>
<tr><th>Code</th><th>Course</th><th>Semesters</th><th>Professional elective</th><th colspan="2">Credit</th></tr>
<tr><td>23MEE470</td><td>Electrical Drives and Controllers</td><td>-</td><td>1</td><td>3</td><td rowspan="4">13</td></tr>
<tr><td>23MEE471</td><td>Electric Vehicle Design</td><td>-</td><td>2</td><td>3</td></tr>
<tr><td>23MEE472</td><td>Vehicle Energetics and Battery Management System</td><td>-</td><td>3</td><td>3</td></tr>
<tr><td>23MEE473</td><td>Modelling and Simulation of EHV</td><td>-</td><td>4</td><td>4</td></tr>
<tr><td colspan="6">Any two of the following courses can be selected in addition to above four courses</td></tr>
<tr><td>23MEE454</td><td>E-Noise Vibration and Harshness</td><td rowspan="6">-</td><td rowspan="6">5 & 6</td><td>3</td><td rowspan="6">6</td></tr>
<tr><td>23MEE474</td><td>Testing and Certification of Electric Hybrid Vehicles</td><td>3</td></tr>
<tr><td>23MEE475</td><td>Electric and Hybrid Vehicles</td><td>3</td></tr>
<tr><td>23MEE476</td><td>Materials for EVs</td><td>3</td></tr>
<tr><td>23MEE477</td><td>Automotive Infotronics</td><td>3</td></tr>
<tr><td>23MEE478</td><td>MEMS for EV Applications</td><td>3</td></tr>
<tr><td></td><td></td><td></td><td></td><td>Total</td><td>19</td></tr>
</table>

Note: Specializations offer to B.Tech Mechanical Engineering Students;

* : Mandatory courses

SPECIALIZATION - DIGITAL MANUFACTURING

Preamble:

In the modern era of high-end precision manufacturing, digital manufacturing has an important role. Digital manufacturing offers several benefits for industries, such as enhanced efficiency, greater flexibility, improved quality, established supply chain management and sustainable environment-friendly solutions, which help industries to compete globally. Digitization has become necessary as we enter the world of modern computing, where everyone discusses Industry 4.0 / Industry 5.0, the Internet of Things (IoT) and Artificial Intelligence.

Digital manufacturing, also referred to as Industry 4.0 / Industry 5.0 or Smart Manufacturing, integrates the technologies of computing such as Artificial Intelligence, Machine Learning and Robotics into the field of manufacturing while the most common area of interest, “Internet of Things” gathers data using various data gathering that impacts manufacturing.

Thus, the combination of digital manufacturing and modern computing areas such a IoT, Artificial Intelligence would revolutionise manufacturing systems by enabling real-time monitoring, controlling of production processes, optimization of supply chains and improving product quality. Additionally, this combination will enable the adoption of more new sustainable business models, leading to more profitability for any organization.

At Amrita Vishwa Vidyapeetham, the specialization on Digital Manufacturing has been designed in consultation with industrial experts. The faculties of Amrita Vishwa Vidyapeetham work very closely with industries and hence, brings the latest syllabus in line with the industrial demands. The students enrolled in B.Tech Mechanical Engineering with Specialization in Digital Manufacturing will not only study the core mechanical engineering but will also study the subjects which are of high demand in the industry, such as additive manufacturing, digital twin, smart manufacturing, MEM/NEMS, IoT, Cyber Security etc. The subjects are designed to meet industrial needs and make the student industry ready.

<table>
<tr><th>Code</th><th>Course</th><th>Semesters</th><th>Professional elective</th><th colspan="2">Credit</th></tr>
<tr><td>23MEE455</td><td>Industrial Internet of Things</td><td>-</td><td>1</td><td>3</td><td rowspan="4">12</td></tr>
<tr><td>23MEE421</td><td>Additive Manufacturing</td><td>-</td><td>2</td><td>3</td></tr>
<tr><td>23MEE422</td><td>Digital Twins</td><td>-</td><td>3</td><td>3</td></tr>
<tr><td>23MEE423</td><td>Smart Manufacturing</td><td>-</td><td>4</td><td>3</td></tr>
<tr><td colspan="6">Any two of the following courses can be selected in addition to above four courses</td></tr>
<tr><td>23MEE424</td><td>Computer Integrated Manufacturing</td><td rowspan="5">-</td><td rowspan="5">5 & 6</td><td>3</td><td rowspan="5">6</td></tr>
<tr><td>23MEE425</td><td>Applied Analytics</td><td>3</td></tr>
<tr><td>23MEE426</td><td>Design for Additive Manufacturing</td><td>3</td></tr>
<tr><td>23MEE427</td><td>Sustainable Manufacturing</td><td>3</td></tr>
<tr><td>23MEE428</td><td>Cybersecurity in Manufacturing</td><td>3</td></tr>
<tr><td></td><td></td><td></td><td></td><td>Total</td><td>18</td></tr>
</table>

Note: Specializations offer to B.Tech Mechanical Engineering Students;

* : Mandatory course

PROFESSIONAL ELECTIVES

Common Basket

Elective list: for students not opting for specialization / dropping from specialization in between

Category	Code	Course	Credit
DESIGN			
ENGG	23MEE331	Failure Analysis and Design	3
ENGG	23MEE332	Optimization Techniques in Engineering	3
ENGG	23MEE333	Experimental Methods	3
ENGG	23MEE334	Theory of Vibrations	3
ENGG	23MEE335	Modelling and Simulation of Engineering Systems	3
ENGG	23MEE336	Tool Design	3
ENGG	23MEE337	NVH for Automotive Applications	3
ENGG	23MEE338	Systems Engineering	3
ENGG	23MEE339	Machine Condition Monitoring	3
ENGG	23MEE340	Experimental Stress Analysis	3
ENGG	23MEE341	Non-linear dynamics and Chaos	3
ENGG	23MEE342	Materials Selection in Mechanical Design	3
ENGG	23MEE343	Geometric Modelling & Computer Graphics	3
ENGG	23MEE344	Robust Design	3
ENGG	23MEE345	Industrial Tribology	3
ENGG	23MEE346	Product Design and Development	3
MANUFACTURING AND MATERIALS			
ENGG	23MEE351	Composite Materials and Design	3
ENGG	23MEE352	Fundamentals of Nanomaterials	3
ENGG	23MEE353	Industrial Robotics	3
ENGG	23MEE354	Nano Technology and Surface Engineering	3
ENGG	23MEE355	Advanced Casting Technology	3
ENGG	23MEE356	Advanced Manufacturing Processes	3
ENGG	23MEE357	Advanced Materials and Processes	3
ENGG	23MEE358	Advanced Welding Technology	3
ENGG	23MEE359	Micro-Manufacturing	3
ENGG	23MEE360	Non-Destructive Testing	3
ENGG	23MEE361	Quality Control and Reliability Engineering	3
ENGG	23MEE362	Simulation Modelling of Manufacturing Systems	3
ENGG	23MEE363	Environmental Engineering and Management	3
ENGG	23MEE364	Design for Manufacturing and Assembly	3
ENGG	23MEE365	Geometric Dimensioning and Tolerancing	3
ENGG	23MEE366	Advanced Forming Technology	3
ENGG	23MEE367	Theory of Metal Cutting	3
ENGG	23MEE368	Electronics Materials Science	3
ENGG	23MEE369	Reverse Engineering and Additive Manufacturing	3
ENGG	23MEE370	Materials Characterization	3
ENGG	23MEE373	Corrosion Science and Engineering	3
ENGG	23MEE374	Automotive Materials and Engineering	3
ENGG	23MEE375	Computer Aided Manufacturing	3

INDUSTRIAL ENGINEERING AND MANAGEMENT			
ENGG	23MEE431	Financial Management	3
ENGG	23MEE432	Supply Chain Management	3
ENGG	23MEE433	Project Management	3
ENGG	23MEE434	Managerial Statistics	3
ENGG	23MEE435	Total Quality Management	3
ENGG	23MEE436	Industrial Safety	3
ENGG	23MEE437	Engineering Economic Analysis	3
ENGG	23MEE438	Lean Manufacturing	3
ENGG	23MEE439	Manufacturing Planning and Control	3
ENGG	23MEE440	Introduction to Ergonomics	3
THERMAL AND FLUIDS			
ENGG	23MEE441	Gas Dynamics and Jet Propulsion	3
ENGG	23MEE442	HVAC Systems & Applications	3
ENGG	23MEE443	Power Plant Engineering	3
ENGG	23MEE444	Automotive Technology	3
ENGG	23MEE445	Solar and Wind Power Technologies	3
ENGG	23MEE446	IC Engines and Emission	3
ENGG	23MEE447	Cryogenic Engineering	3
ENGG	23MEE448	Design of Thermal systems	3
ENGG	23MEE449	Aerospace Engineering	3
ENGG	23MEE460	Turbo Machinery	3

Note:

Students those who have not opted for specialization course can choose any courses as an elective from the specialization (Automation and Robotics, Computational Mechanics, Electric Vehicle Technology, and Digitl Manufacturing) / common elective basket.

Value Added Courses

The experts offer value-added courses to students during the weekend/summer/ winter vacations. These courses are non-credit courses. Certificates will be issued to the students after the successful completion of the course. Additional courses will be added to this list based on the demand from the students as well as requirements from the industry.

MOOC Courses

Instead of Professional elective courses, students who maintain a CGPA of more than 7.0 can choose two MOOC courses with total credits not exceeding 8 after getting approval from the department. The list of MOOC courses will be informed to the students well in advance. The students can opt for MOOC courses during the 3rd and 4th years of the study.

List of courses in Amrita Value Programme I & II			
Course Code	**Title**	**L-T-P**	**Credits**
22ADM201	Strategic Lessons from Mahabharatha	1-0-0	1
22ADM211	Leadership from Ramayana	1-0-0	1
22AVP210	Kerala Mural Art and Painting	1-0-0	1
22AVP218	Yoga Therapy and Lessons	1-0-0	1
22AVP212	Introduction to Traditional Indian Systems of Medicine	1-0-0	1
22AVP201	Amma's Life and Message to the modern world	1-0-0	1
22AVP204	Lessons from the Upanishads	1-0-0	1
22AVP205	Message of the Bhagavad Gita	1-0-0	1
22AVP206	Life and Message of Swami Vivekananda	1-0-0	1
22AVP207	Life and Teachings of Spiritual Masters of India	1-0-0	1
22AVP208	Insights into Indian Arts and Literature	1-0-0	1
22AVP213	Traditional Fine Arts of India	1-0-0	1
22AVP214	Principles of Worship in India	1-0-0	1
22AVP215	Temple Mural Arts in Kerala	1-0-0	1
22AVP218	Insights into Indian Classical Music	1-0-0	1
22AVP219	Insights into Traditional Indian Painting	1-0-0	1
22AVP220	Insights into Indian Classical Dance	1-0-0	1
22AVP221	Indian Martial Arts and Self Defense	1-0-0	1
22AVP209	Yoga and Meditation	1-0-0	1

PROFESSIONAL ELECTIVES UNDER SCIENCE STREAM

CHEMISTRY				
Cat.	**Course Code**	**Title**	**L T P**	**Credit**
SCI	23CHY240	Computational Chemistry and Molecular Modelling	3 0 0	3
SCI	23CHY241	Electrochemical Energy Systems and Processes	3 0 0	3
SCI	23CHY242	Fuels and Combustion	3 0 0	3
SCI	23CHY243	Green Chemistry and Technology	3 0 0	3
SCI	23CHY244	Instrumental Methods of Analysis	3 0 0	3
SCI	23CHY245	Batteries and Fuel Cells	3 0 0	3
SCI	23CHY246	Corrosion Science	3 0 0	3
PHYSICS				
SCI	23PHY240	Advanced Classical Dynamics	3 0 0	3
SCI	23PHY241	Electrical Engineering Materials	3 0 0	3
SCI	23PHY242	Physics of Lasers and Applications	3 0 0	3
SCI	23PHY243	Concepts of Nanophysics and Nanotechnology	3 0 0	3
SCI	23PHY244	Physics of Semiconductor Devices	3 0 0	3
SCI	23PHY245	Astrophysics	3 0 0	3
MATHEMATICS				
SCI	23MAT240	Statistical Inference	3 0 0	3
SCI	23MAT241	Introduction to Game Theory	3 0 0	3
SCI	23MAT242	Numerical Methods and Optimization	3 0 0	3

FREE ELECTIVES

FREE ELECTIVES OFFERED UNDER MANAGEMENT STREAM				
Cat.	**Course Code**	**Title**	**L T P**	**Credit**
HUM	23MNG331	Financial Management	3 0 0	3
HUM	23MNG332	Supply Chain Management	3 0 0	3
HUM	23MNG333	Marketing Management	3 0 0	3
HUM	23MNG334	Project Management	3 0 0	3
HUM	23MNG335	Enterprise Management	3 0 0	3
HUM	23MNG336	Operations Research	3 0 0	3
HUM	23MEE321	Industrial Engineering	3 0 0	3
HUM	23MEE322	Managerial Statistics	3 0 0	3
HUM	23MEE323	Total Quality Management	3 0 0	3
HUM	23MEE324	Lean Manufacturing	3 0 0	3
HUM	23CSE321	Software Project Management	3 0 0	3
HUM	23CSE322	Financial Engineering	3 0 0	3
HUM	23CSE323	Engineering Economic Analysis	3 0 0	3
HUM	23CSE324	Information Systems	3 0 0	3

FREE ELECTIVES OFFERED UNDER HUMANITIES / SOCIAL SCIENCE STREAMS				
Cat.	**Course Code**	**Title**	**L T P**	**Credit**
HUM	23CUL230	Achieving Excellence in Life - An Indian Perspective	2 0 0	2
HUM	23CUL231	Excellence in Daily Life	2 0 0	2
HUM	23CUL232	Exploring Science and Technology in Ancient India	2 0 0	2
HUM	23CUL233	Yoga Psychology	2 0 0	2
HUM	23ENG230	Business Communication	1 0 3	2
HUM	23ENG231	Indian Thought through English	2 0 0	2
HUM	23ENG232	Insights into Life through English Literature	2 0 0	2
HUM	23ENG233	Technical Communication	2 0 0	2
HUM	23ENG234	Indian Short Stories in English	2 0 0	2
HUM	23FRE230	Proficiency in French Language (Lower)	2 0 0	2
HUM	23FRE231	Proficiency in French Language (Higher)	2 0 0	2
HUM	23GER230	German for Beginners I	2 0 0	2
HUM	23GER231	German for Beginners II	2 0 0	2
HUM	23GER232	Proficiency in German Language (Lower)	2 0 0	2
HUM	23GER233	Proficiency in German Language (Higher)	2 0 0	2
HUM	23HIN230	Hindi I	2 0 0	2
HUM	23HIN231	Hindi II	2 0 0	2
HUM	23HUM230	Emotional Intelligence	2 0 0	2
HUM	23HUM231	Glimpses into the Indian Mind - the Growth of Modern India	2 0 0	2
HUM	23HUM232	Glimpses of Eternal India	2 0 0	2
HUM	23HUM233	Glimpses of Indian Economy and Polity	2 0 0	2
HUM	23HUM234	Health and Lifestyle	2 0 0	2
HUM	23HUM235	Indian Classics for the Twenty-first Century	2 0 0	2
HUM	23HUM236	Introduction to India Studies	2 0 0	2
HUM	23HUM237	Introduction to Sanskrit Language and Literature	2 0 0	2
HUM	23HUM238	National Service Scheme	2 0 0	2

HUM	23HUM239	Psychology for Effective Living	2 0 0	2
HUM	23HUM240	Psychology for Engineers	2 0 0	2
HUM	23HUM241	Science and Society - An Indian Perspective	2 0 0	2
HUM	23HUM242	The Message of Bhagwat Gita	2 0 0	2
HUM	23HUM243	The Message of the Upanishads	2 0 0	2
HUM	23HUM244	Understanding Science of Food and Nutrition	2 0 0	2
HUM	23HUM245	Service Learning	2 0 0	2
HUM	23JAP230	Proficiency in Japanese Language (Lower)	2 0 0	2
HUM	23JAP231	Proficiency in Japanese Language (Higher)	2 0 0	2
HUM	23KAN230	Kannada I	2 0 0	2
HUM	23KAN231	Kannada II	2 0 0	2
HUM	23MAL230	Malayalam I	2 0 0	2
HUM	23MAL231	Malayalam II	2 0 0	2
HUM	23SAN230	Sanskrit I	2 0 0	2
HUM	23SAN231	Sanskrit II	2 0 0	2
HUM	23SWK230	Corporate Social Responsibility	2 0 0	2
HUM	23SWK231	Workplace Mental Health	2 0 0	2
HUM	23TAM230	Tamil I	2 0 0	2
HUM	23TAM231	TAMIL II	2 0 0	2

MECHANICAL ENGINEERING SYLLABUS

S1

SEMESTER 1

23MAT121	**CALCULUS AND LINEAR ALGEBRA**	**L-T-P-C: 3-1-0-4**

Course Objectives

The course will enable the students to

- Understand the concept of continuous function and be familiar with definite integrals and integration techniques.
- Obtain partial derivatives of multi-variable functions to find Jacobian and use them in practical cases.
- Use important theorems in vector calculus to solve engineering problems.
- Solve the system of linear equations using matrix methods.
- Use vector space methods and diagonalization in practical problems.

Course Outcomes

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Generate graphs for functions using the concepts of single variable calculus and apply the fundamental theorem of calculus to evaluate integrals.	Apply
CO02	Select suitable parameterization of curves and find their arc lengths.	Evaluate
CO03	Find partial derivatives of multivariable functions and use the Jacobian in practical problems.	Evaluate
CO04	Apply the fundamental theorem of Line Integrals, Green's Theorem, Stokes' Theorem, or Divergence Theorem to evaluate integrals.	Analyze
CO05	Apply concepts of matrix algebra for solving simultaneous linear algebraic equations.	Analyze
CO06	Apply the power of mathematical abstraction through concepts like vector spaces, inner product spaces, and linear transformations.	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3			1							1				
CO02	3	3			1							1				
CO03	3	3			1							1				
CO04	3	3			1							1				
CO05	3	3			1							1				
CO06	3	3			1							1				

Syllabus

Unit 1: Single Variable Calculus

Calculus graphs: Functions and their graphs. Shifting and scaling of graphs. Limit and Continuity: Limit (one sided and two sided) of functions. continuous functions, discontinuities, monotonic functions, infinite limits and limit at infinity. Graphing: Extreme values of functions, concavity and curve sketching, Integration: Definite integrals, The mean value theorem for definite integrals, Fundamental theorem of Calculus, Integration techniques. [20 Hrs]

Unit 2: Multi variable Calculus

Functions of severable variables: Functions, limit and continuity. Partial differentiations, total derivatives, differentiation of implicit functions and transformation of coordinates by Jacobian. Taylor's series for two variables.

Vector Differentiation: Vector and scalar functions, Derivatives, curves, tangents, arc length, Curves in mechanics, velocity and acceleration, gradient of a scalar field, directional derivative, divergence of a vector field, curl of a vector field.

Vector Integration: Line integral, Line integrals independent of path. Green's theorem in the plane, Surfaces for surface integrals, surface integrals, Triple Integrals – Gauss Divergence Theorem, Stoke's Theorem. [20 Hrs]

Unit 3: Basic Linear Algebra

Vectors in *Rn*, notion of linear independence and dependence, linear span of a set of vectors, vector subspaces of *Rn,* basis of a vector subspace.

Linear system of equations, Gauss elimination, Linear independence, rank of a matrix, row space and column space, existence and uniqueness of system of linear equations, Determinants, Cramer's' rule, Inverse of a matrix, Gauss-Jordan elimination.

Vector spaces, subspaces, linear independence, basis, dimension, change of basis, row, column and null spaces, linear transformation, eigen values and eigen vectors, diagonalization, inner product spaces, Gram-Schmidt orthogonalization. [20 Hrs]

Topics for Assignments/ Tutorials/ Case studies

a) Electric circuits
b) Principle moment of inertia and planes of principle moments of inertia
c) Heat transfer problem – finite difference equations
d) Equilibrium equations in statics – truss problems, support reactions in beams
e) Coupled spring mass system
f) Concept of vorticity and incompressibility based on differential equations.
g) Concept of stress and strain gradient
h) Coordinate transformation using Jacobian matrix
i) Simple problems in Dynamics
j) Computing Areas and Volumes of structural components
k) Machine Learning applications for data representation and dimensionality reduction.
l) The linear regression model is used to predict data related to decision-making, medical diagnosis, statistical inferences.
m) MATLAB based computational assignments.

Textbooks:

1. Advanced Engineering Mathematics, E Kreyszig, John Wiley and Sons, Tenth Edition, 2018.

Reference Books:

1. Elementary Linear Algebra, Howard Anton and Chris Rorres, 11th Edition, Wiley, 2015.
2. Calculus', G.B. Thomas Pearson Education, 2009, Eleventh Edition.
3. Calculus', Monty J. Strauss, Gerald J. Bradley and Karl J. Smith, 3rd Edition, 2002
4. Engineering Mathematics, Srimanta Pal and Subodh C Bhunia, , John Wiley and Sons, 2012, Ninth Edition.

S1

23PHY108	ENGINEERING PHYSICS	L-T-P-C: 2 1 0-3

Course Objectives

- To expose the essentials of Newtonian mechanics, Wave optics and elemental Quantum Mechanics to the Engineering students to enable them to apply in their engineering applications.

Course Outcomes

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Apply the principles of Newtonian Mechanics to Engineering problems.	Apply
CO02	Understand the fundamentals of wave optics and its applications in engineering.	Apply
CO03	Understand the essentials of Quantum mechanics and apply them to simple applications.	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3										1				
CO02	3	2										1				
CO03	3	2										1				

Syllabus

Unit 1

Classical Mechanics: Review of Newton's third law and Free Body diagrams. Rigid body dynamics: Centre of mass. Moment of inertia. Torque, angular momentum, and angular acceleration. Work, power, and energy. Conservation of momentum. Conservation of energy. Elastic and inelastic collisions. Circular motion: Radial and tangential forces. Centripetal acceleration and centripetal force. [15 Hours]

Unit 2

Fundamentals of Wave optics: Theory of superposition -Qualitative: Superposition of two and many Wave trains of the Same Frequency and random phase, Vector addition of amplitudes, Fresnel and Fraunhofer Diffraction - Diffraction by a single and double Slit, intensity variation in single and double slit interference, Effect of increasing the number of Slits(Grating), Intensity distribution from an Ideal grating. Resolving power of grating and grating spectra. Principles of interferometry- Theory of Michelson's Interferometer and its applications. [15 Hours]

Unit 3

Quantum mechanics: Wave function, Probability density, expectation values - Schrodinger equation – time-dependent and independent, Linearity and superposition, expectation values, operators, Eigen functions, and Eigen values. Application of 1D Schrodinger Wave equation: Free particle, Particle in a box, Finite potential well- Essentials of semiconducting materials. [15 Hours]

Textbooks:

1. Richard Wolfson, "Essential University Physics", Vols. 1 and 2. Pearson Education, Singapore, 2011.

Reference Books:

1. Halliday D., Resnick R. and Walker J., "Fundamentals of Physics", Wiley Publications, 2008.
2. Francis A. Jenkins, Harvey E.White, "FUNDAMENTALS OF OPTICS" Forth edition- McGraw-Hill Publications
3. Beiser A., "Concepts of modern physics", McGraw-Hill India, 2006.

S1

23PHY188	ENGINEERING PHYSICS LAB	L-T-P-C: 0-0-3-1

Course Objectives

- To introduce experiments to test the understanding of physics concepts in mechanics, optics, solid state physics, quantum mechanics, electricity, and magnetism.
- To make the student acquire practical skills in finding properties of mater, optical properties, electrical characteristics of semiconductor materials, and quantum behavior of materials.

Course Outcomes:

After successful completion of the lab course, students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Experiments to study the elastic properties of materials	Evaluate
CO02	Design and perform experiments on dispersion, interference, and diffraction.	Evaluate
CO03	Design; perform experiments to measure semiconducting properties.	Evaluate
CO04	Experiment to study the atomic spectrum of the H2 atom and the quantum nature of light.	Analyze

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	1	1	1					1	1	3	1				
CO02	3	1	1	1					1	1	3	1				
CO03	3	1	1	1					1	1	3	1				
CO4	3	1	1	1					1	1	3	1				

Syllabus

S.No	List of Experiments	CO mapping
1.	Determination of Young's modulus of the given material using non-uniform bending.	CO01
2.	Determination of the Rigidity modulus of the given wire using the torsional oscillation method.	CO01
3.	Find the dispersive power of the material of the prism.	CO02
4.	Determination of the wavelength of a diode laser using a diffraction grating and finding the mean size of Lycopodium particles.	CO02
5.	Find the radius of curvature of a given convex lens by Newton's rings method.	CO02
6.	Determination of the efficiency and fill factor of the given solar cell and study its characteristics.	CO03
7.	Determine the band gap of a semiconductor.	CO03
8.	Determination of Planck's constant and work function of a given metal using the photoelectric effect.	CO04
9.	Experiment to verify the quantum nature of the hydrogen atom by measuring the wavelengths of spectral lines in the Balmer series.	CO04

S1

23MEE101	PROBLEM SOLVING USING C	L-T-P-C: 2-0-3-3

Course Objectives

- To provide the foundations of problem-solving and algorithmic thinking
- To familiarize programming languages using C as a tool for problem-solving
- To include the concept of arrays and structures in programming
- To write programs that solve simple practical engineering problems

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Apply algorithmic thinking to understand, define and solve problems	Apply
CO02	Acquire the concepts of typical programming constructs: data (primitive and compound), control, modularity, recursion etc., thereby understanding a given program.	Understand
CO03	Analyze a given program by tracing and identifying syntax errors and debugging them.	Analyze
CO04	Make use of the programming constructs appropriately and effectively while developing computer programs.	Apply
CO05	Develop computer programs that implement suitable algorithms for problem scenarios and applications.	Analyze

CO-PO Mapping:

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2	1		2				2	1		1	2			3
CO02	3	2			2				2	1		1	2			3
CO03	3	2	2		2				2	1		1	2			3
CO4	3	2	3		2				2	1		1	2			3
CO5	3	2	3		2				2	1		1	2			3

Syllabus

Unit 1

Introduction to Problem Solving and Algorithmic Thinking

Overview – problem definition, logical reasoning; Algorithm –definition, practical examples, properties, representation. Constituents of algorithms – Sequence, Selection and Repetition.

Introduction to C: C for problem solving – Introduction, structure of C programs, data types, data input, output statements, control structures. [10 hours]

Unit 2

Functions–Inter function communication, standard functions, scope. **Arrays** – 1D numeric, searching and sorting, 2D numeric arrays. Pointers: introduction, compatibility, arrays and pointers, Dynamic memory allocation, arrays of pointers, pointer arithmetic. **Strings**: fixed length and variable length strings, strings and characters, string input, output, array of strings, string manipulation functions, sorting of strings. Solving engineering problems. [10 hours]

Unit 3

Recursion – Recursive definition, recursive solution, designing recursive functions, limitations of recursion. **Structures:** structure vs array comparison, complex structures, structures and functions, **Union**. Files and streams, file input output, command line arguments. Solving engineering problems, case studies. [10 hours]

Laboratory Components:

Lab No.	Topic	Remarks
1	Familiarizing with the working environment Programs using I/O Statements.	Exercises on various input and output commands, use of appropriate datatypes, range of datatypes, various operators, precedence and associativity of operators
2	Programs using Control structures	Exercises on if, if else, switch, for loop, nested for, while, do while, break, go to and continue.
3	Functions	Exercises on standard functions, user defined functions, functions with different return types, different number of parameters, and function calls with call by value method
4	Arrays (1D)	Exercise on Arrays, passing arrays in inter function communications, sorting and searching
5	2D Arrays	Exercises with 2-Dimensional Matrix based problems
6	Strings	Exercises on various string operations
7	Pointers	Exercises on Pointers with functions using call by reference method, and memory allocation functions
8	Pointers	Exercises on Pointers with Functions and Arrays
9	Recursion	Exercise on direct and Indirect recursion calls
10	Structures	Exercises on simple structures
11	Structures	Exercises on structures within structures and Unions
12	File handling	Exercises on various file handling operations

Textbooks:

1. Riley DD, Hunt KA. Computational Thinking for the Modern Problem Solver. CRC press; 2014 Mar 27.
2. Behrouz A. Forouzan and Richard F. Filberg, “Computer Science A Structured Programming Approach Using C”,Third Edition, Cengage Learning, 2006

Reference Books:

1. Beecher K. Computational Thinking: A beginner's guide to Problem-solving and Programming. BCS Learning &
Development Limited; 2017
2. Byron Gottfried. Programming With C. Fourth Edition, McGraw Hill,;2018
3. Brian W. Kernighan and Dennis M. Ritchie, “The C Programming Language”, Second Edition, Prentice Hall, 1988.
4. Eric S. Roberts, “Art and Science of C”, Addison Wesley, 1995.
5. Jeri Hanly and Elliot Koffman, “Problem Solving and Program Design in C”, Fifth Edition, Addison Wesley (Pearson), 2007

S1

23MEE102	ENGINEERING GRAPHICS AND 3D MODELLING	L-T-P-C: 2-0-3-3

Course Objectives

- To understand the BIS and its importance in Technical Drawings.
- To acquire proficiency in orthographic and isometric projection techniques for 2D representation of 3D objects.
- To appreciate the significance of 3D modeling in engineering design and drafting.
- To familiarize with 3D modeling software.
- Develop lateral surface development principles for creating 2D representations of 3D objects.

Course Outcomes:

After successful completion of the course, Students will be able to:

Sl. No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Demonstrate proficiency in using BIS for drafting.	Apply
CO02	Construct engineering drawings using principles of orthographic and isometric projection.	Analyze
CO03	Develop models using principles of lateral surface development.	Analyze
CO04	Create proficiency in developing 3D solid models using the software.	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	1	3		1			3	3	3		1	1	2		
CO02	3	2	3	1	2				3	3		1	1	2		
CO03	3	3	3	1	3	1		1	3	2		1	1	2		
CO4	3	2	3	1	2			1	3	2		1	1	2		

Syllabus

Module 1: Introduction to Engineering Graphics and 3D Modeling.

- Introduction to BIS of Engineering Drawing – Line type, dimensioning,
- Significance of 3D modeling
- Introduction to 3D Modeling Software

Module 2: Orthographic and Isometric Projections in 3D

- Understanding orthographic projections of points, lines, planes, and solids in 3D
- Developing 2D projections of 3D models.
- Developing sectional views of 3D models of solids
- Developing isometric projections from 3D models of solids
- Real-world applications of orthographic projections.

Module 3: Development of Lateral Surfaces

- Developing lateral surfaces of right regular prisms, cylinders, pyramids, and cones
- Understanding the development of surfaces in 3D models
- Real-world applications of surface development

Module 4: Advanced 3D Modeling Techniques

- Advanced modeling techniques in 3D Modeling Software (Autodesk® Fusion 360®)
- Creating complex 3D models using multiple tools and techniques
- Applications of advanced 3D modeling techniques in various industries
- Exporting 3D models for prototyping and manufacturing

Note: The course is designed to provide students with a comprehensive understanding of engineering graphics, including 2D and 3D modeling techniques. The course will also cover various real-world applications of these techniques and how they are used in different industries. Students will be expected to complete assignments and projects using 3D Modeling Software (Autodesk® Fusion 360®).
The classroom learning will be supplemented with a workbook, where the students shall have manual drawing practice for all projection-related topics.

Textbooks:

1. Basant Agarwal and C M Agarwal., "Engineering Drawing," 2e, McGraw Hill Education, 2015
2. Autodesk Fusion 360: A Power Guide for Beginners and Intermediate Users by John Willis, Sandeep Dogra, and Cadartifex, 4e, CADArtifex

Reference Books:

1. Jain, Maheshwari, Gautam (2021), Engineering Graphics & Design, Khanna Book Publishing.
2. Autodesk Fusion 360 For Beginners: Part Modeling, Assemblies, and Drawings – Tutorial Book
3. Bhatt N.D., Panchal V.M. & Ingle P.R., (2014), Engineering Drawing, Charotar Publishing.
4. John K.C., "Engineering Graphics for Degree", 1e, Prentice Hall India, 2009
5. Shah, M.B. & Rana B.C. (2008), Engineering Drawing and Computer Graphics, Pearson.

S1

23MEE105	MANUFACTURING PRACTICE-A (Only for BTech Mechanical Engineering)	L-T-P-C: 0-0-3-1

Course Objectives

- Introduce the general safety procedures that should be observed on the shop floor.
- Identify types of sensors
- Arduino microcontrollers, including programming and integration of input and output devices
- Introduce using the right tools for various operations, including dismantling and assembling the products.
- Measure the dimensions using appropriate measuring instruments.
- Practically verifying the principles of development of surfaces through fabricating the sheet metal components.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Practice the safety procedures in the shop floor environment.	Apply
CO02	Select the suitable sensors for the given application	Apply
CO03	Integrate input and output devices with the microcontroller	Understand
CO04	Realize the functionality of parts in an assembly through dismantling and assembling.	Understand
CO05	Fabricate sheet metal components using lateral surface development principles.	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	1	1		1	1			1	1		2	1	1	1	
CO02	2	2	1		1	1	1		1	3	1	2	1	1	1	1
CO03	3	2	1		1	1			1	3	1	2	1	1	1	1
CO04	2	3	2			1			1	3	3	2	1	1	1	
CO05	3	3	3			1	1		1	3	3	2	1	1	1	

Syllabus (Only for BTech Mechanical Engineering students)

Workshop Safety Measures and Practices - Proper training and supervision before operating unfamiliar or complex equipment.

a. Product Workshop

Disassemble the product or sub-assembly - Measure various dimensions using measuring instruments- Free hand sketching of the assembly and components - Prepare the bill of materials - Study the assembly's functioning and parts- assemble the product or subassembly. [12 hours]

b. Sheet Metal Fabrication

Study of tools and equipment - Sheet Metal cutting and bending techniques – Sheet metal design principles and practices-Joining & finishing sheet metal parts. Introduction to Mechanical/hydraulic press. [12 hours]

c. Sensors lab

Principles of essential sensing technologies and selecting a specific technology for a given application. Types of sensors - Analog and Digital sensors, Presence vs measurement sensing, inductive, capacitive and photoelectric sensors, Magnetic field sensors, Ultrasonic sensors, Pressure, temperature, flow, RFID sensors. Arduino microcontrollers – programming, integration of input and output devices with Arduino controllers. Demonstration of automation sensing applications. [21 hours]

List of equipment required for meeting the COs

a	Product Workshop Tools and accessories for assembly and disassembly Measuring instruments Different Mechanical assemblies such as gearbox, pump, hydraulic cylinder etc.
b	Sheet Metal Fabrication Marking and Measuring Tools Punches and Files Striking Tools – Mallet and hammers Slip gauge and sheet metal gauge. Shearing Tools – Shear cutter, Hand snippers, Chisels Sheet metal bending tools -Press Brake Disc Grinders, Drill bits Anvil and Bench vice
c	Sensors Laboratory Experimental setup - Measuring pressure, distance, temperature, flow, magnetic field, colour, light intensity, sound, and force. Arduino board with necessary input and output devices Arduino IDE (open source) and computers

Laboratory Components:

S.No.	List of Exercises	CO mapping
1	General Workshop Safety Measures and Practices	CO01
2.	Product Workshop Disassembly and assembly of mechanical assemblies such as Centrifugal Pump, Two-Stage Pump, Gear Pump, Worm Gear Box, Pneumatic Double-Acting Cylinder etc. Measurement and free hand sketching of parts and assemblies and preparing a bill of materials.	CO04
3	Sheet Metal Fabrication Surface development of geometries for sheet metal fabrication. Fabrication of simple geometries using sheet metal operations. Demonstration of Mechanical /Hydraulic press.	CO01, CO05
4	Sensors Laboratory Study of various sensors used in manufacturing applications. Measurement of physical parameters like pressure, distance, temperature, flow, magnetic field, colour, light intensity, sound and force using appropriate sensors Introduction to Arduino programming Interfacing of input and output devices with the controller	CO02, CO03

S1

22AVP103	MASTERY OVER MIND	L-T-P-C: 1-0-2-2

Course Objectives

The course will enable the students to

- Mastery Over Mind (MaOM) is an Amrita initiative to implement schemes and organize university-wide programs to enhance health and wellbeing of all faculty, staff, and students (UN SDG -3)
- It gives an introduction to immediate and long-term benefits of MA OM meditation and equips every attendee to manage stressful emotions and anxiety, in turn facilitating inner peace and harmony.
- This course will enhance the understanding of experiential learning based on the University's mission: "Education for Life along with Education for Living" and is aimed to allow learners to realize and rediscover the infinite potential of one's true Being and the fulfilment of life's goals.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	To be able to describe what meditation is and to understand its health benefits	Understand
CO02	To understand the causes of stress and how meditation improves well-being	Remember
CO03	To understand the science of meditation	Apply
CO04	To learn and practice MAOM meditation in daily life	Understand
CO05	To understand the application of meditation to improve communication and relationships	Evaluate
CO06	To be able to understand the power of meditation in compassion-driven action	Analyse

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01								1	2	2		2				
CO02			2		2				2	2		2				
CO03					2			2	2	2		2				
CO04			3		3		2	3	3	3		3				
CO05			2		2			2	2	3		3				
CO06			2					2	2	3		3				

Syllabus

Unit 1: Describe Meditation and Understand its Benefits (CO1)

A: Importance of meditation. How does meditation help to overcome obstacles in life (Pre-recorded video with Swami Shubhamritananda Puri)

Reading 1: Why Meditate? (Swami Shubamritananda ji)

Unit 2: Causes of Stress and How Meditation Improves Well-being (CO2)

A: Learn how to prepare for meditation. Understand the aids that can help in effectively practicing meditation. Understand the role of sleep, physical activity, and a balanced diet in supporting meditation. (Pre-recorded video with Dr. Ram Manohar)

B: Causes of Stress. The problem of not being relaxed. Effects of stress on health. How meditation helps to relieve stress. Basics of stress management at home and the workplace. (Pre-recorded video with Prof Udhaykumar)

Reading 1: Mayo Clinic Staff (2022, April 29). Meditation: A Simple, Fast Way to Reduce Stress. Mayo Clinic. https://www.mayoclinic.org/tests-procedures/meditation/in-depth/meditation/art-20045858 (PDF provided)

Reading 2: 'Efficient Action.' Chapter 28 in Amritam Gamaya (2022). Mata Amritanandamayi Mission Trust.

Unit 3: The Science of Meditation (CO3)
A: A preliminary understanding of the Science of meditation. What can modern science tell us about this tradition-based method? (Pre-recorded video with Dr. Shyam Diwakar)
B: How meditation helps humanity according to what we know from scientific research (Pre-recorded video with Dr. Shyam Diwakar)
Reading 1: Does Meditation Aid Brain and Mental Health (Dr Shyam Diwakar)
Reading 2: 'Science and Spirituality.' Chapter 85 in Amritam Gamaya (2022). Mata Amritanandamayi Mission Trust.

Unit 4: Practicing MA OM Meditation in Daily Life (CO4)
Guided Meditation Sessions following scripts provided (Level One to Level Five)
Reading 1: MA OM and White Flower Meditation: A Brief Note (Swami Atmananda Puri)
Reading 2: 'Live in the Present Moment.' Chapter 71 in Amritam Gamaya (2022). Mata Amritanandamayi Mission Trust.

Unit 5: Improving Communication and Relationships (CO5)
How meditation and mindfulness influence interpersonal communication. The role ofmeditation in improving relationship quality in the family, at the university and in theworkplace. (Pre-recorded video with Dr Shobhana Madhavan)
Reading 1: Seppala E (2022, June 30^{th}) 5 Unexpected Ways Meditation Improves Relationships a Lot. Psychology Today. https://www.psychologytoday.com/intl/blog/feeling-it/202206/5-unexpected-ways-meditation-improves-relationships-lot
Reading 2: 'Attitude.' Chapter 53 in Amritam Gamaya (2022). Mata AmritanandamayiMission Trust.

Unit 6: Meditation and Compassion-driven Action (CO6)
Understand how meditation can help to motivate compassion-driven action. (Pre-recorded video with Dr Shobhana Madhavan)
Reading 1: Schindler, S., & Friese, M. (2022). The relation of mindfulness and prosocialbehavior: What do we (not) know?. Current Opinion in Psychology, 44, 151-156.
Reading 2: 'Sympathy and Compassion.' Chapter 100 in Amritam Gamaya (2022). MataAmritanandamyi Mission Trust.

Course Assessment Specification Table:

		CO1	CO2	CO3	CO4	CO5	CO6	Total
1	Reflection					10	10	20
2	Group Activities	20*						20
3	Class Participation				40			40
4	Written Examination	5	5	5		5		20

*The Group Activities could be related to CO1, CO2 or CO3 depending on the preference of the instructor

Textbooks:
1. Meditation and Spiritual Life-Swami Yatiswarananda, Ramakrishna Math
2. The Complete Works of Swami Vivekananda Vol Vii by Advaita Ashram Mayavati Almora Himalayas
3. Dhyana Yoga-Holy Gita Swami Chinmayanda
4. Voice of God, Chandrasekharendra Saraswati, 68th Acharya of Sri Kanchi Kamakoti Peetam,
5. Hindu Dharma-Chandrasekharendra Saraswati, 68th Acharya of Sri Kanchi Kamakoti Peetam,
6. Mind: It's Mysteries and control-Swami Sivananda Saraswati
7. Amritam Gamaya (2022). Mata Amritanandamayi Mission Trust.
8. Books on Amma's teachings like Awaken children, From Amma's Heart etc.
9. The Science of Meditation: How to Change Your Brain, Mind and Body by Daniel Goleman and Richard. J. Davidson.
10. Allen, Cynthia (2020) The Potential Health Benefits of Meditation

11. Seppala E (2022, June 30th Unexpected Ways Meditation Improves Relationships a Lot.Psychology Today
12. Sharma, Hari (2022) Meditation: Process and Effects
13. Mayo Clinic Staff (2022, April 29). Meditation: A Simple, Fast Way to Reduce Stress.
14. Schindler, S., & Friese, M. (2022). The relation of mindfulness and prosocial behavior: Current Opinion in Psychology

S1

22ADM101	FOUNDATION OF INDIAN HERITAGE	L-T-P-C: 2-0-1-2

Course Objectives

The course will enable the students to

- This Course offers students an opportunity to delve into the depths and richness of the Indian culture and knowledge traditions.
- It aims to provide a synoptic view of the grandiose achievements of India across diverse fields, enabling students to develop a comprehensive understanding of their country and its eternal values.
- Aligned with the Indian Knowledge Systems (IKS) framework outlined in the National Education Policy, this course serves as an introduction to the vast reservoir of wisdom and knowledge rooted in Indian heritage.
- By the end of this course, students will develop a sense of pride in their heritage, appreciate the eternal values of India, and recognize the relevance of Indian wisdom in the modern world.
- This also explores the historical contributions of India in various fields such as mathematics, science, medicine, astronomy, and architecture.

Course Outcomes:

After successful completion of the course, Students will be able to:

Sl.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Recall key historical events, philosophies, and perspectives presented in the chapters on Indian heritage. Statement: Demonstrate the ability to remember significant historical events, philosophical concepts, and diverse viewpoints discussed in the chapters on Indian heritage.	Remembering
CO02	Explain the interconnectedness of Indian heritage, philosophy, and culture (as presented across various chapters). Statement: Understand the intricate relationships between chapters, recognizing how Indian heritage, philosophies, and cultural elements form a cohesive tapestry	Understanding
CO03	Apply principles from chapters on becoming a strategic thinker, personality development through yoga, and compassion to real-life scenarios. Statement: Utilize insights gained from chapters on strategic thinking, yoga, and compassion to address contemporary challenges and personal growth.	Applying
CO04	Analyze the impacts of colonialism, historical timelines, and foreign perspectives on India's identity, (as discussed in relevant chapters). Statement: Deconstruct the influences of colonialism, historical evolution, and foreign views on India, assessing their implications for the nation's heritage	Analyzing
CO05	Evaluate the significance of Indian Mahatmas and Advaita Vedanta in shaping Indian traditions and values (drawing from relevant chapters). Statement: Assess the lasting impact of Indian Mahatmas and Advaita Vedanta on India's cultural and spiritual landscape, considering their contributions and relevance	Evaluating
CO06	Develop projects that integrate themes of life, happiness, nature, celebration, and selflessness, (drawing inspiration from multiple chapters). Statement: Create innovative projects that synthesize themes from various chapters, reflecting the holistic and multifaceted nature of Indian heritage.	Creating

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01												3				
CO02							2	2	2			2				
CO03			2			3	2	3	2							
CO04						2		2				3				
CO05						3	3	2	2			2				
CO06						3		3				3				

Syllabus:

Chapter 1 - Educational Heritage of Ancient India
Chapter 2 - Life and Happiness
Chapter 3 - Impact of Colonialism and Decolonization
Chapter 4- A timeline of Early Indian Subcontinent
Chapter 5 - Indian approach towards life
Chapter 6 - Circle of Life
Chapter 7- Pinnacle of Selflessness and ultimate freedom
Chapter 8- Ocean of love; Indian Mahatmas.
Chapter 9 - Become A Strategic Thinker (Games / Indic activity)
Chapter 10 - Man's association with Nature
Chapter 11 - Celebrating life 24/7
Chapter 12 - Metaphors and Tropes
Chapter 13 - India: In the Views of foreign Scholars and Travellers.
Chapter 14 - Personality Development Through Yoga.
Chapter 15 - Hallmark of Indian Traditions: Advaita Vedanta, Theory of oneness
Chapter 16 - Conversations on Compassion with Amma

SEMESTER 2

23MAT129	DIFFERENTIAL EQUATIONS AND TRANSFORMS	L-T-P-C: 3-1-0-4

Course Objectives:
The course will enable the students to

- Apply different solution techniques to ordinary differential equations of various orders.
- Model and solve engineering problems using ordinary and partial differential equations.
- To understand the Fourier series and integral transforms and their applications to differential equations.
- Solve classical partial differential equations using analytical methods

Course Outcomes:
After successful completion of the course, students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Model, solve and analyze homogeneous and non-homogeneous first-order ordinary differential equations.	Analyze
CO02	Solve and analyze homogeneous linear second-order ordinary differential equations corresponding to different practical scenarios.	Analyze
CO03	Develop Fourier series representation for periodic functions and understand its properties.	Apply
CO04	Use Laplace Transform to solve ordinary differential equations.	Apply
CO05	Model the wave and heat equations as partial differential equations and use the Fourier series to obtain solutions.	Analyze

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	2	3			1							1				
CO02	2	3		1	1							1				
CO03	2	3			1							1				
CO04	2	3			1							1				
CO05	2	3		1	1							1				

Syllabus

Unit 1
Ordinary Differential Equations – Basic concepts, modeling, first order ODEs, exact ODEs, integrating factors. Second-order ODEs, homogeneous linear ODEs, Euler-Cauchy equations, existence and uniqueness of solution, Wronskian, non-homogeneous ODEs, variation of parameters. Simple example.Higher order ODEs, homogeneous and non-homogeneous linear ODEs. System of ODEs – Phase space, velocity field, flow, fixed points, stability of fixed points. Qualitative methods for ODEs. [20 Hrs]

Unit 2
Fourier series, arbitrary period, even and odd expressions, half range expressions, Fourier Integral, Fourier transforms. Laplace transform, transform of derivatives and integrals, solution of initial value problems by Laplace transform. Transfer functions. [20 Hrs]

Unit 3
Partial Differential Equations – Basics of PDEs. Modeling of a vibrating string, wave equation, solution by separation of variables, D'Alembert's solution, Heat flow modeling, heat equation, solution of heat equation by Fourier series, heat equation in very long bars, solution by Fourier transforms Laplace equation and its solution. [20 Hrs]

Topics for Assignments/ Tutorial/ Case studies

(a) Population model.
(b) Law of cooling.
(c) Undamped and damped oscillations.
(d) Wheel suspension.
(e) Forced oscillation – resonance.
(f) Electric circuits.
(g) Bending of an elastic beam under load – Different boundary conditions.
(h) Coupled spring mass system.
(i) Limit cycle oscillations – phase plane, equilibrium points.
(j) Laplace transforms – Response of systems to various inputs.
(k) Transfer function and its application in linear system theory.
(l) Solution of wave and heat equations.
(m) MATLAB based computational assignments.

Textbooks:

1. Advanced Engineering Mathematics, E Kreyszig, John Wiley and Sons, Tenth Edition, 2018.

Reference Books:

1. Engineering Mathematics', Srimanta Pal and Subhodh C Bhunia, John Wiley and Sons, 2012, Ninth Edition.
2. Advanced Engineering Mathematics by Dennis G. Zill and Michael R.Cullen, second edition, CBS Publishers, 2012

S2

23CHY116	**ENGINEERING CHEMISTRY**	**L-T-P-C: 2-0-0-2**

Course Objectives

The course will enable the students to

- The objective of the course is to impart knowledge on the concepts of chemistry involved in the application of engineering materials used in the industry/day-to-day life.
- To familiarize the fundamental concepts of electrochemistry required for the fabrication of batteries.
- To introduce the concepts of different corrosion types and its control.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Analyze different solids using X-ray diffraction techniques and using computational tools.	Analyze
CO02	Apply the fundamental principles of electrochemistry to illustrate the functioning of electrochemical energy systems.	Apply
CO03	Apply chemistry knowledge to predict the corrosion type in engineering materials and suggest suitable prevention methods.	Apply

CO-PO Mapping: [affinity[#]: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2														
CO02	3	2										1				
CO03	3	2					1					1				

Syllabus

Solid state

Crystalline and amorphous solids, isotropy and anisotropy, - Miller indices, space lattice and unit cell, Bravais lattices, the seven crystal systems and their Bravais lattices, X-ray diffraction - Bragg's equation and experimental methods (powder method and rotating crystal technique), types of crystals - molecular, covalent, metallic and ionic crystals - close packing of spheres – hexagonal, cubic and body centred cubic packing, elements of symmetry in crystal systems, defects in crystals – stoichiometric, non-stoichiometric, extrinsic and intrinsic defects. Vesta – for visualization of crystal structures.

Electrochemical energy system

Faradays laws, origin of potential, electrochemical series, reference electrodes, Nernst equation, introduction to batteries - classification - primary, secondary and reserve (thermal) batteries. Kinetics of electrochemical reaction – Tafel equations. Characteristics - cell potential, current, capacity and storage density, energy efficiency. Construction, working and application of Leclanche cell-Duracell, lead acid batteries. Ni-Cd battery, Lithium ion batteries. Fuel cell - construction and working of PEMFC and biofuel cell.

Corrosion control and metal finishing

Introduction, causes and different types of corrosion and effects of corrosion, theories of corrosion - chemical corrosion, Pilling Bed-worth ratio, electrochemical corrosion and its mechanism, factors affecting corrosion - galvanic series. Over potential and Tafel polarization. Corrosion control methods - cathodic protection, sacrificial anode, impressed current cathode. Surface coatings - galvanizing, tinning, electroplating of Ni and Cr, anodizing of aluminium.

Textbooks:

1. Chemistry: A Molecular Approach, 4th Edition Nivaldo J. Tro, Santa Barbara City College, 2020.
2. Jain and Jain, "Engineering Chemistry", Dhanpat Rai Publishing company, 2015

Reference Books:

1. Patrick M. Woodward, ,Pavel KarenJohn S. O. Evans, Solid State Materials Chemistry, Cambridge University Press, 2021
2. Vladimir S. Bagotsky, Alexander M. Skundin, Yurij M. Volfkovich, Electrochemical Power Sources Batteries, Fuel Cells, and Supercapacitors, John Wiley and Sons, 2015.
3. Bansi D. Malhotra, Handbook of Polymers in Electronics, Rapra Technology Limited, 2002
4. Ye Zhou, Guanglong Ding, Polymer Nanocomposite Materials: Applications in Integrated Electronic Devices, Wiley-VCH, 2021.

S2

23CHY188	ENGINEERING CHEMISTRY LAB	L-T-P-C: 0-0-3-1

Course Objectives

The course will enable the students to

- Using instrumental techniques to analyze the ions present in water.
- To understand the kinetics of chemical reactions and adsorption principles.
- To determine the rate of corrosion and its control.
- To synthesize nanoparticles and determine the surface charge of oxide particles.
- To estimate the amount of given substances using electrochemical methods

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Analyze the ions present in the given sample water.	Analyze
CO02	Analyze the adsorption isotherm and determine the rate constant of a reaction.	Analyze
CO03	Apply solid-state chemistry principles to prepare nanoparticles and determine oxides' surface charge.	Apply
CO04	Apply the fundamental principles of electrochemistry to analyze a given substance and understand the corrosion kinetics.	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	1			1		1		1	1						
CO02	3	1							1	1						
CO03	3	1							1	1						
CO04	3	1							1	1						

Syllabus

Chemical Kinetics and surface chemistry: Understanding the principle of adsorption, determining the rate constant of a reaction.
Electrochemistry: Evaluating the dissociation constant of acids, estimation of acid and ferrous ion present in water.
Corrosion and control: Anodization and Tafel plot
Instrumentation techniques: Estimating ions in water using a flame photometer and UV-Visible spectrophotometer.
Solid state: Determination of point of zero charges of metal oxide.

List of Equipment required for meeting the COs

1. Conductivity Bridge
2. Potentiometer
3. UV-Visible spectrophotometer
4. Colorimeter
5. pH meter
6. Flame photometer
7. Weighing balance
8. DC Power source
9. Multimeter

List of Exercises

S.No.	List of Exercises	CO mapping
1	Adsorption of acetic acid by charcoal	CO2
2	Adsorption of dye on charcoal	CO2
3	Determination of rate constant for acid catalyzed ester hydrolysis	CO2
4	Estimation of ferrous ion by potentiometric titration	CO1
5	Potentiometric titration of dibasic acid Vs strong base	CO4
6	Conductometric titration of mixture of acid Vs NaOH	CO4
7	Verification of B-L law by UV-spectrophotometer	CO1
8	Determination of point of zero charge of metal oxide	CO3
9	Synthesis of polyaniline conducting polymer via electrochemical polymerization	CO4
10	Synthesis of silver nanoparticle by chemical reduction method	CO3
11	Determination of sodium and potassium ions in water using Flame photometry	CO1
12	Kinetics of electrochemical reactions - Construction of Tafel linear polarization curves	CO4
13	Determination of optimum current density for the anodization of aluminium	CO4

S2

23EEE102	BASIC ELECTRICAL AND ELECTRONICS ENGINEERING	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- To impart basic knowledge of electric circuits
- To understand the construction and working principles of DC and AC machines.
- To facilitate understanding of basic electronics and operational amplifier circuits.
- To understand the basic gates and their applications
- To impart basics on microprocessor/microcontroller with basic programming skills.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Familiarize the basic concepts of electrical circuits.	Understand
CO02	Comprehend the study on construction and working of various electrical machines.	Understand
CO03	Illustrate the working of basic electronic circuits.	Apply
CO04	Develop various logic circuits for real-world applications.	Analyze

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2														
CO02	3	2														
CO03	3	2	1		1											
CO04	3	2	2	1	2											

Syllabus

Unit 1

Review of Electrical Engineering: Current and Voltage sources, Resistance, Inductance and Capacitance; Ohm's law, Kirchhoff's law, Series parallel combination of R, L and C components, Voltage Divider and Current Divider Rules. Faraday's Laws of Electro-magnetic Induction, Definition of Self and Mutual Inductances, Generation of sinusoidal voltage, Instantaneous & RMS values of sinusoidal signals, Introduction to 3-phase systems. [7 hours]

Unit 2

Electrical Machines: DC Motor: Construction, principle of operation, Different types of DC motors, significance of back EMF, Torque-Speed characteristics, Output Power, Efficiency and applications. Single Phase Transformer: Construction, principle of operation, EMF Equation. Regulation and Efficiency of a Transformer. Induction Machine: Three Phase Induction Motor: Construction and Principle of Operation, Slip and Torque, Speed Characteristics. Stepper motor: Construction, working principle and modes of operation. [18 hours]

Unit 3

Basic Electronic Circuits: Review of PN junction diodes, Voltage regulator, BJT- Transistor as a switch, 555 Timers, Operational Amplifiers – Inverting and Non-inverting amplifier – Instrumentation amplifiers

Fundamentals of Digital Electronics: Boolean algebra, Basic and Universal Gates, Truth tables, logic expressions, simplification using K-map, Logic ICs, half and full adder/subtractor, Introduction to multiplexers, demultiplexers and flip-flops. [15 hours]

Unit 4

Introduction to microprocessor and microcontrollers: Case study on applications of microprocessors and microcontrollers. [5 hours]

Textbooks:

1. Alexander C K and Sadiku M N O, "Fundamentals of electric circuits", 5th edition, New York, McGraw-Hill, 2013.
2. Adel S. Sedra, Kenneth Carless Smith, Tony Chan Carusone, "Microelectronic Circuits" 7th Edition, Oxford University Press, 2020
3. Edward Hughes. "Electrical Technology".7th Edition, Pearson Education Asia,2011

Reference Books:

1. Vincent Del Toro, 'Electrical Engineering Fundamentals', Prentice Hall of India Private Limited, 2003, 2nd Edition.
2. David A Bell, "Electronic Devices and Circuits", 5th Edition, Oxford University Press, 2008.
3. D. P. Kothari, I J Nagrath, "Electric Machines", 5th Edition, Tata McGraw Hill, 2017.
4. A. P. Malvino, "Electronic Principles", 7th Edition, Tata McGraw Hill, 2007. References S. K.
5. Bhattcharya, "Basic Electrical and Electronics Engineering", Pearson, 2012.
6. Michael Tooley B. A., "Electronic circuits: Fundamentals and Applications", 3rd Edition, Elsevier Limited, 2006.

S2

23MEE111	ENGINEERING MECHANICS	L-T-P-C: 3-1-0-4

Course Objectives

The course will enable the students to

- To inculcate the fundamental knowledge to solve static equilibrium problems.
- To familiarize the concept of solving engineering problems related to friction and analysis of trusses.
- To determine the centroids and MI of composite areas and Rigid bodies.
- To introduce the concepts of dynamics to of particles
- To introduce the concepts of kinematics to both particle and rigid body.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Apply the principles of equilibrium to solve statically determinate problems on particles.	Analyze
CO02	Apply the principles of equilibrium to solve statically determinate problems on rigid bodies.	Analyze
CO03	Evaluate engineering problems related to dry friction	Evaluate
CO04	Analyze the equilibrium conditions of trusses	Analyze
CO05	Evaluate centroids and MI of composite areas and Rigid bodies.	Evaluate
CO06	Evaluate the dynamics of particles	Evaluate
CO07	Evaluate the kinematics of particles and rigid bodies.	Evaluate

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3	3	2	1							2	1	1		
CO02	3	3	3	2	1							2	1	1		
CO03	3	3	3	2	1							2	1	1		
CO04	3	3	3	2	1							2	1	1		
CO05	3	3	3	2	1							2	1	1		
CO06	3	3	3	2	1							2	1	1		
CO07	3	3	3	2	1							2	1	1		

Syllabus

Unit 1

Principles of statics: Introduction to vector approach – free body diagrams- forces in a plane – forces in space – concurrent forces – resolution of forces – equilibrium of particles. Statics of rigid bodies in two and three dimensions: Moment of force about a point – moment of force about an axis – moment of a couple – equivalent force couple system – rigid body equilibrium – support reactions. [20 hours]

Unit 2

Application of statics: Friction – ladder friction – wedge friction – analysis of trusses – method of joints and method of sections. Centroid and center of gravity: centroid of lines, areas and volumes – composite bodies. Second moment of area – polar moment of inertia – mass moment of inertia – radius of gyration. [15 hours]

Unit 3

Dynamics of particles: kinetics of particles – rectilinear motion – relative motion –Newton's second law of motion – D'Alembert's principle-Linear and angular momentum and their conservation- Principle of work and energy - Principle of impulse and momentum. [15 hours]

Unit 4

Dynamics of rigid bodies: General plane motion – translation and rotation of rigid bodies –Instantaneous centre of rotation- Chasle’s theorem–– velocity and acceleration calculation in moving frames Coriolis acceleration [10 hours]

Computational exercise to be given as assignments using GeoGebra or MATLAB.

Textbooks:

1. Beer,F.P. & Johnston,E.R., “Vector Mechanics for Engineers-Statics and Dynamics”, 11/e, McGraw Hill International Book Co., 2017

Reference Books:

1. Hibbeler, R.C., “Engineering Mechanics- Statics and Dynamics”, 14/e, Pearson Education Pvt. Ltd., 2017
2. Meriam and L.G. Kraige, “Engineering Mechanics – Statics and Dynamics”, 7/e, John Wiley & sons, 2013
3. Shames,I.H, “Engineering Mechanics-Statics and Dynamics”, 4/e, Prentice-Hall of India Pvt. Ltd., 2005

S2

23EEE182	BASIC ELECTRICAL AND ELECTRONICS ENGINEERING LAB	L-T-P-C: 0-0-3-1

Course Objectives

The course will enable the students to

- Understand the basics of electrical connections
- Analyze the performance of electrical machines,
- Analyze the electronics, digital circuit and microprocessor programs.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Analyze the performance of electrical machines	Analyze
CO02	Develop basic electronic & digital circuits for real-world applications	Apply
CO03	Implement basic programs in microprocessor	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2	1						1	1		1				
CO02	3	2	3	1	1				1	1		2				
CO03	3	2	2	1	2				1	1		2				

Syllabus

1. a) Wiring practices b) Study of Electrical protection systems.
2. Speed control of the DC shunt motor
3. Load test on single-phase transformer
4. Load test on three-phase induction motor
5. Transistor as a switch
6. Implementation of inverting and non-inverting amplifier using Op-amp
7. Full adder and subtractor
8. Program on addition and subtraction
9. Program to storing and retrieving a data

Reference Books:

1. Alexander C K and Sadiku M N O, "Fundamentals of electric circuits", 5th edition, New York, McGraw-Hill, 2013
2. Adel S. Sedra, ,Kenneth Carless SmithTony Chan Carusone, "Microelectronic Circuits" 7th Edition, Oxford University Press, 2020
3. Edward Hughes. "Electrical Technology".7th Edition, Pearson Education Asia,2011

List of Equipment required for meeting the COs

a) Basic Electrical and Electronics

1. Electric Wiring Setup
2. Electrical Protection Devices
3. DC shunt motor
4. Single Phase Transformer
5. Three phase induction motor
6. BJT
7. Op-amp
8. Logic Gate ICs, Digital Trainer Kit
9. Microprocessor

S.No.	List of Exercises	CO mapping
1.	a) Wiring practices b) Study of Electrical protection systems	CO01
2.	Speed control of DC shunt motor	CO01
3.	Load test on single phase transformer	CO01
4.	Load test on three phase induction motor	CO01
5.	Transistor as a switch	CO02
6.	Implementation of inverting and non-inverting amplifier using Op-amp	CO02
7.	Full adder and subtractor	CO02
8.	Program on addition and subtraction	CO03
9.	Program to storing and retrieving a data	CO03

S2

23MEE181	INTRODUCTION TO PYTHON PROGRAMMING	L-T-P-C: 0-0-3-1

Course Objectives

The course will enable the students to

- Introduction to the python language, its modules, recommended programming styles and idioms
- The fundamental concepts of datatypes, operators, variables, and function in programming.
- Writing simple programs using Python for mechanical engineering problems
- Demonstrating principles of object-oriented programming in a well-written modular code

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Describe the Python language constructs and solve simple problems using the same	Understand
CO02	Identify Python's data types, operators, control structures, and implement functions effectively in their programs.	Analyze
CO03	Create arrays, lists, and plot the data	Evaluate
CO04	Employ Python's built-in libraries to solve real-world problems	Evaluate

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2	2	1	3				1	1		1				2
CO02	3	2	2	1	3				1	1		1				2
CO03	3	2	2	1	3				1	1		1				2
CO04	3	2	2	1	3				1	1		1				2

Syllabus

Unit 1

Introduction to Python: motivation for learning Python in scenarios like rapid prototyping. Installing Python: basic syntax, interactive shell, editing, saving, and running a script. The concept of Data Types, Basic data types: integers, floats, and strings. Variables and assignments; immutable variables; numerical types; arithmetic operators and expressions; comments in the program; understanding error messages. [5 hours]

Unit 2

Conditions, Boolean logic, logical operators: ranges; Control statements: if-else, loops (for, while); short-circuit (lazy) evaluation. Functions, Defining and calling functions, Parameters and arguments. Working with text files: manipulating files and directories, os and sys modules; text files: reading/writing text and numbers from/to a file; creating and reading a formatted file (csv or tab-separated). Arrays, Data Structures, Lists, tuples, and dictionaries, Indexing and slicing, List and dictionary comprehensions. Plotting the data and data analysis. [5 hours]

Unit 3

Use of popular Python packages for scientific computing: Exercises to understand usage of libraries like Numpy, Matplotlib, SciPy, Pandas, Scikit-learn, TensorFlow. [5 hours]

Laboratory Exercises:

1. Familiarization of python programming and way to run the script
2. Implement the program based on conditions and loops
3. Writing programs on string functions
4. Create an array and print its attributes
5. Writing programs on file handling
6. Graph Plot using libraries
7. Python Class Project using libraries

Textbooks:

1. Python Crash Course, 2nd Edition" by Eric Matthes
2. Guttag, John. Introduction to Computation and Programming Using Python: With Application to Understanding Data Second Edition. MIT Press, 2016. ISBN: 9780262529624.
3. William McKinney, Python for Data Analysis: Data Wrangling with Pandas, NumPy, and Ipython, Second edition (27 October 2017), Shroff/O'Reilly, ISBN-10: 9789352136414, ISBN-13: 978-9352136414
4. Hans Fangohr, Faculty of Engineering and the Environment, University of Southampton, Introduction to Python for Computational Science and Engineering (A beginner's guide),September 7, 2015. Online version available at:https://www.southampton.ac.uk/~fangohr/training/python/pdfs/Python-for-Computational-Science-andEngineering.pdf

Reference Books:

1. "Python Programming for the Absolute Beginner, Third Edition" by Michael Dawson
2. "Python Pocket Reference, 5th Edition" by Mark Lutz.
3. Al Sweigart, Automate the Boring Stuff with Python, April 2015, ISBN-13: 978-1-59327-599-0, also available for free at https://automatetheboringstuff.com

S2

23MEE182	**MANUFACTURING PRACTICE - B** (COMMON TO ALL BRANCHES)	**L-T-P-C: 0-0-3-1**

Course Objectives

The course will enable the students to

- Imparting the knowledge of general safety procedures that should be observed on the shop floor.
- Use modelling software to design and print simple geometry for additive manufacturing processes.
- Hands-on experience in edge preparation, plate, wire and sheet joining operations.
- Explain the different tools and equipment used for basic manufacturing processes.
- Get familiar with the essential components for automation and pneumatic circuit design.
- Discuss the components and functioning of various sub-systems of automobiles, such as the power train, steering system, suspension system, and braking system.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Practice safety procedures in a shop floor environment.	Understand
CO02	Select appropriate tools and methods for basic manufacturing processes.	Understand
CO03	Build simple geometries using an Additive Manufacturing process.	Apply
CO04	Perform basic metal joining using welding and soldering.	Apply
CO05	Design, simulate, and testing of simple pneumatic and electro-pneumatic circuits for automation application.	Apply
CO06	Understand the functioning of automotive systems and realize the importance of recent technological developments.	Understand

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	1	1			1			1	1		2				
CO02	2	3				2			1	2		3				
CO03	2	2	1		3	1	1		1	2	1	3				1
CO04	2	3	2						1	2	1	3				
CO05	3	2	2		3				1	2	1	3				1
CO06	3	2	2		3				1	3	1	3				

Syllabus

Workshop Safety Measures and Practices - Proper training and supervision before operating unfamiliar or complex equipment.

a. Additive Manufacturing Laboratory –12 hours

Introduction to digital manufacturing. Introduction to Additive Manufacturing - types – additive manufacturing applications - Materials for 3D printing, CAD Modelling for Additive Manufacturing, Slicing and STL file generation- G code generation - 3D printing of simple geometries.

b. Mechanical Engineering Laboratory –12 hours

Study of tools and equipment used for basic manufacturing processes.
Manual arc welding practice for making Butt and Lap joints - Soldering Practice
Introduction to Machine Tools and Machining Processes.

c. Automation Laboratory –12 hours

Design, simulation, and testing of pneumatic and electro-pneumatic circuits. Introduction to PLC–PLC programming for automation applications.

d. **Automobile Engineering Laboratory –9 hours**
Overview of automobiles – components –functioning of various sub-systems; Power train, steering system, suspension system and braking system. Introduction to electric vehicles, hybrid vehicles, alternate fuels. Introduction to E Mobility.

Reference Books:

1. Laboratory Manual.

List of Equipment required for meeting the COs

a) **Additive Manufacturing Laboratory**
   1. Fused filament 3D printing machines
   2. Modelling software & Computers (Minimum i5 Processor)
   3. Slicing software

b) **Mechanical Engineering Laboratory**
   1. Tools and accessories for welding & soldering.
   2. SMAW welding power source with electrodes and safety equipment.
   3. Soldering setup
   4. Basic Machine Tools for various process demonstration – Lathe, Drilling, Milling, Grinding, and CNC.

c) **Automation Laboratory**
   1. Basic pneumatic kit
   2. Basic electro-pneumatic kit
   3. PLC trainer kit
   Software:
   4. FluidSIM/ Automation Studio

d) **Automobile Engineering Laboratory**
   1. Cut section/ Working model of 2-stroke and 4 -Stroke engine.
   2. Cut section/ Working model of Braking Mechanism, Steering Mechanism, suspension System, Automobile Gearboxes & Differential Unit
   3. Electric vehicle
   4. Hybrid Vehicle.

S.No.	List of Exercises	CO mapping
1.	**General Workshop Safety Measures and Practices**	**CO01**
2.	**Additive Manufacturing Laboratory** 1. Introduction to sketching and CAD modeling for Additive Manufacturing. 2. Conversation of CAD Model to STL file, slicing, and G-code generation 3. Prototyping using 3D printing	**CO02, CO03**
3.	**Mechanical Engineering Laboratory** 1. Manual arc welding practice: butt and Lap joint. 2. Soldering practice- wire joints 3. Introduction to basic Machine tools and Machining Process – Demonstration	**CO01 CO02, CO04**
4.	**Automation Laboratory** 1. Study of pneumatic actuators and control valves. 2. Design, simulate, and testing of pneumatic circuits. 3. Design, simulate, and testing of electro-pneumatic circuits 4. PLC programming for automation applications.	**CO05**
5.	**Automobile Engineering Laboratory** 1. Demonstrate the working of various subsystems of automobiles- Power train, steering system, suspension system, and braking system. 2. Demonstrate the working of electric and hybrid vehicles.	**CO06**

S2

23ENG101	TECHNICAL COMMUNICATION	L-T-P-C: 2-0-3-3

Course Objectives

The course will enable the students to

- To introduce the students to the fundamentals of mechanics of writing.
- To facilitate them with the style of documentation and specific formal written communication.
- To initiate in them the art of critical thinking and analysis.
- To help them develop scanning techniques for specific information, comprehension and organization of ideas.
- To enhance their technical presentation skills.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Gain knowledge about the mechanics of writing and the elements of formal correspondence	BTL1&2
CO02	Understand and summarize technical documents.	BTL2&3
CO03	Apply the essential elements of language in formal correspondence	BTL3
CO04	Interpret and analyze information and organize ideas logically and coherently	BTL4
CO05	Compose project reports/documents, revise them for language accuracy and make technical presentations.	BTL5&6

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01										3						
CO02				1						2						
CO03										3						
CO04				1						2						
CO05									2	1						

Syllabus

Unit 1

Mechanics of Writing: Grammar rules -articles, tenses, auxiliary verbs (primary & modal) prepositions, subject-verbagreement, pronoun-antecedent agreement, discourse markers and sentence linkers

General Reading and Listening comprehension - rearrangement & organization of sentences

Unit 2

Different kinds of written documents: Definitions- descriptions- instructions-recommendations- user manuals - reports– proposals

Formal Correspondence: Writing formal Letters Mechanics of Writing: impersonal passive & punctuation Scientific Reading & Listening Comprehension

Unit 3

Technical paper writing: documentation style - document editing – proof reading - Organizing and formatting Mechanics of Writing: Modifiers, phrasal verbs, tone and style, graphical representation

Reading and listening comprehension of technical documents Mini Technical project (10 -12 pages)

Technical presentations

Text / Reference books:

1. Hirsh, Herbert. L “Essential Communication Strategies for Scientists, Engineers and Technology Professionals”.IIEdition. New York: IEEE press, 2002
2. Anderson, Paul. V. “Technical Communication: A Reader-Centred Approach”. V Edition. Harcourt Brace CollegePublication, 2003
3. Strunk, William Jr. and White.EB.“The Elements of Style” New York.Alliyan& Bacon, 1999.
4. Riordan, G. Daniel and Pauley E. Steven.“Technical Report Writing Today” VIII Edition (Indian Adaptation). NewDelhi: Biztantra, 2004.
5. Michael Swan. ‘’ Practical English Usage’’, Oxford Univ.Press, 2000

S2

22ADM111	GLIMPSES OF GLORIOUS INDIA	L-T-P-C: 2-0-1-2

Course Objectives

The course will enable the students to

- The course aims at introducing Bhārath in nutshell to the student, which includes the sources of Indian thoughts, eminent personalities who shaped various disciplines, India's significant contribution to the man kind, the current stature of Indian in the geopolitics and Indian approach to science and ecology
- This course is designed to provide a multifaceted understanding of India's cultural heritage, encompassing historical insights, philosophical perspectives, and contemporary relevance. By delving into diverse chapters, this course aims to foster deep insights into the intricate web of India's past, present, and its role on the global stage.
- Aligned with the Indian Knowledge Systems (IKS) framework outlined in the National Education Policy, this course serves as an introduction to the vast reservoir of wisdom and knowledge rooted in Indian heritage.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Recall key historical events, personalities, and philosophical concepts presented in the chapters on Indian heritage. Statement: Demonstrate the ability to remember significant historical events, noteworthy individuals, and fundamental philosophical ideas discussed in the chapters on glorious India.	Remembering
CO02	Explain the diverse roles of women, the teachings of Acharya Chanakya, and the concepts of God and Iswara as foundational elements of Indian culture. Statement: Understand the significance of women's roles, Chanakya's teachings, and spiritual concepts, appreciating their contributions to Indian society.	Understanding
CO03	Apply lessons from the Bhagavad Gita to real-life scenarios, demonstrating the relevance of its teachings. Statement: Utilize insights from the Bhagavad Gita to navigate challenges, transforming from a soldier to a seeker on a spiritual journey.	Applying
CO04	Analyze the synthesis of yoga, spirituality, and life principles in Indian culture, as explored in the chapters on Bhagavad Gita and Lessons of Yoga. Statement: Deconstruct the integration of yoga and spiritual wisdom in Indian culture, examining how these principles enhance holistic well-being.	Analyzing
CO05	Evaluate the impact of Indian soft power, the preservation of nature through faith, and ancient Indian cultures on global perceptions. Statement: Assess the influence of India's cultural soft power, environmental values, and ancient traditions on its international image and ecological practices.	Evaluating
CO06	Develop projects that illustrate Indian contributions to the world, practical applications of Vedanta, and the Indian approach to science. Statement: Create innovative presentations or projects that showcase India's global influence, practical insights from Vedanta, and unique scientific perspectives inspired by Indian thought.	Creating

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01						3						2				
CO02						2		3	2			2				
CO03		2	2			3	2	3	2	2		3				
CO04			3			3						3				
CO05						3	2	2	2			2				
CO06	1	2	2		2	2						2				

Syllabus

Chapter 1 – Face the Brutes
Chapter 2 – Role of Women in India
Chapter 3 – Acharya Chanakya
Chapter 4 – God and Iswara
Chapter 5 – Bhagavad Gita: From Soldier to Samsarin to Sadhaka
Chapter 6 – Lessons of Yoga from Bhagavad Gita
Chapter 7 – Indian Soft powers
Chapter 8 – Preserving Nature through Faith
Chapter 9 - Ancient Indian Cultures (Class Activity)
Chapter 10 - Practical Vedanta
Chapter 11 - To the World from India (For Continuous Assessment)
Chapter 12 - Indian Approach to Science
Chapter 13 - India: In the Views of foreign Scholars and Travellers.
Chapter 14 - Personality Development Through Yoga.
Chapter 15 - Hallmark of Indian Traditions: Advaita Vedanta, Theory of oneness
Chapter 16 - Conversations on Compassion with Amma

Textbooks:

Glimpses of Glorious India

Reference Books:

Topic wise PPTs will be uploaded in Teams

S3

SEMESTER 3

23MAT222	PROBABILITY AND COMPLEX VARIABLES	L-T-P-C: 3-1-0-4

Course Objectives

The course will enable the students to

- Understand discrete and continuous random variables and compute important measures.
- Perform statistical tests using experimental data and arrive at conclusions.
- Perform calculus of complex variables.
- Apply complex analysis to series and integrals.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Formulate and solve problems involving discrete and continuous random variables.	Apply
CO02	Apply statistical methods for analyzing experimental data and draw statistical inferences.	Analyze
CO03	Analyze the complex function about their analyticity and perform differentiation of complex functions.	Analyze
CO04	Understand the different infinite series and their importance in engineering.	Understand
CO05	Apply the Cauchy residue theorem to integrate complex functions.	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2	1		1							1				
CO02	2	2	2		1							1				
CO03	2	2	2		1							1				
CO04	2	2	1		1							1				
CO05	3	2	2		1							1				

Syllabus

Unit 1: Probability

Probability – Probability models and axioms, conditioning, and Bayes' rule. Discrete random variables; probability mass functions; expectations, examples, two dimensional discrete random variables: Joint PMFs and expectations. Continuous random variables, probability density functions, expectations, examples, two dimensional continuous random variables: Joint PDFs. [25 hrs]

Unit 2: Statistics

Statistics – Bayesian statistical inference, point estimators, parameter estimators, test of hypotheses, tests of significance. [15 Hrs]

Unit 3: Complex Variables

Complex numbers, complex plane, polar form of complex numbers. Powers and roots, derivative. Analytic functions, Cauchy Riemann equations Conformal mapping (definition and examples only). Exponential function, trigonometric functions, hyperbolic functions, logarithms. Complex line integral, Cauchy integral theorem, Cauchy integral formula, derivatives of analytical functions. Power series, Taylor series and McLaurin series. Laurent series, zeroes and singularities, residues, Cauchy residue theorem, evaluation of real integrals using residue theorem (simple examples) [20 Hrs]

Topics for Assignments/ Tutorials/ Case studies

1. Problems in manufacturing and assembly
2. Examples can also be taken from various probability distributions and its applications.

Textbooks:

1. Advanced Engineering Mathematics, E Kreyszig, John Wiley and Sons, Tenth Edition, 2018.
2. Introduction to Probability, D. Bertsekas and J. Tsitsiklis, 2nd Edition, Athena Scientific, 2008.

Reference Books:

1. Engineering Mathematics', Srimanta Pal and Subhodh C Bhunia, John Wiley and Sons, 2012, Ninth Edition.
2. Advanced Engineering Mathematics by Dennis G. Zill and Michael R.Cullen, second edition, CBS Publishers, 2012

S3

23MEE201	MECHANICS OF SOLIDS	L-T-P-C: 3-1-0-4

Course Objectives

The course will enable the students to

- Understand the theory of linear elastic response of materials subjected to different types of loads
- Evaluate the deformation and stress of elastic materials under axial, torsional, and transverse loading conditions
- Construct shear force, and bending moment diagrams
- Familiarize the stress of pressurized cylinders
- Evaluate the buckling load of columns

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Apply the fundamental principles to estimate the deformation and stress of linear elastic solids under axial loading.	Apply
CO02	Calculate principal stresses and identify principal planes.	Analyze
CO03	Construct shear force and bending moment diagrams.	Apply
CO04	Evaluate bending stress in beams.	Analyze
CO05	Calculate slope and deflection in beams.	Analyze
CO06	Compute stress in shafts subjected to torsion.	Apply
CO07	Determine stress developed in pressurized thin and thick cylinders.	Apply
CO08	Compare Euler's and Rankine's buckling load of columns under different end conditions.	Analyze

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3	2									1	2	1		
CO02	3	3	2									1	2	1		
CO03	3	3	2									1	2	1		
CO04	3	3	2									1	2	1		
CO05	3	3	2									1	2	1		
CO06	3	3	2									1	2	1		
CO07	3	3	2									1	2	1		
CO08	3	3	2									1	2	1		

Syllabus

Unit 1

Simple Stress and Strain: Introduction, Properties of materials, Stress, Strain, Hook's Law, Poisson's ratio, Stress-Strain Diagram for structural steel, Principles of superposition, Total elongation of tapering bars of circular and rectangular cross sections. Elongation due to self weight, Composite sections, Volumetric strain, Elastic constants, Relationship among elastic constants, Thermal stresses in compound bars. Strain Energy & Impact loading. [16 Hours]

Compound Stresses: Introduction, Stress components on inclined planes, General two-dimensional stress system, Principal planes and stresses and Mohr's circle of stresses. [6 Hours]

Unit 2

Bending Moment and Shear Force in Beams: Introduction, Types of beams, loadings and supports, Shear force in beam, Bending moment in beam, Sign convention, Relationship between loading, shear force and bending moment, Shear force and bending moment equations, SFD and BMD with salient values for Cantilever beams, Simply

supported beams and Overhanging beams considering Point loads, UDL, UVL and Couple. Bending and shear stresses in beams. [12 Hours]
Deflection of beams: Introduction, Definition of Slope, Deflection, Elastic curve, Deflection using Macaulay's method, Moment Area method for prismatic beams subjected to transverse Point loads, UDL and Couple. [8 Hours]

Unit 3
Thick and Thin Cylinders and Shells: Analysis of thin cylindrical shells, Analysis of thick cylindrical shells using Lame's equation [6 Hours]
Torsion of Circular Shafts: Introduction pure torsion, Torsion equation of circular shafts, Torsional rigidity and polar modulus, Power transmitted by shaft of solid and hollow circular sections. [6 Hours]
Elastic Stability of Columns: Introduction, Short and long columns, Buckling load, Euler's theory on columns, Derivation, Effective length, Slenderness ratio, Radius of gyration, Limitations of Euler's theory, Rankine's formula, Problems [6 Hours]

Textbook:
1. Ferdinand Beer & Russell Johnston – "Mechanics of Materials" - Tata Mc Graw Hill 2020, 8th Edition

Reference Books:
1. James M. Gere, Barry J. Goodno - 'Mechanics of Materials' - Cengage Learning Custom Publishing 2021, 9th Edition
2. R. C. Hibbeler, - 'Mechanics of Materials' - Prentice Hall - 2022 - 10th Edition
3. Egor. P. Popov – 'Engineering Mechanics of Solids' - Pearson Edu. India - 2015 - 2nd Edition
4. Mubeen – 'Mechanics of Solids' - Pearson India - 2012 - 2nd Edition
5. W.A.Nash, Schaum's Outline Series – 'Strength of Materials' – 2019 – 7th Edition

23MEE202	ENGINEERING THERMODYNAMICS	L-T-P-C: 3-1-0-4

Course Objectives

The course will enable the students to

- Educate the properties of ideal gases, real gases, and pure substances.
- Elucidate basic concepts and thermodynamic properties.
- Familiarize with various laws of thermodynamics.
- Instruct the method of applying energy, entropy, and exergy balance to systems.
- Distinguish the measurable and non-measurable properties.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Apply relevant thermodynamic relations based on the type of working fluid.	Apply
CO02	Evaluate thermodynamic properties and moving boundary work based on the type of process.	Apply
CO03	Apply the first law of thermodynamics to closed and open systems to arrive solutions.	Analyze
CO04	Check the feasibility of a thermodynamic system and evaluate its performance by applying the second law of thermodynamics.	Analyze
CO05	Apply entropy and exergy balance to closed and open systems for the performance evaluation.	Analyze
CO06	Express the derived properties in terms of measurable properties.	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3	1		1								1			
CO02	3	3	1										1			
CO03	3	3	3			1	1						1			
CO04	3	3	3		1								1			
CO05	3	3	3		1								1			
CO06	3	3	1										1			

Syllabus

Unit 1

Properties of working fluids: ideal gas behaviour, real gas behaviour, equation of state, compressibility factor, compressibility chart, properties of pure substance. [10 hours]

Basic concepts and Thermodynamic properties: system, surroundings, boundary, properties, state and equilibrium, process, cycle, temperature, pressure and specific volume, heat and work, internal energy and enthalpy. [10 hours]

Unit 2

Laws of Thermodynamics:

Zeroth law: thermal equilibrium, temperature measurement in various scale [3 hours]

First law: static and dynamic form of energy, law of conservation of energy, energy balance to closed and open systems – steady and unsteady flow devices and limitations of the first law of thermodynamics [8 hours]

Second law: Kelvin-Planck and Clausius statements, Carnot theorem, Clausius inequality, the concept of entropy, principle of increase of entropy [8 hours]

Third law: absolute entropy [1 hour]

Unit 3

Entropy and Exergy Balance: irreversibilities change in entropy, entropy transfer by heat and mass, entropy generation, entropy balance applied to closed and open systems**.** [7 hours]

Available and unavailable energy, exergy destruction, second law or exergetic efficiency, exergy transfer by heat, work and mass, exergy balance applied to closed and open systems. [7 hours]

Thermodynamic property relations: Maxwell relations, Clausius-Clapeyron equation, change in internal energy, change in enthalpy, change in entropy relations, Joule Thomson coefficient and inversion line. [6 hours]

Textbooks:

1. Cengel Y. A. and Boles M. A., “Thermodynamics – an Engineering Approach”, 8/e, Tata McGraw hill, 2016

Reference Books:

1. Sonntag R. E., Borgnakke C. and Van Wylen, G., “Fundamentals of Thermodynamics”, 7/e, John Wiley and Sons, 2008
2. Pramod Kumar and Atul Dhar., “Basics of Thermodynamics”, 1/e, AICTE, 2023
3. Michael J. Moran and Howard N. Shapiro., “Fundamentals of Engineering Thermodynamics”, 9/e, John Wiley and Sons, Inc., 2018

S3

23MEE203	METALLURGY AND MATERIALS SCIENCE	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- To impart knowledge on fundamental concepts of metallic materials' behavior and crystal structures
- To familiarize various phases and phase diagrams of metal and alloys and crystalline defects.
- To inculcate the theory of fracture mechanics, fatigue, and creep properties
- To facilitate an understanding of various strengthening mechanisms and heat treatment for specific materials and requirements.
- To familiarize with the properties and applications of non-ferrous materials, composite materials, and advanced materials.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Analyze the structure and mechanical properties of engineering materials and apply them to engineering problems.	Analyze
CO02	Assess different types of ferrous and non-ferrous materials and determine the appropriate material for the given application.	Evaluate
CO03	Analyze the effects of phase transformations on material behaviour.	Analyze
CO04	Investigate the effects of heat treatment on microstructures and mechanical properties.	Analyze
CO05	Understand the characteristics and applications of advanced materials and material selection concepts for engineering applications.	Understand

CO-PO Mapping: [affinity[#]: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2				1	1					2	1		1	
CO02	3	3				1	1					2	1		1	
CO03	3	3	1			1	1					2	1		1	
CO04	3	3	1			1	1					2	1		1	
CO05	3	3	2			1	1					2	1		1	

Syllabus

Unit 1

Classification of Engineering Materials, Structure of Crystalline Solids - Crystal Systems - unit cells. Metallic Crystal Structures - Miller indices - Crystallographic planes and directions - Linear and Planar Atomic Densities.
Imperfections in Solids: Point – Linear - Interfacial defects - Surface and Volumetric defects.
Mechanical properties: Elastic, Anelastic and Plastic behavior - Stress-strain curves for Ductile and Brittle alloys - Ductility – Resilience – Toughness - Hardness and testing. [15 hours]

Unit 2

Phase diagram-phase rule - lever principle – isomorphous - intermetallic compound – eutectic - peritectic and eutectoid reactions - Iron-Carbon phase diagram - equilibrium and non-equilibrium cooling in solid state - isothermal transformation – pearlite, bainite and martensitic transformation.
Dislocations and Plastic deformation - Slip phenomenon - Slip in single crystals.
Strengthening mechanisms - grain boundary hardening - solid solution hardening - Hume-Rothery rule - work hardening - Precipitation hardening – recovery recrystallization and grain growth
Failure of Materials: Ductile and Brittle Fracture - fracture mechanics - Impact fracture - Ductile to brittle transition - Fatigue - Creep properties. [15 hours]

Unit 3

Heat treatment of steels: annealing – normalizing – hardening – tempering – spheroidizing - Surface hardening of steels – carburizing – nitriding - carbo-nitriding - induction method.
Classification of cast iron and steels - properties, microstructures and applications.
Classification of Non-ferrous alloys properties, microstructures and applications.
Introduction to composite materials – ceramics - electronic materials - smart materials.
Introduction to material selection process – Ashby's chart. [15 hours]

Textbooks:

1. Callister W. D. "Materials Science and Engineering", 10/e, John Wiley & Sons, 2018.
2. Avner S. H., "Physical Metallurgy", 2/e, McGraw Hill Education, 2017.

Reference Books:

1. Shackelford J. F., "Introduction to Materials Science for Engineers", 8/e, Prentice Hall, 2014.
2. JavedHashemi, Smith F. W., "Foundations of Materials Science and Engineering", 6/e, McGraw Hill Education, 2022.
3. Dieter G. E., "Mechanical Metallurgy", 3/e, Tata McGraw Hill, 2013.
4. Michael F. Ashby, "Materials Selection in Mechanical Design", 5/e, Butterworth-Heinemann, 2016.

S3

23MEE204	MANUFACTURING PROCESS I	L-T-P-C: 2-0-3-3

Course Objectives

The course will enable the students to

- Impart knowledge of fundamental concepts and applications of metal casting, mold preparation with proper gating-riser system, and plastic manufacturing processes.
- Basic principles, effect of process parameters, forming load calculation, formability estimation, and applications of conventional and advanced forming processes.
- Principles, process parameters, and applications of fusion and solid-state welding processes and design of weld joints
- Principles and applications of powder metallurgy processes for producing net-shape parts from metal powders

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Apply the principles of metal casting processes for ferrous and nonferrous materials involving the design of patterns, molds, and gating and riser system.	Apply
CO02	Prepare sand mold, perform casting trials with a non-ferrous material, and conduct a macroscopic inspection of the cast component.	Analyze
CO03	Understand the principles of plastic manufacturing processes and select suitable processes for the given application.	Apply
CO04	Understand the principle of various metal-forming processes and analyze the concept of yield criteria and estimate the formability limits of different materials.	Analyze
CO05	Select suitable metals joining process for the given material and application.	Apply
CO06	Design of weld joints, selection of welding parameters, joining ferrous and non-ferrous materials using TIG and MIG welding processes, and macroscopic inspection of weldments.	Analyze
CO07	Understand the principle of the powder metallurgy process and identify suitable applications.	Apply
CO08	Follow safety rules and standard codes of practice during machining.	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	1	2	1		1	1		1	1		1	1	1	2	
CO02	3	1	2	1		1	1		1	1		1	1	1	2	
CO03	2	1	2			1	1		1	1		1	1	1	2	
CO04	3	1	2	1		1	1		1	1		1	1	1	2	
CO05	3	1	2	1		1	1		1	1		1	1	1	2	
CO06	3	1	2	1		1	1		1	1		1	1	1	2	
CO07	3	1	2			1	1		1	1		1	1	1	2	
CO08						1	1	1	1	1		1	1	1	2	

Syllabus

Unit 1
Casting and Molding: Metal casting processes and equipment, shrinkage, principles of gating and riser design, Casting processes - sand, die, gravity, centrifugal, shell mold and Investment casting, Single crystal/ direct solidification processes, Squeeze casting. Plastic manufacturing processes-extrusion, injection, and blow molding. [9 Hours]

Unit 2
Metal forming: Plastic deformation and yield criteria; fundamentals of hot and cold working processes, bulk forming processes - forging, rolling, extrusion, drawing and sheet forming processes - shearing, deep drawing, bending, flow forming, advanced metal forming processes –severe plastic deformation- explosive, electro-hydraulic, magnetic pulse and hydroforming. [9 Hours]

Unit 3
Metal Joining Processes: Solid state welding process- diffusion, friction, and friction stir welding, Fusion Welding - arc welding, gas welding, resistance welding, submerged arc welding, high energy welding- Laser, Electron Beam, and Plasma, weld defects and inspection, Soldering, brazing, and adhesive bonding. [9 Hours]

Unit 4
Powder Metallurgy: Powder metallurgy- process- powder production, compaction and sintering, applications. [3 Hours]

Lab Practice:
- Preparation of sand mold and casting of non-ferrous materials
- Design of weld joints, selection of weld parameters, and materials joining using Laser, TIG & MIG welding processes
- Macroscopic inspection of casting and welded components
- Demonstration of the squeeze casting process
- Forming load calculation and formability test
- Design of sheet metal layout and simple sheet metal operations like blanking, bending, and drawing

[15 Hours]

Group Project:
Group projects will be given on any one of the topics (Metal Casting / Welding / Metal forming). The student group has to design and develop a product/process based on the problem statement.

Textbooks:
1. Serope Kalpakjian and Steven R. Schmid – 'Manufacturing Engineering and Technology' - Prentice Hall - 2023 - 8th Edition in SI Units

Reference Books:
1. Amitabha Ghosh and A.K. Mallick, Manufacturing Science. Affiliated East-West Press Pvt. Ltd. 2010.
2. Mikell P Groover, Fundamentals of Modern Manufacturing: Materials, Processes and Systems, 7th Edition, Wiley, 2021.

S3

23MEE205	MACHINE DRAWING	L-T-P-C: 1-0-3-2

Course Objectives

The course will enable the students to

- To understand and apply standards in drawing machine components.
- To understand the concept of various tolerances and fits used for component design.
- To familiarize in drawing assembly, orthographic and sectional views of various machine components.
- Use CAD packages to create solid/surface models and generate orthographic projections of machine components and assembly.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Understand the standards for creating machine drawings.	Understand
CO02	Apply limits and tolerances to assemblies and choose the appropriate fit.	Apply
CO03	Develop solid models of machine components and assembly, and Construct sectional and orthographic views of components.	Develop
CO04	Apply CAD packages for solid/surface modeling of machine parts and create a bill of materials.	Apply
CO05	Interpret and apply the geometric dimensioning & Tolerancing symbols in the drawing and assembly of solid/surface models of machine components using a CAD package.	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3				3	1			1	3		1	1	1		
CO02	2				1	1			1	3		1	1	1		
CO03	1		1		3	1			1	2		1	1	1		
CO04	1				2	1			1	2		1	1	1		
CO05	1		1		3	1			2	2		1	1	1		

Syllabus

Unit 1

Fundamentals of Machine Drawing: Standardization, Inter-changeability, Selective Assembly, Basic principles of GD&T (geometric dimensioning & tolerance), Limits, Fits, Tolerance, Tolerance of form and position, Grades of tolerance, Standard tolerances Machining symbols, Welding symbols, Surface finish indication, Functional and manufacturing datum, Riveted and butt Joints, Fasteners and keys.

Unit 2

Drawing of Machine Elements (Manual & Using Application Packages):
Application package Introduction: Drawing, Editing, Dimensioning, and Assembly.
Shaft joints: Cotter joint and knuckle joint.
Shaft coupling: Muff, Flanged, Flexible, Universal and Oldham's coupling.
Shaft bearing: Solid and bush bearing, Plummer block, Footstep bearing.
Pipe joint: Flanged joint, Socket and Spigot joint, Hydraulic joint, Union joint, Gland & Stuffing Box and Expansion joint.
Sheet metal surface modelling.

Unit 3

Assembly Drawings using prototypes (Manual & Using Application Packages):

Valves: Stop valve, relief valve, safety valve and non- return valve

Machine tool components: Drill Jig, Tail Stock, Tool post, machine vice and screw jack.

Engine: Piston and connecting rod.

Preparation of bill of materials and tolerance data

Project: Students will be assigned to assemble and create three dimensional and part drawings by following standard drawing practices.

Textbooks:

1. Gopalakrishna K. R., “Machine Drawing”, 16th Edition, Subhas publishing House, 2002

Reference Books:

1. Narayana K.L., “Machine Drawing”, 4th Edition, New Age International publishers, 2010
2. Gill P.S. “A Textbook of Machine Drawing”, 18th Edition, S. K. Kataria& Sons, 2013
3. Bhat N.D., and Panchal, V.M., “Machine Drawing” 48th Edition, Charotar Publication House, 2013
4. Ajeet Singh, Machine drawing, 2nd edition, Tata McGraw Hill, India, 2012.

S3

23MEE281	MATERIAL TESTING AND METALLURGY LABORATORY	L-T-P-C: 0-0-3-1

Course Objectives

The course will enable the students to

- To impart the knowledge of material testing methods for estimating mechanical properties
- To study the microstructures of ferrous and non-ferrous metals/alloys
- To analyze the microstructure of steel in various heat-treated conditions.
- To determine the hardenability of steel
- To analyze the microstructure of steel using SEM and XRD

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Determine the tensile properties and torsional shear strength of metals	Evaluate
CO02	Evaluate the stiffness and rigidity of springs and modulus of elasticity of wooden beams.	Evaluate
CO03	Estimate the hardness, shear and impact strength of various materials.	Evaluate
CO04	Prepare the samples and characterize the microstructures of different ferrous and non-ferrous metals / alloys.	Analyze
CO05	Evaluate the effect of various heat treatments on the properties and hardenability of steel	Evaluate
CO06	Analyze the microstructure of the samples using SEM and XRD	Analyze
CO07	Identify the surface defects using NDT	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2	1	1	1	1	1		1	1			2	1		
CO02	3	2	1	1	1	1	1		1	1			2	1		
CO03	3	2	1	1	1	1	1		1	1			2	1		
CO04	3	2	1	1	1	1	1		1	1			2		1	
CO05	3	2	1	1	1	1	1		1	1			2		1	
CO06	3	2	1	1	1	1	1		1	1			2		1	
CO07	3	2	1	1	1	1	1		1	1			2		1	

Syllabus

a) Material testing:

Tension test on metals, Torsion test on mild steel rods, Tension and compression tests on springs (closed coil and open coil), Static bending test on wooden beams, Double shear test on mild steel specimens, Impact tests (Charpy and Izod), Hardness tests (Brinell and Rockwell tests).

b) Metallurgy:

1. Study of metallurgical microscope and sample preparation.
2. Study the microstructure of low, medium, high carbon steel and high-speed steel.
3. Study the microstructure of cast irons.
4. Study the microstructure of Aluminium alloys, copper alloys and Al Metal Matrix Composites.
5. Study the microstructure and hardness measurements of heat-treated steels.
6. Determination of the hardenability of Steels
7. Scanning Electron Microscope (SEM): working principle and study of tensile fractured and wear tested samples

8. X-Ray Diffraction (XRD): working principle, structure factor and indexing BCC and FCC crystal structures
9. Introduction to Non-destructive testing.

Reference Books:

1. H. E. Davis, G. E. Troxell, G. F. W. Hauck, "*The Testing of Engineering Materials", 4ed, McGraw-Hill 1982*.
2. G. E. Dieter*, "Mechanical Metallurgy",* 3ed, McGraw-Hill Book, Co., New York, 1988.
3. P. G. Ormandy "*An introduction to metallurgical laboratory techniques"*, 1st edition, Pergamon series , Canada, 1968, https://doi.org/10.1016/C2013-0-01529-0

List of Equipment required for meeting the COs

a) Material Testing

- Universal Testing Machine
- Spring test machine
- Torsion test machine
- Brinell and Rockwell test machines
- Impact test machine

b) Metallurgy

- Metallurgical optical microscope
- Brinell hardness test
- Rockwell hardness tester
- Muffle furnace
- Jominy End Quench Test Apparatus
- SEM and XRD
- liquid penetrant test kit

List of Exercises

S.No.	List of Exercises	CO mapping
1	Determination of the tensile properties of metals	CO01
2	Determination of the stiffness and modulus of rigidity of helical springs	CO02
3	Estimation of the modulus of elasticity of the given wooden beam	CO02
4	Determination of the modulus of rigidity and torsional shear strength of the given material through a torsion test	CO01
5	Find the shear strength of the given specimen	CO03
6	Determination of the hardness of given materials	CO03
7	Determination of the impact strength of the given specimen by the Izod and Charpy impact test	CO03
8	Study of metallurgical microscope and sample preparation.	CO04
9	Microstructural examination of low, medium, high carbon steel and high-speed steel.	CO04
10	Microstructural examination of various cast irons in etched and unetched condition.	CO04
11	Microstructural examination of Aluminium alloys, copper alloys and Al Metal Matrix Composites.	CO04
12	Microstructural examination and hardness measurements of heat-treated steels	CO05
13	Determination of the hardenability of Steels	CO05
14	Scanning Electron Microscope (SEM): analyze tensile and wear tested samples	CO06
15	X-Ray Diffraction (XRD): structure factor and indexing BCC and FCC patterns	CO06
16	Identification of surface defects of the cast and welded samples using the liquid penetrant test	CO07

S3

22ADM201	STRATEGIC LESSONS FROM MAHĀBHĀRATA	L-T-P-C: 1-0-0-1

Course Objectives

The course will enable the students to

- This course probes into the timeless epic of Mahabharata to uncover valuable insights on strategy, leadership, and decision-making.
- This unique course offers a captivating exploration of the epic, providing students with a comprehensive understanding of its historical and cultural significance, while drawing compelling parallels to modern-day business and life challenges.
- This course equips students with the essential tools to navigate complex situations, make informed choices, and achieve success.
- Aligned with the Indian Knowledge Systems (IKS) framework outlined in the National Education Policy, this course serves as an introduction to the vast reservoir of wisdom and knowledge rooted in Indian heritage.
- Whether you are interested in business, politics, or personal growth, this course offers invaluable wisdom that transcends time, making it an indispensable resource for anyone seeking to master the art of strategy and leadership.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Recall key events and characters from the Mahabharata. Statement: Demonstrate the ability to remember and recount significant events and characters from the Mahabharata, establishing a foundational understanding of the epic.	Remembering
CO02	Explain the strategic decisions made by characters in the Mahabharata and their implications. Statement: Comprehend the strategic choices made by characters in the Mahabharata and elucidate the consequences these decisions had on the unfolding of the narrative.	Understanding
CO03	Apply strategic principles from the Mahabharata to contemporary business scenarios. Statement: Utilize strategic insights derived from the Mahabharata to address modern business challenges, adapting historical lessons to current organizational contexts.	Applying
CO04	Analyze the diverse strategic approaches employed by characters in the Mahabharata. Statement: Dissect the multifaceted strategic tactics used by Mahabharata characters, evaluating their effectiveness and dissecting the factors influencing their outcomes.	Analyzing
CO05	Evaluate the enduring relevance of Mahabharata's strategic wisdom in present-day contexts. Statement: Assess the ongoing significance of strategic lessons from the Mahabharata, appraising their applicability and value within contemporary strategic decision-making processes.	Evaluating
CO06	Develop innovative strategic frameworks by synthesizing insights from the Mahabharata. Statement: Formulate original strategic models by amalgamating and reinterpreting the diverse strategic teachings extracted from the Mahabharata, fostering novel approaches to strategic thinking.	Creating

CO-PO Mapping: [affinity[#]: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01								2				3				
CO02						2	2	2	2			2				
CO03			2			2			2		3	3				
CO04						2			3	2		2				
CO05		2	2		2	3	3	3	2			3				
CO06		2	2			3	3	2	2			2				

Syllabus

1.	Chapter 1	Mahābhārata - A Brief Summary
2.	Chapter 2	A Preamble to the Grand Itihāsa
3.	Chapter 3	The Unbroken Legacy
4.	Chapter 4	Dharmic insights of a butcher
5.	Chapter 5	The Vows we take: Pratijñā
6.	Chapter 6	Mahābhārata - The Encyclopaedia for Kingship and Polity Acumen
7.	Chapter 7	Karna: The Maestro that Went Wide of the Mark
8.	Chapter 8	Strategical Silhouette of An Extraordinary Peace Mission
9.	Chapter 9	Yajñaseni, A Woman from Fire.
10.	Chapter 10	Popular Regional Tales
11.	Chapter 11	Death and Deathlessness
Self-Study / Self-Reading		
12.	Chapter 12	Mahabharata- An All-Encompassing Text
13.	Chapter 13	Mahabharatha- Whats and What Nots
14.	Chapter 14	Mahābhārata in Adages

Reference Books:

1. Rajagopalachari. C, The Mahabharata

Topic wise PPTs will be uploaded in Teams

S3

23ENV300	ENVIRONMENTAL SCIENCE	L-T-P-C: 2-0-0-P/F

Course Objectives

The course will enable the students to

- To study the nature and facts about the environment
- To appreciate the importance of the environment by assessing its impact on the human world
- To study the integrated themes and biodiversity, pollution control, and waste management
- To get awareness about the concept of sustainable development

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Understand aspects of nature and the environment	Understand
CO02	Analyze the impact of the environment on the human world	Analyze
CO03	Understand pollution control and waste management	Understand
CO04	Understand the concept of sustainable development	Understand

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01						3	2	3								
CO02						3	2	3								
CO03						3	2	3								
CO04						3	2	3								

Syllabus

Unit 1

Overview of the global environmental crisis: Biogeochemical cycles, Climate change and related international conventions and treaties and regulations, Ozone hole and related international conventions and treaties and regulations, Energy Crisis, Water crisis [10 hours]

Unit 2

Ecology, biodiversity loss, and related international conventions, treaties, and regulations; Water pollution and related International and local conventions, treaties, and regulations; Domestic and industrial, and effluent treatment; Air pollution and related international and local conventions, treaties, and regulations [10 hours]

Unit 3

Solid waste management, Environmental accounting, Green business, Eco-labeling, Environmental impact assessment – Constitutional, legal, and regulatory provisions, Sustainable development, Sustainable construction materials. [10 hours]

Textbooks:

1. R. Rajagopalan, "Environmental Studies – From Crisis to Cure", Oxford University Press, 2005, ISBN 0-19-567393-X.

Reference Books:

1. G.T.Miller Jr., "Environmental Science", 11^{th} Edition, Cengage Learning Pvt. Ltd., 2008.
2. Benny Joseph, "Environmental Studies", Tata McGraw-Hill Publishing company Limited, 2008.

S3

23MEE282	DESIGN THINKING	L-T-P-C: 0-0-3-1

Course Objectives

The course will enable the students to

- To inculcate the creative process of design and design thinking
- To introduce the various methods and tools used in generating design solutions.
- To provide insights into creating design solutions for people, context, behavior, technology, and business.
- To develop the students as good designers by imparting creativity and problem-solving ability.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO1	Familiarize with design thinking concepts and principles to solve critical problems.	Understand
CO2	Establish a workable design thinking framework to solve critical problems using empathy.	Evaluate
CO3	Interact with users to identify customer needs.	Analyze
CO4	Generate and develop functional design through ideation.	Analyze
CO5	Conceive, organize, lead, and implement projects in interdisciplinary domains.	Analyze

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	2	2	3	3	2	2	2		2	1		1		3		
CO02	2	2	1	1		1						1		3		
CO03	2	2	1	1		3						1		3		
CO04	2	2	1	1	1	2	2		2			1		3		
CO05	2	2	1	1	2	2	2		2	2		1		3		

Syllabus

Unit 1

Design process: Traditional design vs Design thinking, Existing sample design projects, Study on designs around us, Compositions/structure of a design, Innovative design: Breaking of patterns, Reframe existing design problems, Principles of creativity. Overview of Ergonomics. Empathy: Customer Needs, Insight-leaving from the lives of others, Observation.

Unit 2

Design team-Team formation, Conceptualization: Visual thinking, Drawing/sketching, New concept thinking. Ideation Techniques: SCAMPER methodology, Mapping, brainstorming, storyboarding, morphological matrix, and reverse thinking. Concept Selection, Concept Testing, Opportunity identification, and Product target specification.

Unit 3

Prototyping: Principles of prototyping, Prototyping technologies, Prototype using simple things, Wooden model, Clay model, 3D printing, Experimenting/testing. Sustainable product design. Design projects for teams.

Textbooks:

1. Tim Brown, Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation, Harper-Collins Publishers Ltd.
2. Idris Mootee, Design Thinking for Strategic Innovation,2013, John Wiley & Sons Inc

Reference Books:

1. Debkumar Chakrabarti, Indian Anthropometric Dimensions for Ergonomic Design Practice, 1997. National Institute of Design Ahmedabad ISBN 81-86199-15-0
2. Ulrich &Eppinger, Product Design and Development, 3rd Edition, McGraw Hill, 2004

S3

23LSE201	LIFE SKILLS FOR ENGINEERS I	L-T-P-C: 1-0-2-P/F

Pre-requisite: An open mind and the urge for self-development, basic English language skills, knowledge of high school level mathematics.

Course Objectives
- Assist students in inculcating Soft Skills and developing a strong personality
- Help them improve their presentation skills
- Support them in developing their problem solving and reasoning skills
- Facilitate the enhancement of their communication skills

Course Outcomes
CO1 - Soft Skills: To develop greater morale and positive attitude to face, analyse, and manage emotions in real life situations, like placement process.
CO2 - Soft Skills: To empower students to create better impact on a target audience through content creation, effective delivery, appropriate body language and overcoming nervousness, in situations like presentations, Group Discussions and interviews.
CO3 - Aptitude: To analyze, understand and employ the most suitable methods to solve questions on arithmetic and algebra.
CO4 - Aptitude: To investigate and apply suitable techniques to solve questions on logical reasoning and data analysis.
CO5 - Verbal: To infer the meaning of words and use them in the right context. To have a better understanding of the basics of English grammar and apply them effectively.
CO6 - Verbal: To identify the relationship between words using reasoning skills. To develop the capacity to communicate ideas effectively.

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01								2	3	3		3				
CO02									2	3		3				
CO03		3		2												
CO04		3		2												
CO05										3		3				
CO06									3	3		3				

Syllabus

Soft Skills
Soft Skills and its importance: Pleasure and pains of transition from an academic environment to work-environment. New-age challenges and distractions. Learning to benefit from constructive criticisms and feedback, Need for change in mindset and up-skilling to keep oneself competent in the professional world.
Managing Self: Knowing oneself, Self-perception, Importance of positive attitude, Building and displaying confidence, Avoiding being overconfident, Managing emotions, stress, fear. Developing Resilience and handling failures. Self-motivation, Self-learning, and continuous knowledge up-gradation / Life-long learning. Personal productivity - Goal setting and its importance in career planning, Self-discipline, Importance of values, ethics and integrity, Universal Human Values.

Aptitude
Problem Solving I
Numbers: Types, Power Cycles, Divisibility, Prime, Factors & Multiples, HCF & LCM, Surds, Indices, Square roots, Cube Roots and Simplification.

Percentage: Basics, Profit, Loss & Discount, and Simple & Compound Interest.
Ratio, Proportion & Variation: Basics, Alligations, Mixtures, and Partnership.
Averages: Basics, and Weighted Average.
Data Interpretation: Tables, Bar Diagrams, Venn Diagrams, Line Graphs, Pie Charts, Caselets, Mixed Varieties, Network Diagrams and other forms of data representation.

Verbal
Vocabulary: Familiarize students with the etymology of words, help them realize the relevance of word analysis and enable them to answer synonym and antonym questions. Create an awareness about the frequently misused words, commonly confused words and wrong form of words in English.
Grammar (**Basic**): Help students learn the usage of structural words and facilitate students to identify errors and correct them.
Reasoning: Stress the importance of understanding the relationship between words through analogy questions.
Speaking Skills: Make students conscious of the relevance of effective communication in today's world through various individual speaking activities.

References:

1. Students" Career Planning Guide, Corporate & Industry Relations, Amrita Vishwa Vidyapeetham.
2. Soft Skill Handbook, Corporate & Industry Relations, Amrita Vishwa Vidyapeetham.
3. Adair. J., (1986), "Effective Team Building: How to make * winning team", London, U.K
4. Gulati. S., (1006) "Corporate Soft Skills", New Delhi, India: Rupa & Co.
5. The hard truth about Soft Skills, by Amazon Publication.
6. Verbal Skills Activity Book, CIR, AVVP
7. English Grammar & Composition, Wren & Martin
8. Nova's GRE Prep Course, Jeff Kolby, Scott Thornburg & Kathleen Pierce
9. Cracking the New GRE 2012
10. Kaplan's – GRE Comprehensive Programme
11. Student Workbook: Quantitative Aptitude & Reasoning, Corporate & Industry Relations, Amrita Vishwa Vidyapeetham.
12. Quantitative Aptitude for All Competitive Examinations, Abhijit Guha.
13. How to Prepare for Quantitative Aptitude for the CAT, Arun Sharma.
14. How to Prepare for Data Interpretation for the CAT, Arun Sharma.

Evaluation Pattern

Assessment	**Internal**	**External**
Continuous Assessment (CA)* – Soft Skills	30	-
Continuous Assessment (CA)* – Aptitude	10	25
Continuous Assessment (CA)* – Verbal	10	25
Total	50	50
Pass / Fail		

*CA - Can be **presentations, speaking activities and tests.**

SEMESTER 4

23MEE211	FLUID MECHANICS AND MACHINERY	L-T-P-C: 3-1-0-4

Course Objectives

The course will enable the students to

- To provide knowledge on fundamentals of fluid properties and fluid statics.
- To classify the types of flow and evaluate kinematic properties.
- To solve practical problems based on mass, momentum, and energy balance equations.
- To determine the major and minor losses in a piping network.
- To study the performance of centrifugal pumps and hydraulic turbines.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Solve practical problems involving fluid properties and hydrostatic pressure, and predict the stability of floating bodies.	Apply
CO02	Understand fluid kinematic properties to classify types of fluid flow using flow visualization techniques.	Understand
CO03	Apply the governing equations for mass, momentum, and energy based on Reynolds Transport Theorem and utilize them in practical problems.	Apply
CO04	Estimate the pumping power by considering major and minor losses in flow through pipes.	Analyze
CO05	Apply dimensional analysis for fluid problems based on Buckingham-Pi Theorem and utilize it for model testing of fluid machinery.	Apply
CO06	Analyze the performance characteristics of hydraulic pumps and turbines.	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3	1				1		2			1	2			
CO02	3	3	1						2			1	2			
CO03	3	3	1						2			1	2			
CO04	3	3	1			1			2			1	2			
CO05	3	3	1						2			1	2			
CO06	3	3	1						2			1	2			

Syllabus

Unit 1

Fundamentals of Fluid Dynamics

Introduction: Basic concepts of Fluid Mechanics: Definition and applications, fluid properties: density, specific volume, specific weight, specific gravity, pressure, vapor pressure and cavitation, viscosity, surface tension and capillarity, coefficient of compressibility, isothermal compressibility and coefficient of volume expansion. [6 hours]

Hydrostatics

Pressure distribution in a static fluid - Pascal's law and hydrostatic law, absolute, gauge and vacuum pressures, static pressure measurement, manometry, hydrostatic force on plane surfaces and curved surfaces, buoyancy, Archimedes principle, Stability of floating bodies, Metacentric height. [10 hours]

Fluid Kinematics
Eulerian and Lagrangian description of fluid flow - material derivative, system and control volume approach for fluid flow analysis - Reynolds Transport Theorem. Flow visualization – streamlines, streak lines, path lines, Flow kinematic properties– velocity, acceleration, linear strain rate, shear strain rate, vorticity and rotationality, strain rate tensor. [8 hours]

Unit 2
Governing Equations for flow analysis
Mass, linear momentum, angular momentum, energy and Bernoulli’s equation– its applications. Flow rate measurement -Venturimeter, Orifice meter and Pitot tube. Hydraulic and energy grade lines. [10 hours]
Flow through Pipes
Flow in pipes-laminar and turbulent flow. Boundary layer development—entry length, developing and developed flows. Average and maximum velocities, shear stress distribution, pressure drop, Major and minor energy losses in pipes. Moody’s chart. Piping systems- series and parallel connections, Equivalent pipe. [9 hours]
Dimensional Analysis and modeling
Significance, Buckingham’s Pi Theorem, Similitude, types of similitude. Model and prototype testing. [4 hours]

Unit 3
Introduction to fluid machines
Centrifugal Pump
Types of pumps, working principle, terminologies and classification. Velocity triangles. Pump performance parameters, performance curves. Introduction to cavitation, NPSH and specific speed. [7 hours]
Hydraulic turbines
Classification. Impulse and reaction machines-Pelton and Francis Turbines. Velocity Triangles. Performance characteristics. [6 hours]

Textbooks:

1. Cengel Y. A. & Cimbala J., “Fluid Mechanics -Fundamentals and Applications”, 3/e, McGraw Hill Edition, 2013.

Reference Books:

1. White F.M., “Fluid Mechanics”, 7/e, McGraw Hill Edition, 2010.
2. Pritchard, P.J, Fox &McDonald, “Introduction to Fluid Mechanics”, 8/e, Wiley & Sons, 2011.
3. Munson B.R., Okiishi T. H., Wade W.Huebsch W.W. & Rothmayer A.P., “Fundamentals of Fluid Mechanics”, 7/e, John Wiley & Sons, 2013.

S4

23MEE212	MANUFACTURING PROCESS II	L-T-P-C: 2-0-3-4

Course Objectives

The course will enable the students to

- Mechanism of material removal and forces during machining, the influence of tool geometry in machining, tool materials, and tool wear mechanisms
- Conventional machining processes, machine tools, and their process capabilities, the influence of process parameters on machining (cutting force, tool wear, and surface finish)
- Preparation of process plan and product cost estimation for the given component
- Principles and applications of advanced machining processes
- CNC programming for turning and machining centers

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Understand the chip formation mechanisms, force, and heat transfer models in different machining processes.	Understand
CO02	Develop experimental procedures to validate the empirical and analytical models in machining.	Apply
CO03	Select suitable cutting tool material and process parameters to maximize the material removal rate, tool life, and surface finish.	Analyze
CO04	Develop process plans for machining components in conventional, CNC, and advanced machining processes and conduct machinability studies.	Analyze
CO05	Develop a CNC part program for the given component drawing and perform machining operations in CNC machining / turning centers.	Apply
CO06	Follow safety rules and standard codes of practice during machining.	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	2	1	1				1		1	1		1	2		2	
CO02	2	1	2	1			1		1	1		1	2		2	
CO03	3	1	2	1			1		1	1		1	2		2	
CO04	3	1	2	1			1		1	1		1	2		2	
CO05	3	1	3				1		1	1		1	2		2	
CO06						1	1	1	1	1		1				

Syllabus

Unit 1

Theory of metal cutting: Types of metal cutting processes, Orthogonal and Oblique cutting, cutting tool nomenclature, Mechanism of chip formation – shear deformation and shear plane, the effect of machining parameters on chip reduction coefficient, Forces and temperature in metal cutting, Merchant's Force Circle, Tool wear -types, mechanisms, Tool life - Machinability and surface finish, cutting tool materials and cutting fluids, Economics of Machining. [15 Hours]

Unit 2

Conventional Machining Processes- Turning, milling, shaping, slotting – machines- types of operations, tool geometry, material removal mechanisms, the influence of process parameters on MRR and Tool Life, process plan and process capability, finishing processes: Grinding – abrasives, operations, and super finishing processes, product cost estimation. [15 Hours]

Unit 3

Advanced Machining Processes: Introduction to Computer Numerical Control Machines (CNC) – features and construction, Micro Machining, Electrical Discharge Machining, Wire EDM, Electro-Chemical Machining, Laser Beam, Plasma Arc Machining, and High-Speed Machining, Metrology for micromachined components. [15 Hours]

Lab Exercises:

- Preparation of process plan for machining of a given component.
- Machining practice: Study and practice various metal cutting operations in Lathe, Milling, Drilling, and Grinding machines.
- Validating analytical and empirical metal cutting models using an experimental procedure
- CNC Programming and Practice – Turning Centre and Milling
- Laser Cutting: Sample Preparation Exercises
- Cutting force measurement: Using tool dynamometers to measure cutting forces in turning, milling, and drilling processes.
- Group Project: Process planning, Tool life studies, selection of optimum machining conditions for MRR and Surface finish criteria, and manufacture & assembly of the products as per the given drawing using the machines available in the workshop. [15 Hours]

Text Books:

1. Amitabha Ghosh and A.K. Mallick, Manufacturing Science. Affiliated East-West Press Pvt. Ltd. 2010.

Reference Books:

1. Serope Kalpakjian and Steven R. Schmid – ‘Manufacturing Engineering and Technology’ - Prentice Hall - 2023 - 8th Edition in SI Units
2. P. M. Agrawal, V. J. Patel, ‘CNC Fundamentals and Programming’, Charotar Publishing House Pvt. Ltd, 2nd Edition-2017.
3. V. K. Jain, Micro manufacturing, CRC press, 2012.
4. Joseph McGeough, Micromachining of Engineering materials, Marcel Dekker Publishers, New York, 2002.

S4

23MEE213	COMPUTATIONAL METHODS IN ENGINEERING	L-T-P-C: 2-0-3-3

Course Objectives

The course will enable the students to

- To familiarize different numerical methods to solve engineering problems.
- To write computer programs and use toolboxes in the software packages.
- To select a specific numerical method to solve practical problems.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Evaluate solutions for nonlinear equations and systems of nonlinear equations using numerical techniques.	Apply
CO02	Solve the system of linear equations using direct and iterative methods.	Apply
CO03	Apply regression and interpolation methods for curve fitting.	Apply
CO04	Select and Apply numerical schemes integrating complicated functions.	Apply
CO05	Apply computational schemes for solving systems of ordinary differential equations.	Apply
CO06	Solve PDEs by numerical methods.	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	2	2	2	2	1				1			2	1			1
CO02	2	2	2	2	1				1			2	1			1
CO03	2	1	1	2	3				1			2	1			1
CO04	2	2	3	3	3				1			2	1			1
CO05	2	2	3	3	3				1			2	1			1
CO06	2	2	2	2	2				1			2	1			1

Syllabus

Unit 1*

Roots of equations – Bisection method, Regula Falsi, fixed point iteration, Newton-Raphson method, Secant method, systems of nonlinear equations. [6 hours]

Numerical linear algebra – Direct Methods: Gauss elimination, LU decomposition, Matrix inversion, TDMA, Iterative Methods: Gauss-Seidel, Gauss-Jacobi. Eigen Values: Power method, Inverse Power Method for finding eigen values, QR factorisation (Using Matlab) [6 hours]

Unit 2

Curve Fitting – Linear regression, polynomial regression, nonlinear regression [2 hours]

Interpolation - Newton's divided difference interpolation, Lagrange interpolation, Spline interpolation [3 hours]

Numerical Integration – Trapezoidal rules, Simpson's rules, Newton-Cotes algorithm, Gauss quadrature. [3 hours]

Unit 3

Differential Equations – ODE: Euler's method, improved Euler's methods, Runge-Kutta method, Higher order ODE [6 hours]

PDE: Finite difference method, solution of Laplace equation by FDM – 1 D and 2D. [4 hours]

Textbooks:

1. Numerical Methods for Engineers, Steven Chapra and Raymond Canale, 7th Edition, McGraw Hill, 2015.
2. Applied Numerical Analysis, LaureneFausett, 2nd Edition, Pearson, 2008.
3. Advanced Engineering Mathematics, Erwin Kreyszig, 10th Edition, Wiley, 2011.

Reference Books:

1. M. K. Jain, S. R. K. Iyengar and R. K. Jain, Numerical methods for Scientific and Engineering Computation, New Age International Publishers, Fifth edition, 2007

S4

23MEE214	THERMAL ENGINEERING	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- Inculcate the concept of thermodynamics applied to gas and vapor power cycles.
- Familiarize the working principle of two-stroke and four-stroke engines and evaluate their performance.
- Perform thermodynamic analysis on air compressors.
- Elucidate the working principles of refrigeration, air- conditioning, steam nozzle, and turbines and compute their performance.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Analyze gas and vapor power cycles	Analyze
CO02	Compute the performance of Internal Combustion engines	Apply
CO03	Compute the performance of air compressors.	Apply
CO04	Analyze the performance of refrigeration and air-conditioning system.	Analyze
CO05	Evaluate the performance of the steam nozzle and steam turbine.	Analyze

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3	3	1		1	1						2			
CO02	3	3	3	1		1	1						2			
CO03	3	3	3	1		1	1						2			
CO04	3	3	3	1		1	1						2			
CO05	3	3	3	1		1	1						2			

Syllabus

Unit 1

Gas and Vapour Power Cycles: Otto, Diesel, Dual cycle, Brayton cycles, methods to improve the efficiency of gas turbines, Rankine cycle, Regenerative, and Reheat vapour cycle. [10 hours]

Air compressors: Working of reciprocating compressors, the effect of clearance and volumetric efficiency, adiabatic, isothermal, mechanical efficiencies, multistage compressor, intercooler, and its effects. [5 hours]

Unit 2

Internal combustion engines: Working principles of Spark ignition engines and compression ignition engines. Working of 4S engine and 2S engine. Combustion phenomenon in S.I & C.I. engines, Testing, and performance of IC engines. [7 hours]

Refrigeration systems: Refrigerants- types and desirable properties, vapor compression, and vapor absorption systems. [4 hours]

Air conditioning systems: Psychrometry- DBT, WBT, DPT, Specific & relative humidity, Psychrometric process, Air-conditioning Processes- summer and winter air conditioning system, cooling load calculations. [4 hours]

Unit 3

Steam nozzles: Convergent and convergent-divergent nozzles, Supersaturated or metastable expansion of steam in a nozzle- Performance evaluation of steam nozzles. [5 hours]

Steam turbines: Working principle of Impulse and Reactions turbine, Compounding- Pressure compounding, Velocity compounding, Pressure- Velocity compounding, velocity triangle- Performance evaluation of turbines. [10 hours]

Textbooks:

1. Cengel Y. A. & Boles M. A. “Thermodynamics - an Engineering Approach”, 9/e, Tata McGraw Hill, 2019
2. Ganesan.V. “Internal Combustion Engines”, 4/e, Tata McGraw Hill, 2012

Reference Books:

1. Sonntag R. E., Borgnakke C. & Van Wylen, G. - ‘Fundamentals of Thermodynamics’, 10/e John Wiley and Sons , 2019
2. Rajput R. K., “Thermal Engineering”,10/e,Laxmi Publications (P) Ltd., New Delhi , 2020

S4

23MEE215	DATA SCIENCE	L-T-P-C: 2-0-3-3

Course Objectives

The course will enable the students to

- Building the fundamentals of data science
- Imparting design thinking capability to build big-data
- Developing design skills of models for big data problems
- Gaining practical experience in programming tools for data sciences
- Empowering students with tools and techniques used in data science

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Identify the importance and types of data	Understand
CO02	Apply data preprocessing techniques and visualize the data	Apply
CO03	Utilize EDA, and perform statistical inference	Apply
CO04	Apply dimension reduction technique to reduce the dimensions of the data	Apply
CO05	Select the significant features from the data	Apply
CO06	Apply a basic regression model to the processed data	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]											Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2	1										1			3
CO02	3	2	1									1	1			3
CO03	3	2	1									1	1			3
CO04	3	2	1		3							1	1			3
CO05	3	2	1		3							1	1			3
CO06	3	2	1		3							1	1			3

Syllabus

Unit 1

Introduction: Big Data and Data Science - Big Data Analytics, Business Intelligence vs. Big data, Big Data frameworks, Knowledge Domains of Data Analyst, Understanding the Nature of Data, and Data Analysis Process. Quantitative and Qualitative Analysis. Current landscape of analytics, A Data Scientist Profile, data visualization techniques, visualization software. [6 hours]

Unit 2

Data Preprocessing: Data cleaning, Data reduction, Data transformation, Data discretization. Visualization and Graphing: Visualizing Categorical Distributions, Visualizing Numerical Distributions, Overlaid Graphs, plots, Randomness, and Probability. [8 hours]

Unit 3

Exploratory Data Analysis (EDA): Introduction to Statistics, Sampling, Sample Means and Sample Sizes. Descriptive statistics, Basic tools (plots, graphs, and summary of statistics) of EDA, Data Analytics Lifecycle, Discovery.

Basic Statistical Inference: Hypothesis Testing, Assessing Models, Decisions, Uncertainty, Comparing Samples, A/B Testing, P-Values, Causality. [12 hours]

Unit 4

Dimension Reduction: Curse of Dimensionality, Practical Considerations, Correlation Analysis, Principal Components Analysis, Dimension Reduction Using Regression, Classification and Regression Trees (CART).
Feature Selection: Feature Extraction and Feature Selection, Feature Selection Algorithms: Filters- Wrappers - Decision Trees - Random Forests. [12 hours]

Unit 5

Applications of Data Science: Regression model: Linear regression, Logistic regression, Polynomial regression. Case studies. [7 hours]
Lab Content: Introduction to Python programming - Control Structures, Data Structures, Python packages – NumPy, SciPy, Matplotlib, Power Bi, Ski-kit learn, Pandas, Tensorflow, Streamlite etc. Machine Learning algorithms

List of Equipment required for meeting the COs

- Personal Computer (Intel i7 processor, 512 GB SSD HD, 16 GM RAM DDR IV)
- Pyhton IDE / Jupyter Note book

List of Exercises

S.No.	List of Exercises	CO mapping
1	Introduction to Python Programming	**CO1**
2	Reading and writing different types of datasets	**CO1**
3	Data processing using Pandas	**CO2**
4	Correlation and covariance using Python	**CO2**
5	Data visualization using plot, pie chart, bar chart, histogram, and box plot	**CO3**
6	Dashboard creation using Excel / Power bi	**CO3**
7	Time domain analysis	**CO2**
8	Frequency domain analysis	**CO2**
9	Feature selection and dimensionality reduction using PCA	**CO4, CO5**
10	Application of regression model	**CO2, CO6**
Note: For all Laboratory experiments, Rubrics need to be developed for assessment & evaluation		

Textbooks:

1. Nelli, F., 2015. Python data analytics: Data analysis and science using PANDAs, Matplotlib and the Python Programming Language. Apress.
2. Haider, M., 2015. Getting started with data science: Making sense of data with analytics. IBM Press.

Reference Books:

1. Data Mining for Business Analytics: Concepts, Techniques and Applications in R, by Galit Shmueli, Peter C. Bruce, Inbal Yahav, Nitin R. Patel, Kenneth C. Lichtendahl Jr., Wiley India, 2018.
2. Rachel Schutt & Cathy O'Neil, "Doing Data Science" O' Reilly, First Edition, 2013.
3. Brownlee J. Machine learning algorithms from scratch with Python. Machine Learning Mastery; 2016 Nov 16.

23MEE283	THERMAL ENGINEERING LABORATORY	L-T-P-C: 0-0-3-1

Course Objectives

The course will enable the students to

- Experimental methods to find fuel properties
- Experimental methods to evaluate the COP of the refrigerator and air conditioning units.
- Performance characteristics of IC engines, and air compressors.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Compute the various properties of fuels.	Apply
CO02	Analyze the performance of internal combustion engines under various operating conditions.	Analyze
CO03	Analyze the performance of the blower/air compressor.	Analyze
CO04	Analyze the performance of refrigerator and air conditioning units.	Analyze
CO05	Analyze the performance of the boiler, turbine, and condenser.	Analyze

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3	3	1	1	1			1	1			2			
CO02	3	3	3	1	1	1			1	1			2			
CO03	3	3	3	1	1	1			1	1			2			
CO04	3	3	3	1	1	1			1	1			2			
CO05	3	3	3	1	1	1			1	1			2			

Syllabus

Testing of fuels: Determination of flash and fire point, density, viscosity, specific gravity, and calorific value of various fuels.

Testing of IC engines: Study of I.C engines, components and loading devices, Valve timing diagrams. Performance test on Petrol/LPG and Diesel/Biodiesel engines, Performance and Heat Balance test, Morse test, and retardation test.

Performance of engineering devices: Performance test on air compressor/ centrifugal blower. Performance test on refrigeration and air-conditioning systems. Performance test on Boiler, Turbine, and Condenser.

List of Equipment required for meeting the CO's

1. Flashpoint and fire point apparatus
2. Redwood viscometer
3. Bomb calorimeter
4. Cut section model of 4S/2S Engine
5. Single-cylinder diesel/petrol engine
6. Multi-cylinder petrol/diesel engine
7. Air compressor
8. Refrigeration test rig
9. Air conditioning system
10. Mini thermal power plant

List of Exercises

S.No.	List of Exercises	CO mapping
1	Determination of the flash &fire point of the given oil	**CO01**
2	Determination of the kinematic and dynamic viscosity of the given oil	**CO01**
3	Determination of the calorific value of the given oil	**CO01**
4	Evaluation of various efficiencies of air compressor	**CO03**
5	Evaluation of various efficiencies of IC engines	**CO02**
6	Determination of the frictional power of an engine. (Retardation test)	**CO02**
7	Determination of the indicated power of the multi-cylinder engine. (Morse test)	**CO02**
8	Estimate COP of refrigeration and air-conditioning system.	**CO04**
9	Evaluation of the performance of the mini power plant	**CO05**

S4

22ADM211	LEADERSHIP LESSONS FROM RAMAYANA	L-T-P-C: 1-0-0-1

Course Objectives

The course will enable the students to

- To introduce students to the depths and richness of the Indian culture and knowledge traditions.
- To enable them to obtain a synoptic view of the grandiose achievements of India in diverse fields.
- To equip students with a knowledge of their country and its eternal values.
- Through a study of the Rāmāyaṇa, the student should gain a deeper understanding of the ethical grandeur of Indian culture and be inspired to follow the ideals of the characters depicted therein.
- Aligned with the Indian Knowledge Systems (IKS) framework outlined in the National Education Policy, this course serves as an introduction to the vast reservoir of wisdom and knowledge rooted in Indian heritage.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Recall key characters and events from the Ramayana. Statement: Memorize and retrieve significant characters and events, demonstrating a foundational understanding of the Ramayana narrative.	Remembering
CO02	Explain the ethical challenges faced by characters in the Ramayana and their repercussions. Statement: Comprehend the moral dilemmas encountered by Ramayana characters and articulate the effects of their decisions on the storyline	Understanding
CO03	Apply leadership principles from the Ramayana to real-life leadership situations. Statement: Utilize insights gleaned from the Ramayana to solve contemporary leadership predicaments, adapting its teachings to modern contexts.	Applying
CO04	Analyze the diverse leadership styles portrayed by characters in the Ramayana and their impacts. Statement: Examine the multifaceted leadership approaches of Ramayana's characters, assessing their effectiveness and unraveling the factors shaping their outcomes.	Analyzing
CO05	Evaluate the enduring relevance of Ramayana's leadership lessons in the present day. Statement: Assess the ongoing significance of the Ramayana's leadership wisdom, gauging its applicability and worth within contemporary leadership landscapes	Evaluating
CO06	Develop a comprehensive leadership framework by synthesizing lessons from the Ramayana. Statement: Formulate an innovative leadership model by integrating and reimagining the diverse teachings extracted from the Ramayana, fostering a novel approach to effective leadership.	Creating

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01								2				3				
CO02								3				2				
CO03				2		3	3	2	2			2				
CO04								2	3			3				
CO05						2	3					3				
CO06			2	1		1		2	3			2				

Syllabus

Chapter 1 - Introduction to the Great Itihasa
Chapter 2 - Bala-Kāṇḍa: (Preparing for the renowned mission) And Ayodhya-Kāṇḍa: (Harbinger of an Entire Tradition of Nobleness)
Chapter 3 - Araṇya-Kāṇḍa: (Tale of the forest life) And Kishkindha-Kāṇḍa: (The Empire of Holy Monkeys)
Chapter 4 - Sundara-Kāṇḍa: (Heart of the Ramayana) And Yuddha-Kāṇḍa: (The most popular part of the Ramayana)
Chapter 5 - Ramayana and Modern-day learning
Chapter 6 - Ecological Awareness in the Ramayana
Chapter 7 - Different Ramayana: (Epic that connects the world)
Chapter 8 - Uttara-Kāṇḍa: (An attempt to explain the untold stories)

Textbooks:
Leadership Lessons from Ramayana

Reference Books:
1. Rajagopalachari. C, The Ramayana Valmiki, The Ramayana, Gita Press
2. Skanda Purana
3. Hinduism and Ecology

Topic wise PPTs will be uploaded in Teams

S4

22LSE211	LIFE SKILLS FOR ENGINEERS II	L-T-P-C: 1-0-2-2

Pre-requisite: An inquisitive mind, basic English language skills, knowledge of high school level mathematics.

Course Objectives
- Assist students in inculcating Soft Skills and developing a strong personality
- Help them improve their presentation skills
- Aid them in developing their problem solving and reasoning skills
- Facilitate them in improving the effectiveness of their communication

Course Outcomes
CO1 - Soft Skills: To develop greater morale and positive attitude to face, analyse, and manage emotions in real life situations, like placement process.
CO2 - Soft Skills: To empower students to create better impact on a target audience through content creation, effective delivery, appropriate body language and overcoming nervousness, in situations like presentations, Group Discussions and interviews.
CO3 - Aptitude: To analyze, understand and employ the most suitable methods to solve questions on arithmetic and algebra.
CO4 - Aptitude: To investigate and apply suitable techniques to solve questions on logical reasoning and data analysis.
CO5 - Verbal: To learn to use more appropriate words in the given context. To have a better understanding of the nuances of English grammar and become capable of applying them effectively.
CO6 - Verbal: To be able to read texts critically and arrive at/ predict logical conclusions. To learn to organize speech and incorporate feedback in order to convey ideas with better clarity.

CO-PO Mapping: [affinity[#]: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01								2	3	3		3				
CO02									2	3		3				
CO03		3		2												
CO04		3		2						3		3				
CO05									3	3		3				

Syllabus

Soft Skills
Communication: Process, Language Fluency, Non-verbal, Active listening. Assertiveness vs. aggressiveness. Barriers in communication. Digital communication
Presentations: Need, importance, preparations, research and content development, structuring and ensuring flow of the presentation. Ways and means of making an effective presentation: Understanding and connecting with the audience – using storytelling technique, managing time, appropriate language, gestures, posture, facial expressions, tones, intonations and grooming. Importance of practice to make an impactful presentation.

Aptitude
Problem Solving II
Equations: Basics, Linear, Quadratic, Equations of Higher Degree and Problems on ages.
Logarithms, Inequalities and Modulus: Basics
Time and Work: Basics, Pipes & Cistern, and Work Equivalence.
Time, Speed and Distance: Basics, Average Speed, Relative Speed, Boats & Streams, Races and Circular tracks.
Logical Reasoning: Arrangements, Sequencing, Scheduling, Venn Diagram, Network Diagrams, Binary Logic, and Logical Connectives.

Verbal

Vocabulary: Aid students learn to use their vocabulary to complete the given sentences with the right words. Usage of more appropriate words in different contexts is emphasized.

Grammar (**Basic-intermediate**): Help students master usage of grammatical forms and enable students to identify errors and correct them.

Reasoning: Emphasize the importance of avoiding the gap (assumption) in arguments/ statements/ communication.

Reading Comprehension (**Basics**): Introduce students to smart reading techniques and help them understand different tones in comprehension passages.

Speaking Skills: Make students be aware of the importance of impactful communication through individual speaking activities in class.

Writing Skills: Introduce formal written communication and keep the students informed about the etiquette of email writing.

References:

1. Students" Career Planning Guide, Corporate & Industry Relations, Amrita Vishwa Vidyapeetham.
2. Soft Skill Handbook, Corporate & Industry Relations, Amrita Vishwa Vidyapeetham.
3. Adair. J., (1986), *"Effective Team Building: How to make * winning team"*, London, U.K
4. Gulati. S., (1006) "Corporate Soft Skills", New Delhi, India: Rupa & **Co.**
5. The hard truth about Soft Skills, by Amazon Publication.
6. Verbal Skills Activity Book, CIR, AVVP
7. English Grammar & Composition, Wren & Martin
8. Nova's GRE Prep Course, Jeff Kolby, Scott Thornburg & Kathleen Pierce
9. Cracking the New GRE 2012
10. Kaplan's – GRE Comprehensive Programme
11. Student Workbook: Quantitative Aptitude & Reasoning, Corporate & Industry Relations, Amrita Vishwa Vidyapeetham.
12. Quantitative Aptitude for All Competitive Examinations, Abhijit Guha.
13. How to Prepare for Quantitative Aptitude for the CAT, Arun Sharma.
14. How to Prepare for Data Interpretation for the CAT, Arun Sharma.

Evaluation Pattern

Assessment	Internal	External
Continuous Assessment (CA)* – Soft Skills	30	-
Continuous Assessment (CA)* – Aptitude	10	25
Continuous Assessment (CA)* – Verbal	10	25
Total	50	50

*CA - Can be **presentations, speaking activities and tests.**

S4

23LAW300	INDIAN CONSTITUTION	L-T-P-C: P/F

Course Objectives

The course will enable the students to

- To know about Indian constitution.
- To know about central and state government functionalities in India
- To know about Indian society

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Understand the functions of the Indian government	Understand
CO02	Understand and abide the rules of the Indian constitution	Understand
CO03	Understand and appreciate different culture among the people	Understand

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01						3	2	3								
CO02						3	2	3								
CO03						3	2	3								

Syllabus

Unit 1

Historical Background – Constituent Assembly Of India – Philosophical Foundations Of The Indian Constitution – Preamble – Fundamental Rights – Directive Principles Of State Policy – Fundamental Duties – Citizenship – Constitutional Remedies For Citizens.

Unit 2

Union Government – Structures of the Union Government and Functions – President – Vice President – Prime Minister – Cabinet – Parliament – Supreme Court of India – Judicial Review.

Unit 3

State Government – Structure and Functions – Governor – Chief Minister – Cabinet – State Legislature – Judicial System in States – High Courts and other Subordinate Courts.

Textbooks:

1. Durga Das Basu, "Introduction to the Constitution of India ", Prentice Hall of India, New Delhi.
2. R.C.Agarwal, (1997) "Indian Political System", S.Chand and Company, New Delhi.

Reference Books:

1. Sharma, Brij Kishore, "Introduction to the Constitution of India", Prentice Hall of India, New Delhi

SEMESTER 5

23MEE301	KINEMATICS AND DYNAMICS OF MACHINES	L-T-P-C: 3-1-0-4

Course Objectives

The course will enable the students to

- Familiarize with the terminology and classification of mechanisms.
- Perform kinematic analysis and synthesis of planar mechanisms with lower and higher pairs.
- Perform static and dynamic force analysis of planar mechanisms.
- Model and analyze vibration systems.
- Identify sources and effect of unbalance in rotating systems.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Classify and solve for mobility of planar mechanisms	Apply
CO02	Perform kinematic analysis of planar mechanisms and synthesize dimensions of linkages.	Analyze
CO03	Construct and analyze cam profiles for the various motions of the follower.	Create
CO04	Perform static and dynamic force analysis of planar mechanisms.	Analyze
CO05	Create and analyze turning moment diagrams for flywheel design	Analyze
CO06	Analyze and solve static and dynamic balancing of rotating components.	Analyze
CO07	Formulate and solve equations of motion for single degree of freedom vibration systems under free and forced conditions	Analyze

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3	2		1							1	2	1		
CO02	3	3	2		1							1	2	1		
CO03	3	3	2		1							1	2	1		
CO04	3	3	2		1							1	2	1		
CO05	3	3	2		1							1	2	1		
CO06	3	3	2		1							1	2	1		
CO07	3	3	2		1							1	2	1		

Syllabus

Introduction - Basic definitions in kinematics – Mobility **-** Classification of linkages, kinematic pairs, and mechanisms – Open-loop and closed-loop mechanisms – Gasthof's law – Inversions of four-bar, slider-crank and double-slider mechanisms. [5 hours]

Analysis of planar mechanisms

Graphical approach for displacement, velocity, and acceleration analyses of planar mechanisms with up to six linkages. Coriolis's component of acceleration – Quick return mechanism.

Analytical approach – Loop closure method for planar mechanisms – Formulation of equations and their numerical solution – displacement, velocity, and acceleration analyses**.** [14 Hours]

Dimensional synthesis of mechanisms – Graphical methods of synthesizing a four-bar mechanism. [4 Hours]

Cam design – displacement diagram – standard cam motions – graphical layout of cam profiles – analysis of cam motion – correlation with the motion of inlet and exhaust valves of an IC engine. [7 Hours]

Dynamics of Machines
Static force analysis – conditions for equilibrium – static force analysis of four bar and slider crank mechanism – effect of friction. [5 Hours]

Dynamic force analysis – Centroid and centre of mass – mass moments and products of inertia – D'Alembert's principle – Principle of superposition. [5 Hours]

Flywheels and Turning moment diagrams – coefficient of fluctuation of speed. [3 Hours]

Balancing – Static unbalance – Dynamic unbalance – Analysis of unbalance **-** balancing machines. [4 Hours]

Vibration of single degree of freedom systems – undamped and damped free vibrations **-** natural frequency – logarithmic decrement. Forced vibrations harmonic response – resonance – frequency response plot – magnification factor and phase angle. Support harmonic excitation – vibration isolation. [12 Hours]

Textbooks:

1. Uicker, John Joseph, Gordon R. Pennock, and Joseph Edward Shigley. Theory of Machines and Mechanisms. Vol. 1. New York, NY: Oxford University Press, 2011.
2. Norton, Robert L. Kinematics and Dynamics of Machinery. McGraw-Hill Higher Education, 2011
3. W.T.Thomson, M D Dahleh and C. Padmanabhan. Theory of vibrations with applications. 5th edition. Pearson Education Inc. 2015

Reference Books:

1. Ghosh, Amitabha, and Asok K. Mallik. Theory of Mechanisms and Machines. Affiliated East-West Press Private Limited, 2002.
2. Rattan, S. S. Theory of Machines. Tata McGraw-Hill Education, 2014.

S5

23MEE302	DESIGN OF MACHINE ELEMENTS I	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- Introduce basic concepts of design process
- Provide experience to students in solving design problems
- Impart design principles involved in evaluating the critical design parameters of machine elements to satisfy functional and strength requirements.
- To make the students understand about the various failure modes
- Familiarize standard codes and practices to select materials and geometric parameter

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Select suitable materials for the given mechanical components.	Understand
CO02	Evaluate the condition of stress acting in machine elements subjected to static loads.	Evaluate
CO03	Analyze the performance of mechanical components subjected to variable loading.	Analyze
CO04	Estimate the safety factor in any machine elements under different types of loading	Evaluate
CO05	Evaluate the loading condition of mechanical components subjected to combined loading based on failure theories	Evaluate
CO06	Design machine elements such as shaft, key, coupling, springs and fasteners based on design principles, design standards and design catalogue.	Create

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3	3	1		2	2			1			3	2		
CO02	3	3	3	1		2	2			1			3	2		
CO03	3	3	3	1		2	2			1			3	2		
CO04	3	3	3	1		2	2			1			3	2		
CO05	3	3	3	1		2	2			1			3	2		
CO06	3	3	3	1		2	2	3		1		2	3	2		

Syllabus

Unit 1

Introduction to the design process – factors influencing machine design, Selection of materials based on mechanical properties: Material selection for static strength, fatigue strength, wear resistance, corrosion resistance. Design based on static loading: stresses due to direct, bending, torsional and eccentric loading, Factor of safety, Impact and shock loading, Theories of failure, Selection and uses of theories of failure, Factor influencing the selection of Factor of Safety, Standardization, Preferred numbers. [12 Hours]

Unit 2

Design for variable loading: Fluctuating load, reversed and repeated load, Endurance limit, Modifying factors: size, surface finish, stress concentration factors, S-N curves, Low cycle and high cycle fatigue, Design for finite and infinite life, Goodman and Soderberg relationship, Fatigue design under combined loading. [12 Hours]

Unit 3

Design of shaft based on strength and rigidity, shaft subjected to combined twisting, bending moment and axial loading, Design of shaft under fluctuating loads,

Keys & Couplings: Types of keys, Design of key and keyways, Shaft couplings: Types, Design of rigid and flexible couplings. [6 Hours]

Unit 4

Springs: Types, Stresses and defection in helical coil springs, Design of helical spring under static and fluctuating loads, Leaf springs: Construction, Design of leaf spring. [6 Hours]

Unit 5

Design of fasteners: Threaded joints: Types of threads, Standards of thread, Design of threaded joints subjected to different types of loading (direct, shear, bending and eccentric)

Welded joints: Types of joint, Welding symbols, Strength of welded joints: Butt weld, parallel fillet weld, transverse fillet weld, Design of welded joints subjected to direct, bending, torsional and eccentric loading. [9 Hours]

Textbooks:

1. V.B. Bhandari, “Design of Machine Elements”, 5e, TMH, 2020
2. Richard G.Budynas, J.Keith Nisbett, Kiatfa Tangchaichit " Shigley's Mechanical Engineering Design", 11e, MGH, 2020

Reference Books:

1. Hall, Holowenko, Laughlin, "Machine Design", Special Indian Edition, TMH, 2008.
2. Robert L.Norton, “Machine Design- An integrated Approach”, 6e., Pearson Education, 2021
3. J.A.Charles, F.A.A Crane, J.A.G, Furness, Selection and use of engineering materials, Butterworth Heinemann, 1997

S5

23MEE303	HEAT TRANSFER	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- To introduce a basic study of the phenomena of heat transfer in different modes
- To develop methodologies for solving steady and unsteady heat conduction problems
- To elucidate the significance of empirical correlations in convection heat transfer
- To understand the concepts of radiation heat transfer to compute radiation properties
- To familiarize rating and sizing problems in heat exchangers

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Solve steady and unsteady heat conduction problems with different boundary conditions, and assess the performance of fins	Apply
CO02	Estimate the pumping power of the fluid and convective heat transfer rate by using semi-empirical correlation associated with different types of flows and geometries	Apply
CO03	Evaluate emissive and spectral emissive power for a black and grey surface	Apply
CO04	Determine radiation heat transfer between enclosures	Apply
CO05	Solve sizing and rating problems associated with different types of heat exchanger	Analyze

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3	3	2								1	2			
CO02	3	3	3	2								1	2			
CO03	3	3	3	2								1	2			
CO04	3	3	3	2								1	2			
CO05	3	3	3	2								1	2			

Syllabus

Unit 1

Introduction and Basic Concepts: Thermodynamics and Heat Transfer, heat and other forms of energy, Heat Transfer Mechanism: Conduction, Convection and Radiation –fundamental equations, Simultaneous heat transfer mechanisms [3 hours]

Heat conduction equation: General heat conduction equation – One dimensional steady state equation - boundary and initial conditions- Heat generation in solids- generalized thermal resistance network – critical radius of insulation, Variable thermal conductivity, thermal contact resistance

Extended surface heat transfer: Governing equation, boundary conditions, Performance of fins – efficiency and effectiveness, proper length of the fin, Types of fins: Pin fin, rectangular, Parabolic and annular fins [9 hours]

Unsteady heat conduction analysis: Lumped mass analysis with temporal effects – Governing equations - Biot number significance. Heat Conduction in Large Plane Walls, Long Cylinders, and Spheres with both Spatial and temporal Effects –Governing equations - Graphical Solution - Fourier number significance. [4 hours]

Unit 2

Convective heat transfer: Boundary layer theory – physical mechanism of convection – Governing equation, Analogy between momentum and heat transfer: Reynolds analogy and Chilton Colburn analogy. Dimensionless numbers – Nusselt number, skin friction coefficient, Stanton number, Prandtl number, Reynolds number,

Grashoff Number – Significance. [5 hours]
Forced Convection: External flows - Flow over flat plates, cylinders and spheres. Flow over tubes and bank of tubes, Internal Flows – flow through circular and non-circular
Natural convection: External surface Combined natural and forced convection
Phase change heat transfer: Condensation and boiling- Application of heat transfer in Phase Change Materials (PCM) [10 hours]

Unit 3
Fundamental of Radiation: Thermal radiation and basic laws of radiation: Stefan-Boltzmann Law, Wien's displacement law and Planck's Law, radiation intensity, solid angle, irradiation and radiosity, radiation properties- emissivity, absorptivity, transmissivity and reflectivity, atmospheric and solar radiation: greenhouse effect Radiation Heat Transfer: Shape factor- diffuse and gray surfaces. Radiative heat transfer between two and three enclosures, Radiation shield. [7 hours]
Heat Exchangers: Types of heat exchangers: parallel flow, counter flow, cross flow, shell and tube, and compact heat exchanger. Overall heat transfer coefficient, fouling factor. [4 hours]
Analysis of Heat Exchanger: LMTD and ε-NTU methods. [3 hours]

Textbooks:
1. Yunus A Cengel&Afshin J. Ghajar, "Heat Transfer and Mass Transfer – Fundamentals & Applications", 5/e, McGraw-Hill., 2017

Reference Books:
1. Frank P. Incropera& David P DeWitt, "Fundamentals of Heat and Mass Transfer", 7/e, John Wiley and Sons, 2011.
2. C P Kothandaraman, 'Fundamentals of Heat and Mass Transfer', New Age International Publishers, New Delhi, 2012.
3. Holman J P, 'Heat and Mass Transfer', Tata McGraw-Hill Publishing Company Limited, 10/e, 2009

S5

23MEE304	INSTRUMENTATION AND CONTROL SYSTEMS	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- Familiarize with basic principles and characteristics of measuring instruments
- Inculcate knowledge on performing error analysis
- Familiarize with analysis of control systems in time domain and frequency domain

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Analyze static and dynamic characteristics of measuring instruments and identify the errors involved	Analyze
CO02	Apply signal conditioning techniques and analyze the signal	Apply
CO03	Select and use various measuring instruments for a practical application	Understand
CO04	Derive the transfer function to obtain steady state response	Understand
CO05	Analyze dynamic systems for their stability and performance	Analyze
CO06	Design controllers based on stability and performance requirements	Create

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2	1		1				2			1	2	1		1
CO02	3	1	1		1								2	1		1
CO03	3	1	1		1				1			1	2	1		1
CO04	3	3	2		1				2				2	1		1
CO05	3	3	2		1				1			1	2	1		1
CO06	3	3	3		1				1			1	2	1		1

Syllabus

Unit-I

Measurements and measuring systems: Fundamentals of measurement systems, Classification of measurement systems, Performance Characteristics, Errors in measurements, Uncertainty analysis, Regression analysis, Signal processing (operational amplifiers, and filters) and Signal conditioning (ADC and DAC), Wheatstone bridge. [8 hours]

Sensors/Transducers: Pressure Measurement-Elastic transducers, Bourdon gauge, Bellows and Diaphragm. Flow Measurement-Turbine meter, hot-wire anemometer and Laser Doppler anemometer. Level Measurement-Float gauge, Capacitive and ultrasonic level sensors. Temperature Measurement-Thermometer, thermistor, Thermocouple, RTD and Pyrometer. Strain measurement-Strain gauges. [4 hours]

Unit-II

Control systems: Introduction to control systems, Types of control systems, modeling of simple mechanical and electrical systems, transfer functions, block diagrams and its reduction techniques, signal flow graphs. Time response characteristics of control systems, Time response of first order systems- response to step, ramp and impulse, Time response of second order system to step input- time domain specifications and steady state error. [15 hours]

Unit-III

Stability analysis: Stability analysis of control Systems-Concept of poles and zeros, Routh-Hurwitz criterion and Root locus technique. Frequency Response- Frequency response specifications, Bode diagram, Polar Plot and

Nyquist Plot, Stability analysis using Nyquist Stability Criterion, Relative stability, Gain & Phase Margin. Lag-Lead Compensation. Control systems analysis and design in state space. Basic control actions- Introduction to PI, PD and PID controllers, Design of a PID controller with Ziegler-Nichols rule with applications. [18 hours]

Textbooks:

1. Doebelin’s E.O., and Manik D.N., “Doebelin's Measurement Systems”, 6th Edition, McGraw Hill Education, 2011
2. Katsuhiko Ogata, “Modern Control Engineering”, 5th Edition, Pearson Education, New Delhi, 2010

Reference Books:

1. John P. Bentley, “Principles of Measurement Systems”, 4th Edition, Pearson Education, New Delhi, 2005
2. Richard C. Dorf and Robert H. Bishop, “Modern Control Systems”, 12th Edition, Pearson Education, New Delhi, 2011
3. Norman S. Nise, “Control Systems Engineering”, 7th Edition, John Wiley & Sons, New Delhi, 2015

S5

23MEE305	MACHINE LEARNING	L-T-P-C: 2-0-3-3

Course Objectives

The course will enable the students to

- Building the fundamentals of Machine Learning
- imparting Statistical and linear algebra skills for Machine learning
- Developing neural network models for engineering applications
- Gaining practical experience in programming tools for Machine Learning
- Empowering students with tools and techniques used in Machine learning

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Identify the importance and applications of machine learning	Understand
CO02	Apply linear algebra methods to model engineering data	Apply
CO03	Understand various supervised and unsupervised ML algorithms	Understand
CO04	Apply dimension reduction technique to reduce the dimensions of the data.	Apply
CO05	Design and implement various machine learning algorithms for real-world applications.	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2	1	1						1	1		2			3
CO02	3	2	1	1						1	1	1	2			3
CO03	3	2	1	1						1	1	1	2			3
CO04	3	2	1	1	3					1	1	1	2			3
CO05	3	2	1	1	3					1	1	1	2			3

Syllabus

Unit 1

Review linear algebra, vector spaces, Linear transformations, Eigen values and vectors, random variables, and probability distributions. Introduction to signal processing – Time, Frequency, Time-Frequency domain analysis. Regression – Simple and regularized Linear Regression, Gradient descent, Multiple linear regression in multiple variables –Linear models for classification, Discriminant functions, Logistic regression. [12 Hours]

Unit 2

Introduction: Basic motivation, examples of machine learning applications Unsupervised, Supervised, Reinforcement, Hybrid models, Handling datasets, Performance metrics. [7 Hours]

Unit 3

Dimensionality reduction - Principal Component Analysis, Singular Value decomposition, Fundamentals of Deep Learning and Reinforcement Learning. [10 Hours]

Unit 4

Classification - Decision Tree, Support Vector Machine, Naïve Bayes, Neural networks model representation-Feed-forward network functions, Network training, Back-propagation algorithm. Clustering, Mixture densities, K-Means clustering, Expectation maximization, Spectral clustering. [10 Hours]

Unit 5

Application of machine learning in mechanical design, case studies in dynamics, fault analysis, system control, modeling, etc. [10 Hours]

<u>Laboratory Exercises</u>

- Write a program to import and export data
- Demonstrate various data pre-processing techniques for a given dataset
- Implement Dimensionality reduction techniques using Principle Component Analysis (PCA) method.
- Write a program to demonstrate various Data Visualization Techniques.
- Implement Linear / Regularized Regression Models for the given data set.
- Develop a Decision Tree Classification model for a given dataset and use it to classify a new sample.
- Implement Naïve Bayes Classification
- Build a KNN Classification model for a given dataset.
- Build an Artificial Neural Network model with back-propagation on a given dataset.
- Write a program to implement the K-Means/Spectral clustering Algorithm.
- Build an Artificial Neural Network model with back-propagation on a given dataset.
- Discuss the application of Reinforcement learning and Deep learning for a Mechanical Engineering application.

Textbooks:

1. T. Hastie, R. Tibshirani, J. Friedman. The Elements of Statistical Learning, 2e, 2008.
2. Christopher Bishop. Pattern Recognition and Machine Learning. 2e.

Reference Books:

1. E. Alpaydin, *Introduction to Machine Learning*, 3rd Edition, Prentice Hall (India) 2015.
2. R. O. Duda, P. E. Hart, and D. G. Stork, *Pattern Classification*, 2nd Edn., Wiley India, 2007.
3. C. M. Bishop, *Pattern Recognition and Machine Learning (Information Science and Statistics)*, Springer, 2006.
4. S. O. Haykin, *Neural Networks, and Learning Machines*, 3rd Edition, Pearson Education (India), 2016

S5

23LSE301	LIFE SKILLS FOR ENGINEERS III	L-T-P-C: 1-0-2-2

Pre-requisite: Willingness to learn, communication skills, basic English language skills, knowledge of high school level mathematics.

Course Objectives

- Help students understand corporate culture, develop leadership qualities and become good team players
- Assist them in improving group discussion skills
- Help students to sharpen their problem solving and reasoning skills
- Empower students to communicate effectively

Course Outcomes

CO1 - Soft Skills: To improve the inter-personal communication and leadership skills, vital for arriving at win-win situations in Group Discussions and other team activities.
CO2 - Soft Skills: To develop the ability to create better impact in a Group Discussions through examination, participation, perspective-sharing, ideation, listening, brainstorming and consensus.
CO3 - Aptitude: To identify, investigate and arrive at appropriate strategies to solve questions on geometry, statistics, probability and combinatorics.
CO4 - Aptitude: To analyze, understand and apply suitable methods to solve questions on logical reasoning.
CO5 - Verbal: To be able to use diction that is more refined and appropriate and to be competent in spotting grammatical errors and correcting them.
CO6-Verbal: To be able to logically connect words, phrases, sentences and thereby communicate their perspectives/ideas convincingly.

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01									3	3	2	3				
CO02										3	2	2				
CO03		3		2												
CO04		3		2						3		3				
CO05									3	3		3				

Syllabus

Soft Skills

Professional Grooming and Practices: Basics of corporate culture, key pillars of business etiquette – online and offline: socially acceptable ways of behavior, body language, personal hygiene, professional attire and Cultural adaptability and managing diversity. Handling pressure, multi-tasking. Being enterprising. Adapting to corporate life: Emotional Management (EQ), Adversity Management, Health consciousness. People skills, Critical Thinking and Problem solving.
Group Discussions: Advantages of group discussions, Types of group discussion and Roles played in a group discussion. Personality traits evaluated in a group discussion. Initiation techniques and maintaining the flow of the discussion, how to perform well in a group discussion. Summarization/conclusion.

Aptitude

Problem Solving III

Geometry: 2D, 3D, Coordinate Geometry, and Heights & Distance.
Permutations & Combinations: Basics, Fundamental Counting Principle, Circular Arrangements, and Derangements.
Probability: Basics, Addition & Multiplication Theorems, Conditional Probability and Bayes' Theorem.
Statistics: Mean, Median, Mode, Range, Variance, Quartile Deviation and Standard Deviation.
Logical Reasoning: Blood Relations, Direction Test, Syllogisms, Series, Odd man out, Coding \& Decoding, Cryptarithmetic Problems and Input - Output Reasoning.

Verbal
Vocabulary: Create an awareness of using refined language through idioms and phrasal verbs.
Grammar (**Upper Intermediate-Advanced**): Train Students to comprehend the nuances of Grammar and empower them to spot errors in sentences and correct them.
Reasoning: Enable students to connect words, phrases and sentences logically.
Oral Communication Skills: Aid students in using the gift of the gab to interpret images, do a video synthesis, try a song interpretation or elaborate on a literary quote.
Writing Skills: Practice closet tests that assess basic knowledge and skills in usage and mechanics of writing such as punctuation, basic grammar and usage, sentence structure and rhetorical skills such as writing strategy, organization, and style.

References:

1. Students" Career Planning Guide, Corporate & Industry Relations, Amrita Vishwa Vidyapeetham.
2. Soft Skill Handbook, Corporate & Industry Relations, Amrita Vishwa Vidyapeetham.
3. Adair. J., (1986), *"Effective Team Building: How to make * winning team"*, London, U.K
4. Gulati. S., (1006) "Corporate Soft Skills", New Delhi, India: Rupa & **Co.**
5. The hard truth about Soft Skills, by Amazon Publication.
6. Verbal Skills Activity Book, CIR, AVVP
7. English Grammar & Composition, Wren & Martin
8. Public Sector – Engineer Management Trainee Recruitment Exam (General English)
9. Nova's GRE Prep Course, Jeff Kolby, Scott Thornburg & Kathleen Pierce
10. Student Workbook: Quantitative Aptitude & Reasoning, Corporate & Industry Relations, Amrita Vishwa Vidyapeetham.
11. Quantitative Aptitude for All Competitive Examinations, Abhijit Guha.
12. How to Prepare for Quantitative Aptitude for the CAT, Arun Sharma.
13. How to Prepare for Data Interpretation for the CAT, Arun Sharma.
14. How to Prepare for Logical Reasoning for the CAT, Arun Sharma.
15. Quantitative Aptitude for Competitive Examinations, R S Aggarwal.
16. A Modern Approach to Logical Reasoning, R S Aggarwal.
17. A Modern Approach to Verbal & Non-Verbal Reasoning, R S Aggarwal.

Evaluation Pattern

Assessment	Internal	External
Continuous Assessment (CA)* – Soft Skills	30	-
Continuous Assessment (CA)* – Aptitude	10	25
Continuous Assessment (CA)* – Verbal	10	25
Total	50	50

*CA - Can be **presentations, speaking activities and tests.**

S5

23MEE381	HEAT TRANSFER AND INSTRUMENTATION & CONTROL SYSTEM LABORATORY	L-T-P-C: 0-0-3-1

Course Ojectives:
The course will enable the students to

- Tofamiliarize the concepts of conduction, convection and radiation heat transfer by conducting experiments
- To conduct experiments to compute the effectiveness of heat exchangers
- To demonstrate the phase change heat transfer-condensation and boiling
- Impart the principles of measurement using various sensors and transducers
- Familiarize with the static characteristics of measuring instruments
- Familiarize with the frequency and time domain analyses to determine stability

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Determine the thermal conductivity of insulating materials	Analyze
CO02	Determine the convective heat transfer coefficient in free and forced convective conditions	Analyze
CO03	Estimate the emissivity of real surfaces	Analyze
CO04	Estimate the rating of a heat exchanger, the rate of evaporation in boiling and rate of condensation heat transfer	Analyze
CO05	Make use of suitable sensors and transducers to measure the various parameters	Apply
CO06	Determine the static performance of measuring instruments	Analyze
CO07	Analyze the time and frequency response of the control systems	Analyze
CO08	Compare PID controller performance in level and flow control system, and linear inverted pendulum	Analyze

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3	3	2					1	1			3			
CO02	3	3	3	2					1	1			3			
CO03	3	3	3	2					1	1			3			
CO04	3	3	3	2					1	1			3			
CO05	3	3	2	2	2				1	1		1	3			1
CO06	3	3	2	2	1				1	1		1	3			1
CO07	3	3	2	2	1				1	1		1	3			1
CO08	3	3	2	2	1				1	1		1	3			1

Syllabus

a) Heat Transfer:

Introduction and Basic Concepts: Thermodynamics and Heat Transfer, heat and other forms of energy, Heat Transfer Mechanism: Conduction, Convection and Radiation –fundamental equations, Simultaneous heat transfer mechanisms.

Heat conduction equation: General heat conduction equation – One dimensional steady state equation - boundary and initial conditions- Heat generation in solids- generalized thermal resistance network – critical radius of insulation, Variable thermal conductivity, thermal contact resistance Extended surface heat transfer: Governing equation, boundary conditions, Performance of fins – efficiency and effectiveness, proper length of the fin, Types of fins: Pin fin, rectangular, Parabolic and annular fins.

Unsteady heat conduction analysis: Lumped mass analysis with temporal effects – Governing equations - Biot number significance. Heat Conduction in Large Plane Walls, Long Cylinders, and Spheres with both Spatial and temporal Effects –Governing equations - Graphical Solution - Fourier number significance.
Convective heat transfer: Boundary layer theory – physical mechanism of convection – Governing equation, Analogy between momentum and heat transfer: Reynolds analogy and Chilton Colburn analogy. Dimensionless numbers – Nusselt number, skin friction coefficient, Stanton number, Prandtl number, Reynolds number, Grashoff Number – Significance.
Forced Convection: External flows - Flow over flat plates, cylinders and spheres. Flow over tubes and bank of tubes, Internal Flows – flow through circular and non-circular.
Natural convection: External surface Combined natural and forced convection
Phase change heat transfer: Condensation and boiling.
Fundamental of Radiation: Thermal radiation and basic laws of radiation: Stefan-Boltzmann Law, Wien's displacement law and Planck's Law, radiation intensity, solid angle, irradiation and radiosity, radiation properties- emissivity, absorptivity, transmissivity and reflectivity, atmospheric and solar radiation: greenhouse effect Radiation Heat Transfer: Shape factor- diffuse and gray surfaces. Radiative heat transfers between two and three enclosures, Radiation shield.
Heat Exchangers: Types of heat exchangers: parallel flow, counter flow, cross flow, shell and tube, and compact heat exchanger. Overall heat transfer coefficient, fouling factor.
Analysis of Heat Exchanger: LMTD and ε-NTU methods.

b) Instrumentation and Control Systems:
Measurements and measuring systems: Fundamentals of measurement systems, Classification of measurement systems, Performance Characteristics, Errors in measurements, Uncertainty analysis, Regression analysis, Signal processing (operational amplifiers, and filters) and Signal conditioning (ADC and DAC), Wheatstone bridge.
Sensors/Transducers: Pressure Measurement-Elastic transducers, Bourdon gauge, Bellows and Diaphragm. Flow Measurement- Turbine meter, hot-wire anemometer and Laser Doppler anemometer. Level Measurement-Float gauge, Capacitive and ultrasonic level sensors. Temperature Measurement-Thermometer, thermistor, Thermocouple, RTD and Pyrometer. Strain Measurement-Strain gauge.
Control systems: Introduction to control systems, Types of control systems, modeling of simple mechanical and electrical systems, transfer functions, block diagrams and its reduction techniques, signal flow graphs. Time response characteristics of control systems, Time response of first order systems- response to step, ramp and impulse, Time response of second order system to step input- time domain specifications and steady state error.
Stability analysis: Stability analysis of control Systems-Concept of poles and zeros, Routh-Hurwitz criterion and Root locus technique. Frequency Response- Frequency response specifications, Bode diagram and Gain & Phase Margin. Lag-Lead Compensation. Basic control actions- Introduction to PI, PD and PID controllers, Design of a PID controller with Ziegler-Nichols rule with application.

Reference Books:

1. Yunus A Cengel & Afshin J. Ghajar, "Heat Transfer and Mass Transfer – Fundamentals & Applications", 5/e, McGraw-Hill., 2017.
2. Frank P. Incropera & David P DeWitt, "Fundamentals of Heat and Mass Transfer", 7/e, John Wiley and Sons, 2011.
3. Doebelin's E.O., and Manik D.N., "Doebelin's Measurement Systems", 6th Edition, McGraw Hill Education, 2011.
4. Katsuhiko Ogata, "Modern Control Engineering", 5th Edition, Pearson Education, New Delhi, 2010.

List of Equipment required for meeting the COs

a) Heat Transfer Laboratory

1. Composite wall apparatus
2. Natural Convection apparatus
3. Forced Convection apparatus
4. Emissivity apparatus
5. Stefan-Boltzmann apparatus
6. Pin-Fin apparatus
7. Parallel and counter flow apparatus

8. Shell and tube Heat exchanger apparatus
9. Drop wise and film wise condensation apparatus
10. Jacketed Kettle evaporator apparatus

b) Instrumentation and Control Laboratory

1. Linear and rotary potentiometer
2. Linear variable differential transformer (LVDT)
3. Load cell
4. Resistance temperature detector, Thermocouple, Bimetallic thermometer
5. Photoelectric sensor, Capacitive and Inductive transducer
6. Stroboscope and optical encoder
7. Dead weight tester
8. Photo elasticity
9. NI DAQ system
10. Accelerometer
11. Flow and level control system
12. Linear inverted pendulum
13. DC motor speed control

List of Exercises

S.No	**List of Exercises**	**CO mapping**
Heat Transfer Laboratory		
1	Determine the thermal conductivity of metal rod and composite wall.	CO01
2	Determine the heat transfer coefficient in free and forced convection.	CO02
3	Performance test on extended surfaces.	CO02
4	Verification of Stefan-Boltzmann constant.	CO03
5	Determine the emissivity of a test plate.	CO03
6	Performance test on heat exchangers-double pipe, shell-tube and single effect evaporator.	CO04
7	Determination of heat transfer coefficient in condensation heat transfer using drop wise and film wise condensation.	CO04
Instrumentation and Control Laboratory		
1	Linear and angular displacement measurement using inductive (LVDT) and resistive (potentiometer) transducer with DAQ system	CO05/CO06
2	Determination of modulus of elasticity, measurement of force and torque using load cell	CO05/CO06
3	Rotational speed measurement using Photo electric, Capacitive, Inductive, stroboscope and Optical encoder	CO05/CO06
4	Temperature measurement using RTD, TC sensors, thermistor, thermocouple, bimetallic thermometer and monitoring DAQ system.	CO05/CO06
5	Calibration of pressure gauge using dead weight tester.	CO05/CO06
6	Study of stress concentration using photo-elasticity for simple machine components.	CO06
7	Measurement of vibration in motor assembly using accelerometer and find the frequency components	CO05/CO06
8	PID control of level and flow control systems.	CO08
9	DC speed motor control	CO08
10	Stability of linear inverted pendulum system	CO08
11	Time domain and frequency domain response plots of systems for test signals (using MATLAB Program)	CO07
12	Determine system stability of the control system (using MATLAB Program)	CO07

S5

23MEE382	KINEMATICS AND DYNAMICS LABORATORY	L-T-P-C: 0-0-3-1

Course Objectives

The course will enable the students to

- Perform kinematic analysis of various mechanism using software package
- Demonstrate of various mechanism using the kinematic Tool kit
- Demonstrate experiments on free and forced vibrations of single and two degrees of translational and rotational systems
- Familiarize students with measurement of moment of inertia and center of gravity of complex objects
- Provide an exposure to governors and gyroscope
- Demonstrate balancing of rotating and reciprocating masses

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Model and analyze planar mechanisms using software package	Analyze
CO02	Create an assembly and demonstrate the various mechanism using the Tool kit	Apply
CO03	Determine the natural frequency, damping, critical speeds in translational and rotating dynamical systems	Analyze
CO04	Analyze free and forced vibration of single and two degree of freedom dynamical system with and without damping	Analyze
CO05	Determine moment of inertia and center of gravity of complex objects	Evaluate
CO06	Construct the characteristic plots for different types of governors	Evaluate
CO07	Evaluate the working of a gyroscope and measure the gyroscopic couple	Evaluate
CO08	Analyze and implement the balancing of rotating and reciprocating masses	Analyze

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3	2	1	2				1	2		1	2	1		
CO02	3	3	2	1	2				1	2		1	3	1		
CO03	3	2	2	1	2				1	2		1	2	1		
CO04	3	2	2	1	2				1	2		1	2	1		
CO05	3	2	2	1	2				1	2		1	2	1		
CO06	3	2	2	1	2				1	2		1	2	1		
CO07	3	2	2	1	2				1	2		1	2	1		
CO08	3	3	2	1	2				1	2		1	2	1		

Syllabus

a) Kinematics:

Introduction - Basic definitions in kinematics – Mobility - Classification of linkages, kinematic pairs, and mechanisms – Open-loop and closed-loop mechanisms – Grashof's law – Inversions of four-bar, slider-crank and double-slider mechanisms

Analysis of planar mechanisms–Graphical approach for displacement, velocity, and acceleration analyses of planar mechanisms with up to six linkages. Coriolis's component of acceleration–Quick return mechanism. Analytical approach – Loop closure method for planar mechanisms– Formulation of equations and their numerical solution–displacement, velocity, and acceleration analyses.

Cam design–displacement diagram–standard cam motions–graphical layout of cam profiles–analysis of cam motion–correlation with the motion of inlet and exhaust valves of an IC engine.

Dimensional synthesis of mechanisms – Graphical methods of synthesizing a four-bar mechanism.

b) Dynamics:

Static force analysis – conditions for equilibrium – static force analysis of four bar and slider crank mechanism – effect of friction.

Dynamic force analysis – Centroid and center of mass – mass moments and products of inertia – Alembert's principle – Principle of superposition.

Flywheels and Turning moment diagrams – coefficient of fluctuation of speed.

Balancing–Static unbalance–Dynamic unbalance–Analysis of unbalance - balancing machines.

Vibration of single degree of freedom systems–undamped and damped free vibrations - natural frequency–logarithmic decrement. Forced vibrations harmonic response–resonance–frequency response plot–magnification factor and phase angle. Support harmonic excitation–vibration isolation.

Reference Books:

1. Uicker, John Joseph, Gordon R. Pennock, and Joseph Edward Shigley. Theory of Machines and Mechanisms. Oxford University Press, 2011.
2. Norton, Robert L. Kinematics and Dynamics of Machinery. McGraw-Hill Higher Education, 2011.

List of Equipment required for meeting the COs

a) **Kinematics**
- Kinematic analysis using software package
- Kinematic Tool kit

b) **Dynamics**
- Undamped and damped free vibration
- Damped forced vibration
- Torsional free vibration
- Free and forced vibration of equivalent spring mass system
- Radius of gyration of a compound pendulum
- Moment of inertia of a connecting rod
- Gyroscope
- Whirling of a shaft
- Different types of governors
- Balancing of rotating mass
- Balancing of reciprocating mass
- Dunkerley's setup

List of Exercises

S.No.	List of Exercises	CO mapping
1	Modelling and analysis of slider crank and four bar mechanism and its inversions	CO01
2	Modelling and analysis of six bar chains	CO01
3	Modelling and analysis of crank and slotted lever and Whitworth quick return mechanism	CO01
4	Modelling and analysis of cam mechanism	CO01
5	Modelling and analysis of practical mechanisms and demonstration of mechanism using the kinematic Tool kit	CO02
6	Undamped and damped free vibration of a translational system	CO04
7	Undamped and damped free vibration of a rotational system	CO04
8	Undamped free vibration of two degree of freedom spring mass system	CO04
9	Undamped and damped forced vibration of equivalent spring mass system	CO04
10	Determination of radius of gyration of a compound pendulum and determination of moment of inertia of a connecting rod	CO05
11	Demonstration of whirling of a shaft and study of governors	CO03/CO06
12	Verification of a Dunkerley's rule and study of Gyroscope	CO03/CO07
13	Balancing of rotating mass	CO08
14	Balancing of reciprocating mass	CO08

S5

23MEE383	FLUID MECHANICS AND MACHINERY LABORATORY	L-T-P-C: 0-0-3-1

Course Objectives

The course will enable the students to

- Experimental methods to find fluid properties
- Hydrostatic force acting on submerged or partially submerged bodies,
- Method of checking the stability of the floating body
- Visualize flow patterns over a streamlined and bluff bodies.
- Experimental measurement of flow rate, pumping power of fluid flow through duct and reaction force of jet impact
- Performance characteristics of pumps and turbines

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Calculate the drag force of the fluid flow using the viscosity of the fluid.	Understand
CO02	Determine the hydrostatic force and centre of pressure for the fully and partially submerged body	Apply
CO03	Investigate the stability of the floating body using metacentric height	Analyze
CO04	Visualize flow pattern on different geometries using Hele-Shaw apparatus	Analyze
CO05	Evaluate the reaction force of the given surface using momentum principle	Analyze
CO06	Measure flow rate using different flow obstruction meters	Apply
CO07	Estimate the pumping power of the fluid by accounting major and minor losses	Analyze
CO08	Characterize the performance of various pumps & turbines	Analyze
CO09	Follow standard operating procedures and codes & practices for conduct of the experiments	Apply
CO10	Interpret the experimental findings and communicate efficiently	Analyze

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3	2	1		1		1	1	3			2			
CO02	3	3	2	1		1		1	1	3			2			
CO03	3	3	2	1		1		1	1	3			2			
CO04	3	3	2	1		1		1	1	3			2			
CO05	3	3	2	1		1		1	1	3			2			
CO06	3	3	2	1		1		1	1	3			2			
CO07	3	3	2	1		1		1	1	3			2			
CO08	3	3	2	1		1		1	1	3			2			
CO09	3	3	2	1		1		1	1	3			2			
CO10	3	3	2	1		1		1	1	3			2			

Syllabus

a) Fluid Mechanics:

Fluid properties: density, specific gravity and viscosity
Hydrostatics: hydrostatic force on plane surfaces and inclined surfaces
Stability of floating body: Meta centric height
Fluid Kinematics: flow visualization – streamlines and streak lines
Fluid dynamics: momentum – Impact of jet, Bernoulli's equation, energy equation – losses in pipes
Flow measurement: venturimeter, orifice meter, notches and mouthpiece

b) Fluid Machines:
Study of Performance Characteristics of Pumps & Turbines:
Pumps: centrifugal pump – single and multistage pump, series and parallel pumps, submersible pump, jet pump, reciprocating pump and gear pump.
Turbines: Pelton wheel – impulse turbine, Francis Turbines and Kaplan turbine – reaction turbine.

Reference Books:

1. Damodara Reddy Annapureddy, "Fluid Mechanics and Hydraulic Machines Lab Manual", 1/e, LAP Lambert Academic Publishing, 2012
2. Kumara Swamy N., "Fluid Mechanics and Machinery Lab Manual", 1/e, Charotar Publishing House Pvt. Ltd., 2008

List of equipment required for meeting the COs
a) Fluid Mechanics
1. Falling ball viscometer
2. Centre of pressure apparatus
3. Metacentric height apparatus
4. Hele-shaw apparatus
5. Impact of jet setup
6. Bernoulli's experimental setup
7. Flow obstruction meters – venturimeter, orificemeter, mouthpiece and v-notch
8. Internal flow – pipe

b) Fluid Machinery
1. Multistage pump- series and parallel pump
2. Gear pump
3. Reciprocating pump
4. Submersible pump
5. Jet pump
6. Pelton wheel
7. Francis turbine
8. Kaplan turbine

List of Exercises

S.No.	List of Exercises	CO mapping
1	To determine the viscosity of the given oil	CO01/CO09/ CO10
2	To determine the centre of pressure and hydrostatic force on submerged and partially submerged body for a plane and inclined surface	CO02/CO09/ CO10
3	To determine the metacentric height of the floating body	CO03/CO09/ CO10
4	To visualize the flow patterns over streamlined and bluff bodies	CO04/CO09/ CO10
5	To determine the reaction force of the flat/curved surface using conservation of momentum principle	CO05/CO09/ CO10
6	To verify the conservation of energy experimentally using Bernoulli setup	CO06/CO09/ CO10
7	To verify the coefficient of discharge for the various flow obstruction meters – orificemeter, venturimeter, mouthpiece and notches	CO06/CO09/ CO10
8	To estimate the pumping power of the fluid by accounting major and minor losses.	CO07/CO09/ CO10
9	To evaluate the efficiency of various pumps & turbines and its performance curve – Multistage pump, gear pump, submersible pump, reciprocating pump, jet pump, Pelton wheel, Francis turbine, Kaplan turbine	CO08/CO09/ CO10

S6

SEMESTER 6

23MEE311	FINITE ELEMENT METHODS	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- To impart the fundamentals of finite element methods and underlying principles
- To understand the various finite elements and their properties
- To derive the interpolation models and element matrices for different finite elements
- To understand the application of finite elements in solving different field problems

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Understand the basic concept of finite element method and distinguish from classical methods	Understand
CO02	Discretize the domain using finite elements and develop interpolation models	Apply
CO03	Formulate finite element equations using direct, variational, and weighted residual approaches	Analyze
CO04	Apply the finite element technique to solve structural, fluid, and thermal problems.	Apply
CO05	Interpret the solutions of finite element analysis.	Analyze

CO-PO Mapping: [affinity$^{\#}$: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2	1							1			3	1	1	
CO02	2	3	3							1			3	1	1	
CO03	2	2	3							1			2	1	1	
CO04	1	2	3	1	1	2				1			2	1	1	
CO05	2	2	2	1	1					1			1	1	1	

Syllabus

Unit 1

Introduction to finite element method: Basic concept, brief historical development, general description and procedure of FEM, boundary conditions, comparison of FEM with classical methods and finite difference methods, convergence, applications of FEM, commercial FEM software, responsibility of the user [4 hours]

Discretization: Types of finite elements, discretization considerations, coordinate systems, automatic mesh generation, techniques to save computer memory. [4 hours]

Unit 2

Interpolation models: Types of interpolation models, mesh refinement, polynomial form of interpolation models, simplex-complex-multiplex elements, interpolation polynomial in terms of nodal degrees of freedom, selection of order of interpolation polynomial, convergence requirements, linear interpolation model in global and local coordinates, higher order and isoparamatric elements. [9 hours]

Unit 3

Derivation of element matrices and assembly: Direct approach, variational approach – Rayleigh-Ritz method, weighted residual method – collocation method, subdomain method, Galerkin method, least squares method. Numerical integration – Gaussian quadrature. [12 hours]

Unit 4

Applications: Solid mechanics – spring and bar elements, truss problems, beam elements; 2D problems – Plane stress, plane strain and axisymmetric problems, Dynamic analysis problems. Heat transfer – one- and two-dimensional problems. [16 hours]

Textbooks:

1. Rao, S.S., “The Finite Element Method in Engineering”, 6/e, Butterworth-Heinemann Publisher, 2018.
2. Hutton, D.V., “Fundamentals of Finite Element Analysis”, McGraw-Hill, 2017.
3. Logan, D.L., “A First Course in the Finite Element Method”, 5/e, Cengage Learning, 2012.

Reference Books:

1. Chandrupatla, T.R., and Belegundu, A.D., “Introduction to Finite Element in Engineering”, 4/e, Prentice Hall of India Pvt. Ltd.’, New Delhi, 2012.
2. Cook, R.D., Malkus, D.S., and Plesha, M.E., “Concepts and Application of Finite Element Analysis”, 4/e, John Wiley & Sons, 2007.
3. Bathe, K.J., “Finite Element Procedures”, Prentice Hall, 1996.

23MEE312	DESIGN OF MACHINE ELEMENTS II	L-T-P-C: 2-1-0-3

Course Objectives

The course will enable the students to

- Impart knowledge in fundamental concepts and apply engineering principles for the design of machine elements in mechanical systems.
- Introduce standards and codes for design of machine elements.
- Inculcate design principles for identifying and designing of various power transmission system and friction drives
- Develop the knowledge of design, drawing, modelling and analysing.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Select the type of bearing and estimate the size based on load carrying capacity in rotating machines	Apply
CO02	Select and Design suitable power transmission systems for specific applications	Apply
CO03	Design multi-stage and epicyclic gearbox for machine tool and automotive applications	Apply
CO04	Design brakes and clutches for suitable applications	Apply
CO05	Validate the design of machine elements using numerical analysis	Analyse

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3	3	1	1	2	1	2		1			2	2		
CO02	3	3	3	1	1	2	1	2		1			2	2		
CO03	3	3	3	1	1	2	1	2		1			2	2		
CO04	3	3	3	1	1	2	1	2					2	2		
CO05	3	3	3	1	2	2	1	2	2	2	2	1	2	2	1	

Syllabus

Unit 1

BEARINGS

Lubrication: Types, Properties of lubricants, Bearings: Introduction, Viscosity, Classification, Hydrodynamic & Hydrostatic Lubrication, Pressure distribution - eccentricity and minimum film thickness, Thick & Thin film lubrication, Bearing materials.

Journal bearings (Sliding contact bearing): Bearing characteristic numbers, Petroff's equation, Sommerfeld number, Mckee's equation, Journal bearings design.

Rolling Contact Bearings: Types, Static & Dynamic load carrying capacity, Reliability, Selection of antifriction bearings for Static & Dynamic conditions, Selection of antifriction bearings for constant and varying loads.

Unit 2

FLEXIBLE TRANSMISSION SYSTEM

Introduction, Classification & Application of flexible power transmission systems,

Belt Drives:

Flat belt drives: Types, belt configuration, velocity ratio, slip & creep, condition for maximum power transmission, length of open and cross belt drives, fast and loose pulleys, centrifugal tension, initial tension, selection of belts, flat belt pulleys.

V-belt: Designation of V-belt, Advantages and Disadvantages of V-belt drives, Selection of V-belt.

Rope Drives: Types, Designation of wire rope, Length of wire rope, factor of safety, Stresses in hoisting wire ropes, Selection of wire ropes.
Chain drives: Introduction, Terms used in chain drives, Classification, Conveyor chains, Power transmitting chains, Roller chains, Factor of Safety for chain drives, Selection of chain drives. [10 Hours]

Unit 3

RIGID DRIVES

GEAR DRIVES: Types, Advantages, Applications and Gear Terminology, Gear Trains: simple, compound and epicyclic gear trains.
Spur Gears: Law of gearing, conjugate action and interference in gears, Gear tooth profiles, Influence of number of teeth and pressure angle, Gear tooth failure modes, beam strength of gear tooth **-** Lewis equation, Gear materials, Force analysis, Design for strength, Dynamic and wear load.
Helical gears: Applications, Herringbone gear, Virtual number of teeth on helical gears, Force analysis, Design of helical gears.
Bevel & Worm Gears: Nomenclature, Types and applications. [10 Hours]

Unit 4

GEAR BOX: Types of gear box, sliding mesh gear box, progression ratio, speed/ray diagram, kinematic arrangement of gear box, design of multi stage, multi speed gear boxes, study of working principle of automatic gear box. [08 Hours]

Unit 5

FRICTION DRIVES

Clutches: types, Uniform pressure and wear theories, single plate, multi plate, centrifugal and cone clutches. **Brakes**: types, self-energizing and self-locking, design of shoe (single and double), band, differential band brakes, internally expanding brakes, and Disc brakes.

Project Component:

At the end of the course, student should complete a design project based on the knowledge gained in the design, drawing and analysis related courses. The students should design a mechanical system involving identification of mechanical parts, material selection, detailed design, drawing, modelling and validation using numerical analysis. Finally prepare a report and present the details of the project.
The evaluation components include periodic review of various elements like design, drawing, modelling, analysis, project report and presentation. [10 Hours]

Textbooks:

1. Bandari V.B, “Design of Machine Elements”, Tata McGraw Hill Publishers Co. Ltd., New Delhi, 2010

Reference Books:

1. Shigley and Mische, “Mechanical Engineering Design”, McGraw Hill, Inc., New Delhi, 2003.
2. Robert L. Norton, Design of Machinery, McGraw-Hill College; 6th edition, 2019
   Design Data Book,
3. Maleev and Hartman’s, “Machie Design”, CBS Publishers & Distributiors, 6th edition, 2015

23MEE313	INDUSTRIAL AUTOMATION	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- Building the fundamentals of fluid power system
- Impart knowledge of circuit design for industrial application
- Developing design skills for PLC programming
- Provides theoretical and practical aspects of implementing automation in the industry

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Analyze the performance of the pump and actuators	Analyze
CO02	Design the hydraulic and electro-hydraulic circuit for the given application	Apply
CO03	Familiarize with fluid conditioning elements and control valves	Apply
CO04	Design a pneumatic and electro-pneumatic circuit with single and multi-cylinders for the given application	Apply
CO05	Design a circuit with MPL device	Apply
CO06	Perform PLC programming for the given application	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2	3									2	2			1
CO02	3	2	3									2	2			1
CO03	3	2	3		2							2	2			1
CO04	3	2	3		2							2	2			1
CO05	3	2	3		2							2	2			1
CO06	3	2	3		2							2	2			1

Syllabus

Unit 1

Hydraulics: Fluid properties, Pascal's Law and applications, Fluid power symbols, Hydraulic pumps, Sizing of Pumps, Pump Performance, Characteristics, and Selection. Actuators, Sizing of actuators. Control valves - Direction, pressure, and flow control valves. Application circuits. Hydraulic Proportional Valves and Servo valves. Accumulator- types, application circuits. [9 Hours]

Unit 2

Pneumatics: Gas laws, Preparation of air, Fluid-conditioning elements, Actuators, Sizing of Actuators, Control valves: Direction, pressure, Flow control valves, shuttle valve, and Time delay valve. Development of single and multiple actuator circuits. Valves for logic functions; Exhaust and supply air throttling, Cascade method, step–counter method. [9 Hours]

Unit 3

Electro hydraulics and Electro-pneumatics: Electro-Hydraulics: Two-hand safety circuit, Pressure Intensifier circuit, Regenerative circuit. Electro-pneumatic circuit design, Application of Material handling and stamping system, Fluidics, MPL devices. Circuits using Fluid logic devices and applications. [9 Hours]

Unit 4

PLC: Introduction, Types of PLC, CPU unit architecture, Memory classification, Input/output devices and their interfacing, Digital-Analog modules, Communication modules, Special function modules, Basic Ladder logic, electrical wiring diagram, scan cycle. Programming languages for PLC, PLC module addressing, registers basics, basic relay instructions, timer-counter instructions, logical operations, Math functions, data handling, and program control instructions. Introduction to SCADA. [9 Hours]

Unit 5

Applications: Industrial application circuits: Hydraulics, pneumatics, Low-cost automation, Robotic process automation, Application of PLC in fluid power circuit design, System maintenance, Failure and troubleshooting in Fluid Power Systems. [9 Hours]

Textbooks:

1. Antony Esposito, "Fluid Power with Applications", Pearson, Seventh Edition., 20103.
2. W. Bolton, "Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering" - Prentice-Hall - 2013 - 5th Edition

Reference Books:

1. Sullivan James A., "Fluid Power - Theory and Applications", Fourth Edition, Prentice-Hall International, New Jersey, 1998.
2. Watton, John. Fundamentals of fluid power control. Vol. 10. Cambridge University Press, 2009.
3. Petruzella, Frank D. Programmable logic controllers. Fourth Edition, Tata McGraw-Hill Education, 2010.

S6

23MEE384	INDUSTRIAL AUTOMATION LABORATORY	L-T-P-C: 0-0-3-1

Course Objectives

The course will enable the students to

- Developing design skills in circuit design
- Gaining practical experience in PLC programming

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Design a hydraulic and electro-hydraulic circuit	Apply
CO02	Design and testing of pneumatic and electro-pneumatic circuit	Apply
CO03	Design and testing of electro-pneumatic circuit	Apply
CO04	Develop a PLC program for the given application	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2	2	1	2					1		1	1			1
CO02	3	2	2	1	2					1		1	1			1
CO03	3	2	2	1	2					1		1	1			1
CO04	3	2	2	1	2					1		1	1			1

Syllabus

Automation: Introduction to the Fluid power system, components, Symbols, Valves, circuit design, Hydraulic, Pneumatic, Electro-Hydraulic, Electro-pneumatic circuit design, and PLC Programming.

Reference Books:

1. Laboratory Manuals
2. Antony Esposito, *"Fluid Power with Applications", Pearson, Seventh Edition. 20103.*
3. Petruzella, Frank D. *Programmable logic controllers. Fourth Edition, Tata McGraw-Hill Education, 2010*

List of Equipment required for meeting the COs

1. Automation Studio V7 Software / FluidSim V6.1
2. Basic Pneumatic Trainer kit
3. Basic Electro-Pneumatic Trainer kit
4. Add on PLC Trainer kit
5. Modular Production System (MPS) with two stations

List of Exercises

S.No.	List of Exercises	CO mapping
1	Design and simulate the hydraulic circuit with control elements.	CO1
2	Design and simulate an electro-hydraulic circuit for industrial application.	CO1
3	Design and simulate the pneumatic circuit with control elements.	CO2
4	Design, simulate and test a pneumatic circuit for multi-cylinder sequences.	CO2
5	Design, simulate and test a sequential circuit using the cascade method.	CO2
6	Design and simulate multiple cylinder sequential circuits using the cascade method.	CO2
7	Design, simulate and test an electro-pneumatic circuit.	CO3
8	Design, simulate and test an electro-pneumatic circuit using PLC.	CO3, CO4
9	Design a Mechatronics system for sorting stations using MPS with PLC.	CO4
10	Design a Mechatronics system for a distribution station using MPS with PLC.	CO4

S6

23MEE314	METROLOGY AND COMPUTER AIDED INSPECTION	L-T-P-C: 1-0-3-2

Course Objectives

The course will enable the students to

- To impart knowledge of various measuring instruments, and calibration procedures and analyze the results of measurements using process control charts.
- To understand the usage of sine bar, comparator, bore gauge, profile projector, and floating carriage micrometer for various measurements.
- To familiarize the measurement of form features using an optical autocollimator, runout setup, and demonstration of surface roughness measurement using a mechanical stylus instrument.
- To impart knowledge on the fundamentals of high-precision measurements using a Coordinate Measuring Machine (CMM)
- To facilitate an understanding of the functioning and applications of a machine vision system for quality control.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Calibrate the basic instruments to find the error and incorporate the errors during measurement.	Apply
CO02	Analyze the results of component feature measurements with the usage of control charts.	Analyze
CO03	Select the appropriate linear and angular measuring instruments to measure the intricate features of a machined component.	Apply
CO04	Measure the geometrical form features of machined features.	Apply
CO05	Measure the various features of a machined component using the CMM.	Apply
CO06	Apply machine vision and image processing techniques to perform online quality control.	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2	1	1	2	1		1	1	1		2	1			1
CO02	3	2	1	1	2	1		1	1	1		2	1			1
CO03	3	2	1	1	2	1		1	1	1		2	1			1
CO04	3	3	1	1	3	1		1	1	1		3	1			1
CO05	3	3	1	1	3	1		1	1	1		3	1			1
CO06	3	3	1	1	3	1		1	1	1		3	1			1

Syllabus

Unit 1

Metrology: Definition and concept of Metrology - need of Inspection – Measurement using vernier-caliper, micrometer, depth and inside micrometer, gear tooth vernier, height gauge, Dial gauge and slip gauge; Control charts and its usage. [3 hours]

Plug and hole gauges; Electrical and pneumatic comparators; Use of sine bar for taper measurement; Auto collimator and runout setup for form measurement. Working of profile projector, floating carriage micrometer , tool makers microscope and surface roughness measurement. [3 hours]

Unit 2

Coordinate Measuring Machine (CMM): CMM & its types: CMM probing system; contact and non-contact probing types; CMM software; Reverse engineering, and application. [3 hours]

CMM programming techniques. Subroutines for shapes and geometric form/positional relationships; multiple circles, spheres, cylinders, cones, multiple lines, perpendicularity, and parallelism of two lines and planes. Example program for determining the center and diameter of a drilled hole. [3 hours]

Unit 3

Machine vision system and online quality control: Introduction: Image Acquisition and Processing - Binary and gray level images, image segmentation and labeling, representation, and interpretation of colors. Edge detection techniques, Normalization, Greyscale correlation Reflectance map concepts. [3 hours]

Application of Machine Vision in inspection - Measurement of length, and diameters. Automated visual inspection - 3D and dynamic feature extraction. Online Quality Control: Data acquisition systems with various sensors for online quality control. Inspection based on color, pattern, and combined with color and pattern. Template and pattern matching. [2 hours]

List of experiments:

1. Calibration of Micrometer using Slip Gauge.
2. Measurement of components features using various measuring instruments.
3. Plotting of $\overline{X}$-R Control Charts for two specific features of a component (Ex. Length and diameter of the bolt)
4. Calibration of Plain Plug Gauge using Electronic Comparator.
5. Checking the outside diameter tolerance of the rod using an Air Gauge Comparator.
6. Taper measurement using Sine bar.
7. Measurement of Chordal Tooth Thickness using Gear Tooth Vernier.
8. Measurement of Thread parameters using a Floating Carriage Micrometer.
9. Measurement of total composite error, tooth to tooth composite error, and backlash of Spur Gear using Gear Roller Tester.
10. Measurement of single-point cutting tool nomenclature and the given component feature using Profile Projector.
11. Measurement of miniaturized component features using Tool Makers Microscope.
12. Measurement of Cylinder Inner Diameter using Bore Gauge.
13. Measurement of shaft Runout using the setup of Bench Centre and Dial Indicator.
14. Measurement of form features using an Autocollimeter.
15. Measure the various features of a machined component using CMM.
16. Perform online quality control using a machine vision system.
17. Demonstration of surface roughness measurement using a Surface Roughness Tester.

List of equipment required:

1. Micrometer, Vernier caliper, Slip gauge, Height gauge, Dial gauge, sine bar, Plug gauge, Bore Gauge & Gear Tooth Vernier
2. Plain Plug Gauge using Electronic Comparator
3. Air Gauge Comparator
4. Floating Carriage Micrometer
5. Gear Roller Tester
6. Profile Projector
7. Tool Makers Microscope
8. Surface roughness measurement
9. Autocollimator (Straightness and parallality)
10. Coordinate Measuring Machine (CMM)
11. Machine vision system

Textbooks:

1. Bechwith-Marangoni-Lienhard, “Mechanical Measurements” Pearson Education India; 6th edition (2013)
2. Robert J. Hocken, Paulo H. Pereira– “Coordinate Measuring Machines and Systems” – CRC Press-Taylor & Francis group, Second edition (2011)
3. NelloZuech – “Understanding and Applying Machine Vision” - Marcel Dekker Inc. 2nd Edition (2000)

Reference Books:

1. Jay L. Bucher – “The Metrology Handbook”, 2nd Edition” – ASQ Measurement Quality Division (2012)
2. John A. Bosch, Giddings, and Lewis Dayton - ‘Coordinate Measuring Machines and Systems’ - Marcel Dekker – Taylor & Francis Inc. (1995).
3. Marshall A. D. and Martin R. R – “Computer Vision, Models and Inspection” World Scientific Series in Robotics and Intelligent Systems: Volume 4 (1992).

S6

23LSE311	LIFE SKILLS FOR ENGINEERS IV	L-T-P-C: 1-0-2-2

Pre-requisite: Self-confidence, presentation skills, listening skills, basic English language skills, knowledge of high school level mathematics.

Course Objectives

- Help students prepare resumes and face interviews with confidence
- Support them in developing their problem-solving ability
- Assist them in improving their problem solving and reasoning skills
- Enable them to communicate confidently before an audience

Course Outcomes

CO1 - Soft Skills: To acquire the ability to present themselves confidently and showcase their knowledge, skills, abilities, interests, practical exposure, strengths and achievements to potential recruiters through a resume, video resume, and personal interview.
CO2 - Soft Skills: To have better ability to prepare for facing interviews, analyse interview questions, articulate correct responses and respond appropriately to convince the interviewer of one's right candidature through displaying etiquette, positive attitude and courteous communication.
CO3 - Aptitude: To manage time while applying suitable methods to solve questions on arithmetic, algebra and statistics.
CO4 - Aptitude: To investigate, understand and use appropriate techniques to solve questions on logical reasoning and data analysis.
CO5 - Verbal: To use diction that is less verbose and more precise and to use prior knowledge of grammar to correct/improve sentences.
CO6 -Verbal: To understand arguments, analyze arguments and use inductive/deductive reasoning to arrive at conclusions. To be able to generate ideas, structure them logically and express them in a style that is comprehensible to the audience/recipient.

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01									3	3		2				
CO02								2	3	3		2				
CO03		3		2												
CO04		3		2						3		3				
CO05									3	3		3				

Syllabus

Soft Skills

Team Work: Value of teamwork in organizations, Definition of a team. Why team? Effective team building. Parameters for a good team, roles, empowerment and need for transparent communication, Factors affecting team effectiveness, Personal characteristics of members and its influence on team. Project Management Skills, Collaboration skills.
Leadership: Initiating and managing change, Internal problem solving, Evaluation and co-ordination, Growth and productivity, Importance of Professional Networking.
Facing an interview: Importance of verbal & aptitude competencies, strong foundation in core competencies, industry orientation / knowledge about the organization, resume writing (including cover letter, digital profile and video resume), being professional. Importance of good communication skills, etiquette to be maintained during an interview, appropriate grooming and mannerism.

Aptitude
Problem Solving II
Sequence and Series: Basics, AP, GP, HP, and Special Series.
Data Sufficiency: Introduction, 5 Options Data Sufficiency and 4 Options Data Sufficiency.
Logical reasoning: Clocks, Calendars, Cubes, Non-Verbal reasoning and Symbol based reasoning.
Campus recruitment papers: Discussion of previous year question papers of all major recruiters of Amrita Vishwa Vidyapeetham.
Competitive examination papers: Discussion of previous year question papers of CAT, GRE, GMAT, and other management entrance examinations.
Miscellaneous: Interview Puzzles, Calculation Techniques and Time Management Strategies.

Verbal
Vocabulary: Empower students to communicate effectively through one-word substitution.
Grammar: Enable students to improve sentences through a clear understanding of the rules of grammar.
Reasoning: Facilitate the student to tap his reasoning skills through Syllogisms, critical reasoning arguments and logical ordering of sentences.
Reading Comprehension (**Advanced**): Enlighten students on the different strategies involved in tackling reading comprehension questions.
Public Speaking Skills: Empower students to overcome glossophobia and speak effectively and confidently before an audience.
Writing Skills: Practice formal written communication through writing emails especially composing job application emails.

References:

1. Students" Career Planning Guide, Corporate & Industry Relations, Amrita Vishwa Vidyapeetham.
2. Soft Skill Handbook, Corporate & Industry Relations, Amrita Vishwa Vidyapeetham.
3. Adair. J., (1986), "Effective Team Building: How to make * winning team", London, U.K
4. Gulati. S., (1006) "Corporate Soft Skills", New Delhi, India: Rupa & Co.
5. The hard truth about Soft Skills, by Amazon Publication.
6. Verbal Skills Activity Book, CIR, AVVP
7. English Grammar & Composition, Wren & Martin
8. Public Sector – Engineer Management Trainee Recruitment Exam (General English)
9. Nova's GRE Prep Course, Jeff Kolby, Scott Thornburg & Kathleen Pierce
10. A Modern Approach to Verbal Reasoning – R.S. Aggarwal
11. Student Workbook: Quantitative Aptitude & Reasoning, Corporate & Industry Relations, Amrita Vishwa Vidyapeetham.
12. Quantitative Aptitude for All Competitive Examinations, Abhijit Guha.
13. How to Prepare for Quantitative Aptitude for the CAT, Arun Sharma.
14. How to Prepare for Data Interpretation for the CAT, Arun Sharma.
15. How to Prepare for Logical Reasoning for the CAT, Arun Sharma.
16. Quantitative Aptitude for Competitive Examinations, R S Aggarwal.
17. A Modern Approach to Logical Reasoning, R S Aggarwal.
18. A Modern Approach to Verbal & Non-Verbal Reasoning, R S Aggarwal

Evaluation Pattern

Assessment	**Internal**	**External**
Continuous Assessment (CA)* – Soft Skills	30	-
Continuous Assessment (CA)* – Aptitude	10	25
Continuous Assessment (CA)* – Verbal	10	25
Total	50	50

*CA - Can be **presentations, speaking activities and tests.**

23MEE385	COMPUTER AIDED ENGINEERING LABORATORY	L-T-P-C: 0-0-3-1

Course Objectives

The course will enable the students to

- To acquire a fundamental understanding of finite element modeling and analysis
- To understand the various steps involved in preprocessing and post-processing.
- To apply the basic principles of finite element methods to solve structural, thermal, fluid flow, and dynamic problems.
- To analyze the different practical field problems using finite element methods

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Create geometric part models, assemble, discretize, select element type and material properties, and apply loads and boundary conditions.	Apply
CO02	Solve and visualize the behavior of various designs on 2D/3D problems	Apply
CO03	Investigate the solutions on structural, thermal, fluid flow, and dynamic problems	Analyze
CO04	Solve practical field problems (structural / thermal / fluid-flow)	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3	2	1	2	1	1	1		1		1	3	2	1	
CO02	3	3	3	2	2	1	1	1		1		1	3	2	1	
CO03	3	3	3	3	2	1	1	1		1		1	3	2	1	
CO04	3	3	2	3	2	1	1	1		1		2	3	2	1	

Syllabus

Introduction to Finite Element packages and their application to solid mechanics, fluid flow, and heat transfer problems.

Model generation, Selection of material properties and element types– Line element (bar, truss, beam and frame element), Plane elements- Triangular, rectangular, quadrilateral, sector and Solid elements – Tetrahedron and hexahedron.

Structural applications – Problems based on line elements and two-dimensional stress analysis (Plane stress, plane strain, and axisymmetric analysis).

Three-dimensional Problems - Application to field Problems - heat transfer, dynamics and fluid flow problems (Transient and Steady state), Couple-Field analysis.

Text Books:

1. Rao, S.S., "The Finite Element Method in Engineering", 6/e, Butterworth-Heinemann Publisher, 2018
2. Logan, D.L., "A First Course in the Finite Element Method", 5/e, Cengage Learning, 2012
3. Moaveni, Saeed. "Finite element analysis theory and application with ANSYS", 3/e. Pearson Education India, 2011

List of Equipment required for meeting the Cos

1. Computers
2. Commercial FEM Package

List of Exercises

S.No.	List of Exercises	CO mapping
1	Bars a. Uniform cross section area, b. Tapered cross section area and Stepped bar	CO1, CO2
2	Plane and Space trusses – (Minimum 2 exercises of different types)	CO1, CO2
3	Beams and Frames a. Simply supported with point load, UVL, UDL b. Cantilever beam with point load, UVL, UDL c. Beams with different end conditions subjected to point load, UVL, UDL (Minimum 6 exercises of different nature)	CO1, CO2
4	Stress analysis of a rectangular plate with a circular hole	CO2, CO2
5	Thermal Analysis – 1D & 2D problem with conduction and convection boundary conditions (Minimum 4 exercises of different types)	CO3
6	Dynamic analysis of a) Fixed beam for natural frequency determination b) Bar subjected to forcing function c) Fixed beam subjected to forcing function	CO3
7	Practical Field problems in a) Structural, b) Thermal, c) Fluid Flow areas. (Minimum 3 exercises on each domain)	CO4

S6

23MEE315	INDUSTRIAL ENGINEERING	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- To inculcate the concepts of work study and its application to industrial practice
- Impart skills to design, develop, implement, and improve manufacturing/service systems
- To develop work system based on ergonomics principles
- To integrate industrial engineering tools and techniques with sustainable practices

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Create value to organizations through the analysis, evaluation, and improvement of work systems using work stud	Understand
CO02	Develop work systems through motion economy principles	Apply
CO03	Apply work measurement techniques to improve productivity, fix wages and incentives	Apply
CO04	Apply systematic layout planning techniques and workstation design principles based on ergonomics and material handling	Apply
CO05	Enable industry 4.0 based manufacturing and service systems through sustainable aspects of Industrial Engineering	Analyze

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	2	1	1	1						1		2	1			
CO02	2	1	2	1						1		2	1			
CO03	1	2		1							1	2	1			
CO04	2	2		1							2	2	1			
CO05		1	3	1		3	3	3			1	2	1			2

Syllabus

Unit 1

Introduction to Industrial Engineering. Work System: Elements of work, maintenance of machines, interaction, effect of working conditions and environment, physical and mental fatigue. Productivity: Productivity, factors affecting production, Production Planning and Control. Measurement of productivity. Plant location & layout: Concept of plant location & layout, types of layout; factors affecting plant layout. Work Study: Definition and scope of work study; Areas of application of work study in industry; Human aspects of work study. (13 Hrs)

Unit 2

Method Study: Information collection, recording techniques, and processing aids; critical examination; development, installation, and maintenance of improved methods. Motion Economy and Analysis: Principles of motion economy; Motion analysis; Micromotion and Memomotion study; Therbligs and SIMO charts. Work Measurement: Work measurement techniques; Calculation of standard time, work sampling and predetermined Motion time systems. Wages and Incentive Schemes: Introduction, wage payment of direct and indirect labour, wage payment plans and incentives, various incentive plans, incentives for indirect labour. (17 Hrs)

Unit 3

Ergonomics: Ergonomic Design of equipment and workplace. workstation design, factors considered in designing a workstation, ergonomic design standards - Study of development of stress in human body and their consequences. Material Handling: Introduction and functions of material handling equipment, selection of material handling equipment for different requirements, safety requirements. Recent advances in Industrial Engineering: Sustainable industrial engineering to develop industrial production for the future. Environmental, social, ethical, economic, and technical point of view of Sustainable Industrial Engineering for industry 4.0. Case Studies. (15 Hrs)

Textbooks:

1. Barnes, R, "Motion and Time Study" - Design and Measurement of Work. NY: John Wiley and Sons, 8th Edition, 1985.
2. "Introduction to Work Study", 4thedition, International Labour Office, Geneva, 2006.

Reference Books:

1. Martand T. Telsang, 'Industrial Engineering and Production Management' S Chand; second Rev Edn 2006.
2. Mahajan M., "Industrial Engineering and Production Management" Dhanpat rai and Sons Publishers, 2005
3. Sustainable Industrial Engineering Along Product-Service Life Cycle/Supply Chain. (2021). Switzerland: MDPI AG.

SEMESTER 7

23MEE401	OPERATIONS RESEARCH	L-T-P-C: 2-0-3-3

Course Objectives

The course will enable the students to

- Establishing capabilities in the students for analysing different situations in the real scenario involving limited resources and finding the optimal solution within constraints.
- Analysing managerial and engineering problems to equip the students to use the resources such as capitals, materials, productions, controlling, directing, staffing, and machines more effectively.
- Developing problem formulation skills and finding solutions using various techniques/algorithms
- Understanding the basics of project management techniques, decision models, inventory models, sequencing problems, queuing models
- Developing discrete event simulation models of a manufacturing environment

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Formulate operations research models to optimize resources.	Apply
CO02	Solve transportation and assignment problems using suitable techniques.	Analyze
CO03	Apply appropriate technique to analyze a project with an objective to optimize resources	Apply
CO04	Solve operational problems using decision theory approaches.	Apply
CO05	Solve problems involving inventory, queuing, and sequencing models.	Apply
CO06	Solve Operations Research problems, modeling and analysis of manufacturing system using software package.	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2	2	1	2				1	1	2	2	2			1
CO02	3	2	2	1	2				1	1	2	2	2			1
CO03	3	2	2	1	2				1	1	2	2	2			1
CO04	3	2	2	1	2				1	1	2	2	2			1
CO05	3	2	2	1	2				1	1	2	2	2			1
CO06	3	2	2	1	2				1	1	2	2	2			1

Syllabus:

Unit1

Linear Programming: Formulations - graphical solutions - Simplex Method - Duality, Dual simplex method. Transportation model: Assignment model – Travelling Salesman Problem. [12 Hours]

Unit 2

Decision Theory: Decision Trees. Game theory - 2 person zero sum; mixed strategies; 2 x n and m x 2 games. Network Models- Project Networks- CPM / PERT- Project Scheduling – crashing networks and cost considerations- Resource leveling and smoothing - shortest route problem, minimal spanning tree problem, maximal flow problem. [8 Hours]

Unit 3

Sequencing model – 2 machines 'n' jobs, 'm' machines 'n' jobs – n jobs 2 machines. Inventory models: deterministic & probabilistic models. Quantity discounts. Selective Inventory Management Queuing models: Poisson arrival and exponential service times. Single server, multi-server. Queues -infinite and finite capacity queues. Simulation –Monte Carlo simulation: simple problems; Performance Modelling of Flow-shops, Job shops, and Assembly shops using Discrete Event Simulation package; Case studies. [10 Hours]

Laboratory session: Practicing case problems with excel solver POM/ package /MATLAB/LINGO package/DES Package / Discrete Event Simulation (DES) package (ARENA) [45 Hours]

Laboratory Exercises

1. Solving Linear programming problem
2. Solving Transportation problem
3. Solving Assignment problems and Travelling sales man problem
4. Solving Project management problems
5. Solving decision making problems
6. Solving sequencing problems
7. Modeling and analyses of manufacturing and service system using DES software
8. Simulation of an inventory system and queuing system using DES software

Textbooks:

1. Hillier, F .S. and Lieberman, G .J, 'Operations Research', 9e, McGraw Hill, 2010
2. Banks J., Carson J. S., Nelson B. L. and Nicol D. M. - 'Discrete Event System Simulation' - Pearson Education -2001 - 3rd Edition

Reference Books:

1. Taha, H.A., 'Operations Research: an Introduction', 8e, Prentice HalI, New Delhi, 2008.
2. Ravindran, A., Phillips, D.J., and Solberg, J.J., 'Operations Research- Principles and Practice', John Wiley & Sons,2005.
3. Wagner, H.M., 'Principles of Operations Research', Prentice Hall, New Delhi, 1998
4. Hardley, G., 'Linear Programming', Narosa Book Distributors Private Ltd 2002.
5 Law A. W. and Kelton D. W. - 'Simulation Modeling and Analysis' - McGraw Hill - 2010 - 5th Edition
6 Kelton D. W., Sadowski R. P. and Sasowski D. A. - 'Simulation with ARENA' - McGraw Hill – 2009

23MEE497	SUMMER INTERNSHIP	1 Cr

Course Objectives

The course will enable the students to

- To identify a suitable and relevant topics which can be developed either through development or research activities and match the level expected of an undergraduate student.
- To identify and collate relevant information pertaining to the project's requirements from various resources.
- To plan, design and propose a feasible project based on the given timeline.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Demonstrate the application of theoretical knowledge and skill sets acquired from the course and workplace in the assigned job function (s)	Apply
CO02	Articulate career options by considering opportunities in company, sector, industry, professional and educational advancement	Evaluate
CO03	Communicate and collaborate effectively and appropriately with different professionals in the work environment through written and oral means	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3		1		1	2		3	1		3		3	1	1	1
CO02	3							3	1	3			3	1	1	1
CO03	3	2	1	2	1		1	3	1		3	3	3	1	1	1

Syllabus

Internships are educational and career development opportunities, providing practical experience in a field or discipline. They are structured, short-term, supervised placements often focused around particular tasks or projects with defined timescales. An internship may be compensated, non-compensated or some time may be paid. The internship has to be meaningful and mutually beneficial to the intern and the organization. It is important that the objectives and the activities of the internship program are clearly defined and understood. Following are the intended objectives of internship training:

- Will expose Technical students to the industrial environment, which cannot be simulated in the classroom and hence creating competent professionals for the industry.
- Provide possible opportunities to learn, understand and sharpen the real time technical/managerial skills required at the job.
- Exposure to the current technological developments relevant to the subject area of training.
- Experience gained from the 'Industrial Internship' in classroom will be used in classroom discussions.
- Create conditions conducive to quest for knowledge and its applicability on the job.
- Learn to apply the Technical knowledge in real industrial situations.
- Gain experience in writing Technical reports/projects.
- Expose students to the engineer's responsibilities and ethics.
- Familiarize with various materials, processes, products and their applications along with relevant aspects of quality control.
- Promote academic, professional and/or personal development.
- Expose the students to future employers.
- Understand the social, economic and administrative considerations that influence the working environment of industrial organizations
- Understand the psychology of the workers and their habits, attitudes and approach to problem solving.

Keeping these considerations in view, the following places are recommended for pursuing an internship

- PSU and private companies including MNCs.
- Small and Medium scale industries.
- Research labs/institutes or Academic Institutions

23MEE498	PROJECT PHASE I	4 Cr

Course Objectives

The course will enable the students to

- To identify a suitable and relevant topics which can be developed either through development or research activities and match the level expected of an undergraduate student.
- To identify and collate relevant information pertaining to the project's requirements from various resources.
- To plan, design and propose a feasible project based on the given timeline.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Identify and define a problem based on the community/industry/research	Analyze
CO02	Plan project activities, considering their underlying requirements, constraints and deliverables.	Create
CO03	Design the solution to the identified problem.	Create
CO04	Communicate and document the project work through technical reports and presentations.	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3	2	1	1	2	1	1	3	1	1	2	3	1	1	1
CO02	3	3	2	1	1	1	1	1	3	1	2	2	3	1	1	1
CO03	3	3	3	1	1	1	1	1	3	1	1	2	3	1	1	1
CO04					1	1	1	1	3	3	1	2	3	1	1	1

Syllabus

The aim of the final year project is to give students opportunity to apply the knowledge they have gained to solve practical engineering problems. By doing so, students will gain knowledge and experience in solving problems systematically thus when they graduate, they will be ready to work as reliable and productive engineers. The project problem may be a theoretical analysis, modeling & simulation, experimentation & analysis, prototype design, fabrication of new equipment, correlation and analysis of data, software development, etc. or a combination of these.

In project phase 1, students are recommended to conduct an exhaustive literature survey to identify the real-life problems. Based on the literature survey they should formulate the problem statement and identify the methodology utilized to solve the problem, and produce preliminary results. At the end of phase 1 of the project, students will have to document their work in the form of project report in the prescribed form. The final evaluation and viva-voce will be conducted after submission of the final project report. Students have to make a presentation on the work carried out, before the departmental committee, as part of project evaluation.

SEMESTER 8

23MEE499	PROJECT PHASE II	8 Cr

Course Objectives

The course will enable the students to

- Develop the project identified in project phase 1 according to the proposed plan and design.
- Verify and validate the developed projects against the proposed objectives and goals.
- Propose future improvement based on project outcomes.
- Communicate project ideas and final product through technical report and presentation

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Develop solution based on the proposed objectives and methodology	Create
CO02	Analyze and discuss the results to draw valid conclusions.	Analyze
CO03	Demonstrate related deliverables needed to support and present the entire project effectively with written and oral means.	Create
CO04	Understand and practice professional and ethical responsibilities for sustainable development of society in the chosen field of project.	Apply
CO05	Communicate and document the project work through technical report and presentations.	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3	3	3	2	2	1		2	2	1	2	3	3	3	3
CO02	3	3	3	3	2	2	1		2	2	1	3	3	3	3	3
CO03	2	2		1	2	2	1		2	2	1	3	3	3	3	3
CO04	2	2	1		2	2	2	2		2	1	3	3	3	3	3
CO05					2			2	3	3	1	3	3	3	3	3

Syllabus

The aim of the final year project is to give students opportunity to apply the knowledge they have gained to solve practical engineering problems. By doing so, students will gain knowledge and experience in solving problems systematically thus when they graduate, they will be ready to work as reliable and productive engineers. The project problem may be a theoretical analysis, modeling & simulation, experimentation & analysis, prototype design, fabrication of new equipment, correlation and analysis of data, software development, etc. or a combination of these.

In phase 2 of the project work, students are recommended to prove the solution to the identified problem statement and methodolog. The solution should be in the form of fabrication/coding/modeling/product design/process design/relevant scientific methodology. The consolidated report along with the developed model to be submitted for the assessment. Project outcome to be evaluated in terms of technical, economic, social, environmental, political and demographic feasibility. Students must make a presentation on the work carried out by them on periodic basis before the committee for continuous evaluation. The final evaluation and viva-voce will be conducted after submission of the final project report in the prescribed form.

SPECIALIZATION

AUTOMATION AND ROBOTICS

SYLLABUS

23MEE450	ACTUATORS AND DRIVES	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- Introduction of electrical and non-electrical actuators.
- Sizing of pneumatic and hydraulic actuators.
- The terminology, characteristics and construction of electrical actuators
- The classification of electric drives and their performance characteristics.
- Selection of actuators and drives for robotics and automation applications.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Understand the concepts of hydraulic, pneumatic and electrical actuators to industrial applications	Understand
CO02	Determine the specifications of hydraulic, pneumatic actuators for a given application	Apply
CO03	Evaluate the performance characteristics of electrical actuators	Evaluate
CO04	Select suitable actuators and drives for robotics and automation applications	Apply
CO05	Analyze the performance characteristics of drives for different actuators	Analyze

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3										1	3	1		3
CO02	3	3										1	3	1		3
CO03	3	3	1									1	3	1		3
CO04	3	3	1			1			1			1	3	1		3
CO05	3	3	2		1				1			1	3	1		3

Syllabus

Unit 1

Pneumatic Actuators and Hydraulic Linear Actuator types - Single acting, Double Acting, Diaphragm, tandem, telescopic cylinder and cylinders with cushions. Rotary Actuator types - gear, vane, screw, piston types. Sizing of Actuators for industrial applications, Valves, Electro-hydraulic and Electro-pneumatic control devices. Symbols and circuits.

Unit 2

Introduction to Electrical actuators, Solenoids, Rotating electrical machines, operating principles, main terminology and industrial standards. DC, Synchronous, Induction, Stepper, BLDC, Servo motor: principle of operation, main characteristics and construction, Types, Starting, Speed Control and braking, Efficiency, Testing, Selection considerations.

Unit 3

Drives: Introduction, classification of electric drives, Dynamics of Electric drives: Types of loads, Multi quadrant operations, motor dynamics, steady state stability and transient stability. Electrical drives with DC, synchronous, induction, stepper, BLDC motors: Basic characteristics, Operating modes, Different control schemes. Gear boxes and harmonic drives. Case study/projects – automation and robotics applications.

Textbooks:

1. S. R. Deb; Sankha Deb. Robotics Technology and Flexible Automation, Second Edition McGraw-Hill Education: New York, 2010.
2. Kothari D.P. and Nagrath I.J., “Electric Machines”, Tata McGraw-Hill Publishing Company Limited, NewDelhi, 2004.Gopal K. Dubey, Fundamentals of Electrical Drives, Narosa Publishing House, 2016.

Reference Books:

1. Nathan Ida, Sensors, Actuators, and Their Interfaces- A multidisciplinary introduction, 2nd Edition, IET Digital Library, 2020.
2. Pillay. S.K, A First Course on Electric Drives, Wilely Eastern Limited, Bombay, 2012
3. Stephen J. Chapman, ‘Electric Machinery Fundamentals’4th edition, McGraw Hill Education Pvt. Ltd, 2010.
4. Jagadeesha T., “Hydraulics and Pneumatics”, 1st edition, I K International Publishing House, New Delhi, 2015

23MEE451	ROBOT KINEMATICS AND DYNAMICS	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- Analyze the forward and inverse kinematics of planar and spatial robots, developing techniques to compute its workspace.
- Perform comprehensive and rigorous analysis of velocity Jacobians, kinematic singularities and kineto-static duality in mechanisms and robots.
- Formulate the dynamic equation of motion for manipulator using Lagrange's equation.
- Solve the dynamic equations of motion using different techniques.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Understand the frame representation and spatial transformation	Understand
CO02	Derive the DH parameters and perform forward kinematic analysis	Analyze
CO03	Perform inverse kinematic analysis of robots	Analyze
CO04	Compute Jacobian matrix and solve the singularity problems of serial robot manipulators	Analyze
CO05	Apply the Lagrange's equation to derive the equations of motion	Apply
CO06	Analyze the dynamics of robot manipulator using Newton-Euler formulation	Analyze

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3	2		1							1	2	1		1
CO02	3	3	2	1	1							1	2	1		1
CO03	3	3	2	1	1							1	2	1		1
CO04	3	3	2		1							1	2	1		1
CO05	3	3	2		1							1	2	1		1
CO06	3	3	2		1							1	2	1		1

Syllabus

Robot Kinematics

Introduction: Definition, Classification, Robot Components, Degree of Freedom, Mobile robots, Robot Characteristics, Robot Workspace, Robot specifications, and programming. Spatial transformation. Homogeneous transformation of matrices – Representation of combined transformations – Inverse transformation of matrices.
Forward and inverse kinematics – position and orientation. Denavit Hartenberg (DH) representation of forward kinematic equations. Inverse kinematic solution of Robots. Degeneracy and Dexterity.
Differential Motions and Velocities – Linear and angular velocity of rigid bodies. Motion of the links of a robot – velocity propagation from link to link. Jacobians – singularity.

Robot Dynamics

Kinetics of rigid bodies – Work energy principle, Linear and angular momentum, conservation laws. Transformation from Newtonian to Lagrangian formulation – Principle of virtual work – Hamilton's principle – Lagrange's equation. Newton's equation, Euler equation. Iterative Newton – Euler dynamic formulation. Structure of manipulator dynamic equations. Lagrangian formulation of manipulator dynamics. Inclusion of nonrigid body effect. Dynamic simulation.

Textbooks:

1. Niku, Saeed B. Introduction to robotics: analysis, control, applications. John Wiley & Sons, 2020.
2. Craig, John J. Introduction to Robotics. Pearson Higher Ed, 2021.

Reference Books:

1. Spong, Mark W., and Mathukumalli Vidyasagar. Robot dynamics and control. John Wiley & Sons, 2008.
2. Shabana, Ahmed A. Computational dynamics. John Wiley & Sons, 2009.
3. Schilling RJ. Fundamentals of robotics: analysis and control. New Jersey: Prentice Hall; 1990 Jan.

23MEE452	MICROCONTROLLERS AND EMBEDDED SYSTEMS	L-T-P-C: 2-0-3-3

Course Objectives

The course will enable the students to

- Introduction to microprocessor and microcontroller.
- The performance metrics for processors in embedded systems.
- The memory system design for cache and memory management.
- The peripherals for communication with sensors and actuators.
- The demonstration of ARM based controllers for application development in robotics and automation.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Identify various hardware and software architectures in embedded systems	Understand
CO02	Articulate the concepts of microprocessors and microcontrollers	Evaluate
CO03	Describe the detailed architecture, internal modules and addressing modes of ARM based processor	Understand
CO04	Analyze microcontroller peripherals and interfacing of sensors and actuators	Analyze
CO05	Develop robotics and automation applications with microcontrollers	Analyze

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3	2						1	1			2			2
CO02	3	3	1						1	1			2			2
CO03	3	3	1	2	1				1	1			2			2
CO04	3	3	3	2	1				1	1			2			2
CO05	3	3	3	3	3				1	1		1	2			2

Syllabus

Unit 1

Introduction to Embedded Systems; Architecture – Sensors, Processor: Microprocessor & Microcontroller, Actuator; Classifications of embedded systems; Design process; Applications; Processor - evolution and types. CPU Performance, Performance Metrics and Benchmarks.

Unit 2

An introduction to Embedded Processors. ARM Architecture – Programmer's Model, Instruction Set, Addressing modes, Assembly Programs. Pipelined data path design - Pipeline Hazards. Memory system design- Cache Memory, Memory Management unit, Virtual Memory.

Unit 3

Overview of 8-bit and 16-bit microcontrollers. Introduction to ARM based Microcontrollers – Architecture, Peripherals - Input/output ports, Timers, ADC, DAC, PWM, Quadrature Encoder, UART, I2C, SPI, Advanced communication interfaces. Interfacing of sensors and actuators. Application development – Robotics & Automation.

List of Experiments:

1. Familiarization of IDE, simulator, development boards and kits
2. Assembly Language Programs
3. Embedded C Program to configure and use Input/output ports & Timers
4. Embedded C Program to configure and use ADC and DAC
5. Embedded C Program to configure and use PWM
6. Embedded C Program to configure and use UART
7. Embedded C Program to configure and use SPI
8. Embedded C Program to configure and use I2C
9. Interfacing of sensors and actuators to microcontroller
10. Development of robotic and automation applications

Textbooks:

1. Yifeng Zhu, "Embedded Systems with ARM Cortex-M Microcontrollers in Assembly Language and C". Third Edition, E-Man Press LLC, 2017.
2. Saurabh Chandrakar Nilesh Bhaskarrao Bahadure, "Microcontrollers and Embedded System Design", First Edition, Dreamtech Press, 2019.
3. Joseph Yu, "The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors", Third Edition, Newness, 2013.

Reference Books:

1. ARM Technical Reference Manual (https://developer.arm.com/documentation/)
2. ARM Architecture Reference Manual (https://developer.arm.com/documentation/)
3. NXP LPC 17xx user manual (https://www.nxp.com/docs/en/user-guide/UM10360.pdf)
4. Getting started with MDK Create applications with µVision® for ARM® Cortex®-M microcontrollers
5. (https://www2.keil.com/docs/default-source/default-document-library/mdk5-getting-started.pdf?sfvrsn=2)
6. Steve Furber, "ARM System-on-chip Architecture", Second Edition, Addison Wesley, 2000.
7. Andrew Sloss, Dominic Symes and Chris Wright, "ARM System Developer's Guide: Designing and Optimizing System Software", Morgan Kaufumann Publisher, 2011.
8. William Hohl and Christopher Hinds, "ARM Assembly Language: Fundamentals and Techniques", Second Edition, CRC Press, 2016.
9. ARM Technical Reference Manual, NXP LPC 17xx datasheet.

23MEE453	ROBOTICS AND CONTROL	L-T-P-C: 3-0-3-4

Course Objectives

The course will enable the students to

- The fundamental knowledge of robotics, characteristics, workspace specifications, and systems.
- The development of various formulations to describe dynamic models of robotic systems.
- The comprehensive and rigorous treatment of concepts and principles related to manipulator dynamics and trajectory planning.
- The various strategies for trajectory planning and motion control of manipulator.
- The programming and visualization of manipulator dynamics through software and hardware.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Outline the fundamentals of robotics and its components	Understand
CO02	Solve for the manipulator dynamics using Lagrangian formulation.	Evaluate
CO03	Implement the various trajectory planning algorithms and control techniques	Analyze
CO04	Solve the forward and inverse dynamics problems of robotics	Analyze
CO05	Apply different nonlinear and force control algorithms for robot control.	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3	3						1	1		1	2			2
CO02	3	3	3		1				1	1		1	2			2
CO03	3	3	3		1				1	1		1	2			2
CO04	3	3	2		1				1	1		1	2			2
CO05	3	3	3		1				1	1		1	2			2

Syllabus

Unit 1

Application of Robots. End Effectors-Grippers-Types: Pneumatic, Hydraulic, Magnetic, Vacuum Grippers; Selection and Design Considerations. Gripper Force analysis. Resolution, accuracy and repeatability of robot, applications. Static forces in manipulator. Jacobian in the force domain.

Unit2

Manipulator Dynamics: Lagrangian Mechanics, Dynamical models of multiple DOF robots, robot workspace analysis, Static force analysis of robots, Transformation of forces and moments between coordinate frames. Dynamic algorithms and Introduction to recursive robot dynamics.

Trajectory Planning: Robot workspace analysis, joint space trajectories, path and trajectory planning of a robot, Trajectory Interpolation, Set point tracking, Actuator Dynamics. Cartesian-Space Trajectories, Continuous trajectory recording

Unit 3

Motion Control: The control problem, Joint space control, Decentralized control, Computed torque feed forward control, Centralized control, PD Control with gravity compensation, Inverse dynamics control, Operational space control. Nonlinear decoupled feedback control, resolved motion control, robust control, adaptive control, Force control, hybrid control, control of robot trajectory. Robot programming languages. Introduction to motion control in mobile robotics.

List of Exercises:

1. Dynamic modelling and analysis of an industrial robot manipulator.
2. Trajectory Planning of 3R robot based on 3rd order polynomial trajectory
3. Computation of geometric Jacobian for robot manipulator.
4. Trajectory tracking control of industrial robotic arm using robot manipulator blocks
5. Rotational and transform trajectory analysis of robot manipulator
6. Trapezoidal velocity profile trajectory analysis of robot manipulator
7. Visualization of manipulator trajectory tracking in 3D.
8. Design and develop the manufacturing cell using virtual robot simulator.
9. Develop a TCP and work-object for Industrial Robot using Robot simulator.
10. Develop the robot programming for pick and place of objects, material handling and welding operations.
11. Singularity analysis using Robot simulator.
12. Interface and configure the vision system with Industrial Robot.
13. Part identification based on colour & pattern and separate the components using vision system and Robot.
14. Develop a program to draw a pattern using the manipulator.
15. Program the robot manipulator's end effector to travel along a complex 3D path.

Textbooks:

1. Craig, J.J., Introduction to Robotics: Mechanics and Control, 2nd Edition, Addison-Wesley, Reading, MA, 1989.

Reference Books:

1. L. Sciavicco, B. Siciliano, Modeling and Control of Robot Manipulators, Springer, 2002.
2. Angeles, J., Fundamentals of Robotic Mechanical Systems, Springer-Verlag, New York, NY, 1997.
3. Fu, Gonzales, and Lee, Robotics: Control, Sensing, Vision, and Intelligence, McGraw-Hill, 1987.
4. Shames,I.H, "Engineering Mechanics-Statics and Dynamics", 4/e, Prentice-Hall of India Pvt. Ltd., 2005

23MEE454	E-NOISE VIBRATION AND HARSHNESS	L-T-P-C: 2-0-3-3

Course Objectives
The course will enable the students to

- Learn measurement and analysis techniques of vehicle noise and vibration
- Expertise in the application of NVH refinement in vehicles and their systems
- Understanding of advanced techniques for reduction of NVH
- Process and analyze the signals using vibration and noise reduction techniques

Course Outcomes:
After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Analyse vibrations of SDOF, MDOF and Continuous systems, vibration measurement and analysis	Analyze
CO02	Measure vibration and noise signals and evaluate them applying signal processing and analysis techniques including modal analysis	Analyze
CO03	Evaluate acoustic materials and apply them for noise reduction	Evaluate
CO04	Apply Principles of NVH refinement in vehicles and their systems – power train, chassis, body, suspension, etc.,	Apply
CO05	Apply advanced Techniques – NVH simulation, Statistical Energy Analysis, Acoustic Holography, beam forming, etc.,	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2	2		1	1			1	1		1	2	1		1
CO02	3	2	1	2	1	1			1	1		1	2	1		1
CO03	3	2	2		1	1			1	1		1	2	1	1	1
CO04	3	2	2	2	1	1	1		1	1		1	2	1		1
CO05	3	2	2		1	1	1		1	1		1	2	1		1

Syllabus

Unit 1
Introduction to Automotive NVH-Fundamentals of vibrations –Vibration of Single degree of freedom, Multi degrees of freedom - Vehicle vibration measurement and analysis.

Unit 2
Fundamentals of acoustics, Vehicle noise measurement, Noise Standards for electric vehicle, Types of Signals, Signal conditioning and processing, Data Acquisition Systems, Analysis and presentation of data Ride Comfort – Sound Quality and psychoacoustics –Sound Quality Metrics, Subjective–objective correlation –Squeak and Rattle-Vibration isolation and Transmission.

Unit 3
Fourier series – Fourier Integrals –- Discrete Fourier Transforms – Fourier and Laplace Transforms - Filters - Windowing - Time Sampling and Aliasing - Random signal processing and analysis -Theory of modal analysis - Methods for performing modal analysis, Modal analysis of Electric motors, motor drive system, battery and battery management systems.

Unit 4
Refinement of e-Power train systems, Chassis and Suspension and Body –Vibro-acoustics – Aerodynamic noise and its refinement–Aeroacoustics Simulation methods in Automotive NVH – FEM, BEM, MBD, CFD, TPA, SEA,

Vibro and Aero-acoustics,Acoustic shielding and sound packages for electronics system noise and motors – Acoustic materials and their characterization-Special issues related to EHV and NVH.

List of Experiments:

1. Sound Power evaluation using SPL measurements- ISO 3744
2. Motor SPL measurement as per SAE
3. Modal Testing and analysis
4. Signal Analysis using FFT
5. Demonstration of inverse square law
6. Demonstration of the effect of sound absorbing and insulating materials
7. Noise source identification by masking method
8. Motor vehicle pass-by noise- IS 3028/ISO 362
9. Motor vehicle Stationary noise (tail pipe noise)- ISO 10399
10. Sound Quality analysis - Jury Rating, Metrics and its correlation
11. Vibration measurement and Modal analysis

Textbooks:/Reference Books:

1. Xu Wang, "Vehicle Noise and Vibration Refinement", CRC Press Publication, 2010.
2. J.M. KrodkiewskI, "Mechanical Vibration" Univ of Melbourne, 2008
3. Kihong Shin and Joseph K. Hammond "Fundamentals of Signal Processing for Sound and Vibration Engineers", Johe Wiley, 2008.
4. S.S.Rao, " Mechanical Vibrations", Prentice- Hall, 2011

23MEE455	**INDUSTRIAL INTERNET OF THINGS**	**L-T-P-C: 2-0-3-3**

Course Objectives

The course will enable the students to

- The fundamental knowledge on industrial trends and revolutions.
- The industry standards in communication technology and various communication protocols.
- The visualization and data types in communication for the Industrial Internet of Things (IIoT).
- The demonstration of different wireless communication schemes and experimental validation.
- The programming the edge or fog computing node and visualization of sensor data.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom’s Taxonomy]
CO01	Describe the concepts and characteristics of Industry 4.0.	Understand
CO02	Comprehend different enabling technologies and their role in establishing Industry 4.0.	Evaluate
CO03	Understand different communication technologies used in Industry 4.0.	Understand
CO04	Perform edge and cloud computing and visualize the data.	Analyze
CO05	Apply IoT for the given applications.	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2	1		2				1	1		1	2			2
CO02	3	2	1		2				1	1		1	2			2
CO03	3	2	2		2		1		1	1		1	2			2
CO04	3	2	3		2	2	2	1	1	1		1	2			2
CO05	3	2	2		2	2	2	1	1	1		1	2			2

Syllabus

Unit 1

Introduction: The various industrial revolutions, digitalization and the networked economy, drivers, enablers, comparison of industry 4.0 factory and today's factory, challenges. Cyber Physical Systems, Robotic Automation and Collaborative Robots, Support System for Industry 4.0, Mobile Computing, Cyber Security, Augmented / Virtual reality, Artificial Intelligence, System integration, Digital twins. Introduction to Industry 5.0.

Unit 2

Communication Technologies of IIoT

Communication Protocols: IEEE 802.15.4, ZigBee, Z Wave, Bluetooth, BLE, NFC, RFID, Industry standards communication technology (LoRA, WAN, OPC UA, MQTT), connecting into existing Modbus and Profibus technology, wireless network.

Unit 3

Visualization and Data Types of IIoT communication.

Front-end EDGE devices, Emerging descriptive data standards for IIoT, Cloud data base, could computing, Fog or Edge computing. Pushing data to cloud. Grabbing the content from a web page, sending data on the web, Troubleshooting. **Application of IIoT.**

Case study: Health monitoring, smart city, Smart irrigation, Robot surveillance.

List of Experiments:
1. Introduction to Arduino, and ESP8266 (Node MCU)
2. Introduction to Raspberry Pi and Installation of OS
3. Modules and Sensors Interfacing (LM35, DHT 11, POT, IR sensor, Ultrasonic sensors) using Raspberry Pi/Node MCU
4. Modules and Actuators Interfacing (Relay, Motor, Buzzer) using Raspberry Pi/Node MCU
5. Measurement of temperature & pressure values of the process using Raspberry Pi/Node MCU
6. Demonstration of MQTT communication
7. Demonstration of LoRa communication
8. Visualization of diverse sensor data using dashboard (part of IoT's 'control panel')
9. Sending alert message to the user (ways to control and interact with environment)
10. Device control using mobile Apps or through Web pages
11. Machine to Machine communication

Textbooks:

1. Klaus Schwab, "The Fourth Industrial Revolution", Portfolio Penguin, 2017.
2. Bruno S.Sergi, Elena G.Popkova, Aleksei V. Bogoviz and Tatiana N. Litvinova, "Understanding Industry 4.0: AI, The internet of things, and the future of work", Emerald publishing limited, 2019.

Reference Books:

1. Alasdair Gilchrist, "Industry 4.0: The Industrial Internet of Things", Apress, 2016.
2. Kaushik kumar, DivyaZindani, J. Paulo Davim, "Digital manufacturing and assembly systems in Industry 4.0", CRC Press, Taylor and Francis group, 2020.
3. Antonio sartal, Diego Carou, J.PauloDavim, "Enabling technologies for the successful deployment of Industry 4.0, CRC press, 2020.
4. Alp Ustundag, Emrecavikcan, "Industry 4.0: Managing the digital transformation", Springer International publishing, 2018.
5. Christoph Jan Bartodziej, "The Concept Industry 4.0", Springer Gabler, 2017.

23MEE456	INDUSTRIAL PROCESS AUTOMATION	L-T-P-C: 2-0-3-3

Course Objectives
The course will enable the students to

- The fundamentals of PLC, SCADA and DCS for data handling
- The programming languages and skills for PLC and SCADA
- The different architectures for computer based automation and HMI development
- The design of a graphical system using virtual instrumentation software

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Develop the PLC program for the given application	Apply
CO02	Interface the Input and output devices with PLC	Evaluate
CO03	Apply the concepts of SCADA for industrial automation	Apply
CO04	Analyze the communications and networking of distributed control systems	Analyze
CO05	Design a graphical system using Virtual Instrumentation software	Apply

CO-PO Mapping: [affinity[#]: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2	3		2				1	1		2	2			2
CO02	3	2	3		2				1	1		2	2			2
CO03	3	2	3		2	1		1	1	1	1	2	2			2
CO04	3	2	3		2	1		1	1	1	1	2	2			2
CO05	3	2	3		2	1		1	1	1	1	2	2			2

Syllabus

Unit 1

Programmable Logic Controllers: Introduction, Types of PLC, CPU unit architecture, Memory classification, Input/output devices and their interfacing, Digital-Analog modules, Communication modules, Special function modules, Basic Ladder logic, electrical wiring diagram, scan cycle. Programming languages for PLC, PLC module addressing, registers basics, basic relay instructions, timer-counter instructions, Math functions, data handling, and program control instructions.

Unit 2

SCADA: Introduction to computer-based industrial automation- Direct Digital Control (DDC), Distributed Control System (DCS), and supervisory control and data acquisition (SCADA) based architectures and HMI Components, HMI Development, Data Processing, Control Algorithm, Programming, Data Acquisition from PLCs/RTUs, Database Connectivity and Report generation. OPC Configuration with RTUs (PLC), Cyber Security for Industrial Control Systems.

Unit 3

Distributed Control System- Local Control Unit (LCU) architecture, LCU Process Interfacing Issues, Block diagram and Overview of different LCU security design approaches, Networking of DCS. Introduction to communication protocols- Profibus, Field bus, HART protocols. Data gathering, Data analytics, Real-time analysis of data stream from DCS, Historian build, Integration of business inputs with process data.

Introduction to Virtual Instrumentation, Traditional and virtual instruments. Data types, G-Programming, Concept of VIs and sub-VIs, Graphs and charts, Local and Global variables – String and file I/O, Control loops and structures, sequence structures, and Data acquisition system. Signal processing and analysis, Graphical system design.

List of Experiments:
1. Ladder programming for boolean operations & math operations
2. Interfacing of Electro-Pneumatic system with PLC
3. Speed control of DC motor using PLC
4. Interfacing HMI with PLC
5. Interfacing PLC real-time TAG with SCADA
6. Flow and pressure measurement and control using SCADA
7. Develop a SCADA screen program for process plant operation
8. Develop a database and recipe TAG base in SCADA
9. Basic programming using Virtual Instrumentation software
10. Data acquisition and processing using Virtual instrumentation software
11. Graphical system design using Virtual Instrumentation software

Textbooks:

1. Lukas M.P, "Distributed Control Systems," Van Nostrand Reinhold Co., New York, 1986.
2. Petruzella, Frank D. Programmable logic controllers. Tata McGraw-Hill Education, 2005.
3. Gupta, Virtual Instrumentation Using LabVIEW 2E, Tata McGraw-Hill Education, 2010

Reference Books:

1. Elshafei, M., 2016. *Modern Distributed Control Systems: A comprehensive coverage of DCS technologies and standards*. CreateSpace Independent Publishing Platform.
2. Mehra, R., 2012. *PLCs & SCADA: Theory and Practice*. Laxmi Publications.
3. Jennings, R. and De La Cueva, F., 2020. *LabVIEW graphical programming*. McGraw-Hill Education.

23MEE457	MOBILE ROBOTS	L-T-P-C: 2-0-3-3

Course Objectives

The course will enable the students to

- The fundamental knowledge on the essential elements of robotic locomotion.
- The challenges and techniques in realizing robotic locomotion.
- The comprehensive and rigorous treatment of concepts on path planning and navigation.
- The basics of robot learning and collective robotics

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Derive the mathematical models and describe motion control methods	Understand
CO02	Apply various models of localization and navigation.	Apply
CO03	Analyze locomotion challenges and select motion planning algorithms.	Analyze
CO04	Design and develop autonomous mobile robots with obstacle avoidance.	Evaluate

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3	3						1	1		1	2			2
CO02	3	3	3		1				1	1	1	1	2			2
CO03	3	3	3		1				1	1	1	1	2	2		2
CO04	3	3	2		1				1	1	1	1	2	2		2

Syllabus

Unit 1

Introduction to autonomous robotics, terrestrial and aerial locomotion, mobile robot kinematic models, manoeuvrability, workspace, and kinematic control. Perception – non-visual sensors and algorithms, computer vision, image processing, feature extraction – interest point detectors, range data.

Unit 2

Mobile robot localization, Noise and aliasing, belief representation, probabilistic map-based localization – Markoc and Kalman filter localization, Autonomous map building, SLAM paradigms - Extended Kalman filter, graph-based and particle filter. Sensorial, geometric and topological maps, robot collectives – Sensing, communication, formation control, localization and mapping.

Unit 3

Planning and Navigation: Path planning. Graph search – Voronoi diagram, deterministic graph search, Dijkstra's algorithm, A*, D* algorithm, Randomized graph search, Potential field path planning. Obstacle avoidance – Bug algorithm, Techniques viz. bubble band, curvature velocity, dynamic window approach, Schlegel approach, gradient method, Mobile robots in practice, delivery robots, intelligent vehicles, mining automation, space robotics, underwater inspection.

List of Experiments:

1. Design and simulation of a biped robot.
2. MATLAB/Python programming for kinematic control of differential drive vehicle.
3. Line fitting and range data feature extraction.
4. Line-based Kalman filtering for mobile robot localization,
5. Simultaneous localization and mapping based on Extended Kalman Filtering.
6. Simulate a system of collective robots for arbitrary inputs and constraints,
7. Mobile robot path planning with global and local dynamic window approaches.

8. Noise rejection navigation simulation for mobile robot

Textbooks:

1. Roland Siegwart, Illah R. Nourbakhsh, and Davide Scaramuzza. (2011). Introduction to Autonomous Mobile Robots. 2nd edition, The MIT Press.
2. Gregory Dudek, and Michael Jenkin. (2010). Computational Principles of Mobile Robotics. Second edition, Cambridge University press

Reference Books:

1. Ulrich Nehmzow, (2012). Mobile Robotics: A Practical Introduction Second Edition. Springer.
2. Peter Corke (2017). Robotics, Vision and Control Fundamental Algorithms in MATLAB®. Second Edition. Springer
3. Howie Choset, Kevin Lynch, Seth Hutchinson, George Kantor, Wolfram Burgard, Lydia Kavraki, and Sebastian Thrun (2005) Principles of Robot Motion Theory, Algorithms, and Implementation, MIT press.
4. Sebastian Thrun, Wolfram Burgard, Dieter Fox. (2002) Probabilistic Robotics. The MIT press.
5. Steven M. LaValle. (2006). Planning Algorithms, Cambridge University Press.

23MEE458	REAL TIME OPERATING SYSTEM	L-T-P-C: 2-0-3-3

Course Objectives

The course will enable the students to

- The fundamental knowledge on the real-time operating system (RTOS).
- The various approaches to real-time scheduling and other kernel services.
- The comprehensive and rigorous treatment on task communication and synchronization.
- The essential elements of Robot Operating System (ROS).

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Identify the basic concepts in real time systems	Understand
CO02	Apply various services provided by the RTOS Kernel	Apply
CO03	Analyze various algorithms of RTOS kernel services.	Analyze
CO04	Develop real time applications using ROS framework.	Evaluate

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3			1				1	1		2	2			2
CO02	3	3			1				1	1		2	2			2
CO03	3	3	2		1				1	1		2	2			2
CO04	3	3	3	1	1				1	1		2	2			2

Syllabus

Unit 1

Overview of concepts of Operating System, GPOS functionalities, Architecture of OS (Monolithic, Microkernel, Layered, Exokernel and Hybrid kernel structures). Evolution of operating systems. Introduction to real-time systems, RTOS basic architecture, RTOS vs GPOS. POSIX Standards. RTOS Kernel, Kernel services.

Unit 2

Task Management - Tasks, process and threads, task attributes and types - task states and transition, preemption-context switching, task control block, Introduction to real-time task scheduling, clock-driven and priority-driven scheduling, uniprocessor scheduling and multiprocessor scheduling concepts. Blocking, Deadlock and avoidance strategies, priority inversion and solutions. Task Communication and Synchronization - Semaphores and Mutex, Mailbox, Queue, Pipes. Timer Management, Interrupt handling, Memory Management – Cache and Virtual Memory, Input-Output handling.

Unit 3

Familiarization of ROS – architecture, sensors and actuators supported, computing platforms. Experiment on Creating, building, modifying packages and Writing, building source code and nodes, Creating and Running Publisher, Subscriber Nodes, Service Servers, Client Nodes, Action Server and Client Node. Programming experiment on nodes with setting, reading, building, running, displaying parameters list. Programming with ROS.

List of Experiments:

1. ROS launch
2. 3D visualization tool (RViz)
3. Design and development of graphical user interface in ROS environment.
4. Establish communication between robot client and server
5. Analysis of data packet loss Visualization of robot and their movements in Rviz ROS.

Textbooks:

1. Qing Li, Caroline Yao, “Real-Time Concepts for Embedded Systems” First Edition, CRC Press, 2010.
2. Douglas Wilhelm Harder, Jeff Zarnett, Vajih Montaghami and Allyson Giannikouris, “A practical introduction to real-time systems for undergraduate engineering”, First Edition, University of Waterloo, 2015.

Reference Books:

1. Tanenbaum, "Modern Operating Systems,” Fourth Edition, Pearson Edition, 2014.
2. Jane W.S. Liu, “Real -Time Systems”, First Edition, Pearson Education, 2000.
3. Lentin Joseph, “Robot Operating System (ROS) for Absolute Beginners: Robotics Programming Made Easy”, First Edition, Apress, 2018.
4. Kumar Bipin, “Robot Operating System Cookbook”, First Edition, Packt Publishing, 2018.

23MEE459	DRONE TECHNOLOGY	L-T-P-C: 2-0-3-3

Course Objectives

The course will enable the students to

- The basic concepts of drones, propellers and controls of drones.
- Kinematic, dynamics and modeling of multi robot micro drones.
- The various approaches for state estimation.
- The comprehensive and rigorous treatment on path planning of drones.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Solve the kinematics and dynamics of fixed wing drones	Understand
CO02	Solve the kinematics and dynamics of multi rotor micro drones.	Evaluate
CO03	Design the flight controls of drones.	Understand
CO04	Design and develop path planning algorithms for drones	Analyze

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3		3	2				1	1		1	2			2
CO02	3	3		3	2				1	1		1	2			2
CO03	3	3	3	3	3				1	1	1	1	2			2
CO04	3	3	3	3	3				1	1	1	1	2			2

Syllabus

Unit 1

Fixed Wing and Multirotor Micro Drones: Introduction – Drones – Kinematic and dynamics modelling formulation of drones - Transformation and representations – Dynamics of a fixed-wing drones, Propeller theory – Thrust and drag moment – Dynamics of a multi rotor micro drones (MMD) – Mathematical modelling of MMD

Unit 2

State Estimation: Physics and working of navigational sensors – Inertial Sensors – Magnetometer – Pressure sensors, GPS – Camera based navigation – Kalman filter – Position and velocity analysis, Inertial navigation systems – Attitude estimation

Unit 3

Flight Controls and Motion Planning: PIC control – Lateral control of MMD, LQR – Design of servo LQR control, Linear model predictive control – Design and implementation. Holonomic vehicle boundary value solver, Dubins airplane model boundary value solver – collision free navigation, Structural inspection path planning

Textbooks:

1. R. Beard, and T. W. McLain, "Small Unmanned Aircraft: Theory and Practice", Princeton University Press, 2012
2. R. C. Nelson, "Flight Stability and Automatic Control", McGraw Hill, New York, 1998.

Reference Books:

1. L.R. Newcome, Unmanned Aviation, a Brief History of Unmanned Aerial Vehicles, American Institute of Aeronautics and Astronautics, Reston, 2004.
2. Kuo, B. C., "Automatic Control Systems", Prentice Hall, 1991

SPECIALIZATION

COMPUTATIONAL MECHANICS

SYLLABUS

23MEE461	ADVANCED FLUID MECHANICS	L-T-P-C: 2-1-0-3

Course Objectives
The course will enable the students to

- To familiarize the kinematic and dynamic behavior of fluid flow
- To introduce the Navier-Stokes equation pertinent to steady and unsteady flows.
- To introduce flow dynamics over immersed bodies
- To impart knowledge on the origin and nature of turbulence.

Course Outcomes:
After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Evaluate the instantaneous velocity field in fluid flow and calculate vorticity, circulation and stream function from it.	Evaluate
CO02	Evaluate analytically the reduced NSE to estimate the velocity profile and shear stress.	Evaluate
CO03	Apply NSE in real time engineering problems to model low and high Reynolds number flow and boundary layer flows.	Apply
CO04	Estimate the total drag and lift forces associated with structures immersed in the fluid flow.	Apply
CO05	Predict different turbulent length scales and Reynolds stress in various turbulent flows.	Understand

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3	3	2	1							1	2			1
CO02	3	3	3	2								1	2			1
CO03	3	3	3	2	1	1			1			1	2			1
CO04	3	3	3	2		1						1	2			1
CO05	3	3	3	2		1						1	2			1

Syllabus

Unit 1*
Fundamentals of Fluid Dynamics
Revisit basics in fluid mechanics, Differential approach - the Material Derivative, Integral Approach – RTT, Flow visualization - Path Lines, Streamlines, streaklines, Rate of Deformation, Vorticity and Circulation, The Stream Function Equation, The Vorticity Transport Equation, Conservation Equations – mass, momentum, energy, Boundary Conditions. [10 hours]
Exact Solution of Navier Stokes Equation
Couette (wall–driven) steady flow, Poiseuille (Pressure driven) steady duct flow, and Unsteady Duct Flow, Numerical solutions using Python/MATLAB. [6 hours]

Unit 2
Approximate Solution of Navier Stokes Equation
Creeping flow, inviscid region of flow, Irrotational flow – uniform flow, source, sink, doublet, vortex, Hele-Shaw Rankine half body, Rankine Oval, Superposition principle with suitable examples, Numerical solutions using Python/MATLAB. [8 hours]
Boundary Layer Theory
Boundary Layer concept, Boundary layer equations for 2D flows, Numerical solutions of Prandtl's equation for boundary layer, Blasius Similarity Solution, Karman Momentum integral Equation, Boundary layer thicknesses,

Boundary Separation with various pressure gradient, Laminar and Turbulent boundary layers, and sports ball dynamics. **[8 hours]**

Unit 3

Flow Over Bodies: Drag and Lift

Drag and Lift, Friction and Pressure Drag, Reducing Drag by Streamlining, Flow Separation, Drag Coefficients of Common Geometries, Parallel Flow over Flat Plates, Friction Coefficient Flow over Cylinders and Spheres, D'Alembert's Paradox. Effect of Surface Roughness, Lift - End Effects of Wing Tips Lift Generated by Spinning. [7 hours]

Introduction to turbulence

Nature of Turbulence, Origin of turbulence, Characterization of turbulence, Kolmogorov Hypothesis and Energy Cascade, Reynolds modification of Navier-Stokes equations, Reynolds stresses, Turbulence Models – Prandtl Mixing length Mode. [7 hours]

Introduction to Compressible flows

Fundamentals of compressible flows, Concepts of normal and obliques shocks, Prandtl-mayer expansion, Rayleigh and Fanno flows. [4 hours]

List of computational exercises (MATLAB/Python)

1. Compute and plot the stream function and velocity potentials for the source/sink flow, doublet, vortex, Rankine half body, Rankine Oval, flow over cylinder and flow over rotating cylinder with different circulation etc.
2. To deduce the velocity profile and shear stress distribution for Couette flow and Poiseuille flow from reduced from of NS equations
3. Compute and plot Blasius profile as solution to Prandtl's equation for boundary layer.

Textbooks:

1. Robert W. Fox, Alan T. McDonald, &Philip J., "Fluid Mechanics", 8/e, John Wiley & Sons Inc., 2017

Reference Books:

1. Ronald L. Panton, "Incompressible Flow", 4/e,John Wiley & Sons Inc., 2011
2. Pijush K. Kundu, Ira M. Cohen & David M. Dowling, "Fluid Mechanics", 5/e, Academic Press., 2012
3. Yunus A Cengel& John Cimbala, "Fluid Mechanics: Fundamentals and Applications", 3/e McGraw Hill., 2017
4. K Muralidhar and G Biswas, "Advanced Engineering Fluid Mechanics", 3/e,Narosa Publishing House.,2001

23MEE462	ADVANCED MECHANICS OF SOLIDS	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- Understand the theoretical concepts of fundamentals of elasticity
- Understand governing equations of elasticity
- Introduction to plasticity.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Understand fundamentals of stress at a point; Invariants and Traction vectors	Understand
CO02	Apply principles of elasticity theory to estimate stresses and strains in isotropic materials using tensorial approach	Analyse
CO03	Formulate and solve boundary value problems in solid continua using stress and displacement based solution Strategies	Evaluate
CO04	Formulate and solve planar problems using Airy stress function in rectangular and polar co-ordinates	Analyze
CO05	Understand theories of failure, yielding and strain hardening rules of plastic flow	Understand

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2	1	1									3			1
CO02	3	2	1	1		1							3			1
CO03	3	2	1	1	2	1						1	3			1
CO04	3	2	1	1	2							1	3			1
CO05	3	2	1	1	2							1	3			1

Syllabus

Unit 1

Analysis of Stress and Strain: State of stress at a point; stress tensor; Geometrical representation of stress at a point; Traction vector and its components on a plane; Normal and shear stress components on a plane; Stress transformations; Principal stresses and principal planes; Octahedral stress; Invariants of a stress tensor; Decomposition of a stress tensor to hydrostatic and deviatoric components; Equations of equilibrium;

Unit 2

State of strain at a point; Principal strains; Strain-displacement relations for finite and infinitesimal strains; Strain compatibility conditions; Constitutive Equations: General theory; generalized Hooke's law for isotropic and anisotropic material; Common equations of elasticity theory like Mitchel-Beltrami and Navier equations; Principle of Virtual work; Strain energy and Ca stigliano's theorem

Unit 3

Solution of Some Special Boundary Value Problems: Simplifications; two-dimensional problems in rectangular and polar coordinates; Airy's stress function; Principle of superposition, torsion of bars; Membrane analogy; Plane problems in Cartesian and polar coordinates, Stress functions, axisymmetric problems. Criterion of yielding, Tresca and VonMises criterion of yielding, Yield surface; Representation of failure theories in stress space

Textbooks:

1. Timoshenko S. P. and Goodier J. N. - ‘Theory of Elasticity’- McGraw Hill International Editions, 1970 - 3rd Edition
2. L. S. Srinath - ‘Advance Mechanics of Solids’ - McGraw Hill Education - 2009 - 3rd Edition

Reference Books:

1. M. H. Sadd, Elasticity: theory, applications, and numeric, 3rd edition, Academic Press, 2014.
2. R. G. Budynas, Advanced Strength and Applied Stress Analysis, 2nd Edition, McGraw Hill, 1999

23MEE463	COMPUTATIONAL FLUID DYNAMICS	L-T-P-C: 3-0-3-4

Course Objectives

The course will enable the students to

- To study the basic governing equations and understand the basic properties of CFD.
- To understand discretization techniques and solving methods for improving accuracy.
- To inculcate the knowledge required to solve real-time physical problems using simulation software.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Understand the classification of PDEs, and governing equations.	Understand
CO02	Understand the basic principles of computational methods.	Understand
CO03	Apply finite volume method to solve steady and unsteady diffusion, advection-diffusion problems.	Apply
CO04	Select Solution algorithms and various discretization schemes.	Understand
CO05	Solve engineering problems using CFD software.	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3	2	2	3							1	3			1
CO02	3	3	2	2	3							1	3			1
CO03	3	3	2	2	3				1	1		1	3			1
CO04	3	3	2	2	3				1	1		1	3			1
CO05	3	3	2	2	3				1	1		1	3	2		1

Syllabus

Unit 1*

Introduction to Computational Fluid Dynamics and Principles of Conservation: Continuity Equation, Navier Stokes Equation, Energy Equation and General Structure of Conservation Equations, Classification of Partial Differential Equations and Physical Behavior, Approximate Solutions of Differential Equations: Error Minimization Principles. [7 hours]

Fundamentals of Discretization: Finite Element Method, Finite Difference and Finite Volume Method, Consistency, Stability, and Convergence. 1-D Steady State Diffusion Problems- Source term linearization, Implementation of boundary conditions. [7 hours]

Unit 2

1-D unsteady state diffusion problems: implicit, fully explicit and Crank-Nicholson scheme. Finite volume discretization of convection-diffusion problem. Central difference scheme, Upwind scheme, Exponential scheme and Hybrid scheme, Power law scheme, Generalized convection-diffusion formulation, Finite volume discretization of two-dimensional convection-diffusion problem. [8 hours]

The concept of false diffusion, QUICK scheme, TVD schemes and flux limiter functions. [4 hours]

Unit 3

Finite Volume Discretization of 2-D unsteady State Diffusion type Problems, Solution of Systems of Linear Algebraic Equations: Elimination Methods, Iterative Methods [5 hours]

Discretization of Navier Stokes Equations, primitive variable approach, SIMPLE Algorithm, SIMPLER Algorithm, Unstructured Grid Formulation. [4 hours]

Introduction to Turbulence Modeling, Important features of turbulent flow, General Properties of turbulent quantities, Reynolds average Navier stokes (RANS) equation, Closure problem in turbulence: Necessity of turbulence modeling and applications. [6 hours]

Laboratory practice. [10 hours]

List of computational exercises

1. Computational solution of 1-D heat conduction equation using implicit, fully explicit and Crank-Nicholson scheme.
2. Computational solution of 1-D heat conduction equation using implicit, fully explicit and Crank-Nicholson scheme.
3. Computational solution of convection-diffusion problem using Central difference scheme, Upwind scheme, Exponential scheme and Hybrid scheme, Power law scheme.
4. Solve practical fluid dynamics and heat transfer problems using CFD tools such as OpenFOAM, Ansys Fluent etc.

Textbooks:

1. Versteeg, H.K., and Malalasekara, W, "An Introduction to Computational Fluid Dynamics", The Finite Volume Method, 2007.
2. Moukalled, F., Mangani, L., &Darwish, M. "The finite volume method in computational fluid dynamics. An Advanced Introduction with OpenFOAM and Matlab", 2016

Reference Books:

1. Patankar, S.V., "Numerical Heat Transfer and Fluid Flow", Hemisphere Publishing Corporation, 1980.
2. Anderson, J. D., & Wendt, J., "Computational fluid dynamics" (Vol. 206). New York: McGraw-Hill, 1995.

23MEE464	COMPUTATIONAL AND EXPERIMENTAL VIBRATION ANALYSIS	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- Familiarize students with the mathematical modelling and analysis of mechanical vibration systems
- To make students to understand and appreciate the importance of vibrations analysis in design process
- To select appropriate sensors and design experimental setup for vibration analysis
- To perform modal analysis and interpret the experimental data

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Perform free vibration analysis of single degree of freedom system	Analyze
CO02	Perform forced vibration analysis of single degree of freedom system	Analyze
CO03	Solve and find the natural frequency and modes of vibration of multi-dof systems.	Analyze
CO04	Design vibration absorbers for specific applications	Apply
CO05	Select suitable transducers and perform experimental vibration analysis	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3	2	3	1	2						1	3			1
CO02	3	3	2	3	1	2						1	3			1
CO03	3	3	2	3	1	2						1	3			1
CO04	3	2	3	2	1	2						1	3			1
CO05	3	3	3	3	1	2			1			1	3			1

Syllabus

Unit 1

Damped and undamped free vibration of single degree of freedom systems. Forced vibration – response under harmonic excitation – frequency response and phase plots for rotating unbalance and support excitation. Response under arbitrary excitation – Convolution integral, method of Fourier transform. Types of damping – equivalent viscous damping. [12 Hours]

Unit 2

Two degree and multi-degree of freedom systems – formulation and solution of matrix eigenvalue problem – definition of modes of vibration – orthogonality and orthonormality of modal vectors. Decoupling of equations of motion – theoretical modal analysis. Forced vibration of two dof system – undamped and damped vibration absorbers. [12 Hours]

Continuous systems – Free vibration analysis of strings and beams – natural frequency and modes of vibration. [6 Hours]

Unit 3

Experimental vibration analysis – Different types of sensors, exciters and its selection. Introduction to experimental modal analysis – Fast Fourier transforms (FFT) – Measurement of damping from time and frequency domain data. Introduction to condition monitoring – Case studies. [15 Hours]

Textbooks:

1. W. T. Thomson, “Theory of vibrations with applications,” Pearson, 1997
2. Fundamentals of vibrations, Leonard Meirovitch, McGraw Hill International edition,2010
3. Sujatha. C. *Vibration and acoustics*. Tata McGraw Hill Education Pvt. Limited, 2009

Reference Books:

1. Norton M. and Karczub D. - 'Fundamentals of Noise and Vibration Analysis for Engineers' - Cambridge University Press - 2003 - 2nd Edition.
2. Ewins, David J. Modal testing: theory, practice and application. John Wiley & Sons, 2009.

23MEE465	COMPUTATIONAL FRACTURE MECHANICS	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- To introduce fracture mechanics and various fracture parameters
- To understand the concepts of linear-elastic and elastic-plastic fracture mechanics
- To impart the knowledge on experimental methods of determining fracture toughness
- To understand the application of finite elements in solving different field problems

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Estimate linear elastic fracture parameters for components with crack	Evaluate
CO02	Derive the J-integral for analyzing the stress-strain field around the crack for non-linear materials	Analyze
CO03	Determine the fracture toughness of metals as per ASTM standards	Evaluate
CO04	Apply computational techniques to solve fracture mechanics problems.	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2	2	3			1					1	3		1	
CO02	2	3	3	3								1	3		2	
CO03	2	2	3	3		1	2					1	2		2	
CO04	2	2	3	3	3	1	1					1	2	3	3	2

Syllabus

Unit 1

Introduction to Fracture Mechanics: Fundamentals of elasticity and plasticity theory, types of Failure, historical perspective, ductile, brittle fracture, Stress concentration effect of flaws, Griffith energy balance, the energy release rate (G), instability and resistance curve.

Stress analysis of cracks, Linear Elastic Fracture Mechanics (LFEM), modes of fracture, stress intensity factor, prediction, fracture toughness, crack tip plasticity, plastic zone, Dugdale approach. [15 hours]

Unit 2

Elastic Plastic Fracture Mechanics (EPFM): Crack-Tip-Opening Displacement (CTOD), The J contour integral and its determination, relationships between J and CTOD, crack-growth resistance curves, J-controlled fracture.

Applications: Introduction to fracture toughness testing of metals and non-metals for determination of fracture parameters, Application of fracture mechanics concepts in the analysis of fatigue crack growth. [15 hours]

Unit 3

Overview of numerical methods for fracture mechanics problems, traditional methods in computational fracture mechanics – Stress and displacement matching, element crack advance, contour integration, virtual crack extension, The energy domain integral – theoretical background, generalization to three dimensions, finite element implementation, , Design of finite element mesh, Linear elastic convergence study. [15 hours]

Textbooks:

1. Anderson, T. L., "Fracture Mechanics: Fundamentals and Applications", 3/e, CRC Press, 2005.
2. Broek, D., "Elementary engineering fracture mechanics". Springer Science & Business Media.2012.

Reference Books:

1. Prashanth Kumar, "Elements of Fracture Mechanics", McGraw Hill Education (India) Private Limited, 2009.
2. Broek, D., "The Practical Use of Fracture Mechanics". Kluwer Academic Publishers.1989.
3. Knott J. K., "Fundamentals of Fracture Mechanics", 3/e, Butterworth Heinemann, 1993.
4. Suresh, S., "Fatigue of Materials", 2e, Cambridge University Press, 1998.

23MEE466	COMPUTATIONAL MULTIBODY DYNAMICS	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- To introduce concepts and techniques of multibody system dynamics
- To impart the techniques of formulating equations of motion of multibody system
- To enable the students to solve equations of motion using software

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Understand the basic concepts of multibody dynamics	Understand
CO02	Perform kinematic and modeling analysis of multibody systems	Analyze
CO03	Analysis and formulation of dynamic equations of multibody systems	Analyze
CO04	Apply computational techniques to solve equations of motion of multibody systems	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2	1	1									3		1	
CO02	2	2	2	1									2		1	
CO03	2	2	3	1									2		1	
CO04	2	2	3	1	3								2	3	1	2

Syllabus

Unit 1

Introduction to Computational dynamics, motion and constraints, degrees of freedom, kinematic analysis, dynamic equations, forward and inverse dynamics, planar and spatial dynamics. Numerical methods, Linear algebra – Matrices, vectors, solutions of linear system of equations. Kinematics – Velocity and acceleration equations, constrained kinematics, joint and driving constraints, computational approach in kinematics, kinematic modelling and analysis. [15 hours]

Unit 2

Dynamics - D'Alembert's principle and Newton–Euler equations, constrained dynamics, Lagrange multipliers, virtual displacements, virtual work, workless constraints, principle of virtual work in statics and dynamics, augmented formulation, embedding technique, amalgamated formulation, open-chain and close-chain systems, Gibbs-Apple equation, Hamilton formulation. [15 hours]

Unit 3

Constrained dynamics - Generalized Inertia, Mass Matrix and Centrifugal Forces, Equations of Motion, System of Rigid Bodies, Elimination of the Constraint Forces, Lagrange Multipliers, Constrained Dynamic Equations, Joint Reaction Forces, Elimination of Lagrange Multipliers, State Space Representation, Numerical Integration, Algorithm and Sparse Matrix Implementation, Differential and Algebraic Equations, Inverse Dynamics, Static Analysis. [15 hours]

Textbooks:

1. Ahmed A. Shabana, "Computational Dynamics", Wiley, 2010.
2. Roberson R. E., and Richard S, "Dynamics of multibody systems", Springer-Verlag, 1988.

Reference Books:

1. Thomas R. Kane and David A. Levinson, "Dynamics Theory and Application", McGraw-Hill, Book Company, 1985.
2. Reza N. Jazar, "Advanced Dynamics", John Wiley & Sons, Inc. 2011.
3. Chaudhary, H., Saha, S.K., "Dynamics and Balancing of Multibody Systems", Springer, 2009.
4. Parviz E. Nikravesh, Computer-Aided Analysis of Mechanical Systems, Prentice Hall, 1988

23MEE467	COMPUTATIONAL MATERIAL SCIENCE	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- To understand the concepts of statistical mechanics and solid-state physics
- To introduce computational methods for investigating mechanical behavior of materials
- To introduce the usage of computational methods for material design.
- To impart the knowledge of molecular dynamics and its implementation using LAMMPS.
- To identify, formulate, and solve interdisciplinary problems relevant for material science.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	To gain knowledge on fundamental topics like statistical mechanics.	Evaluate
CO02	Have exposure to atomistic simulation techniques and their applications.	Understand
CO03	Develop molecular dynamics simulations for a given application using LAMMPS	Create
CO04	Apply data driven science techniques for material design.	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	2	2	2	2								1	3		1	
CO02	3	2	2	2	1							1	3		2	2
CO03	3	3	3	3	3	1			1				2		2	2
CO04	3	3	3	3	3	1	1		1				2	3	3	2

Syllabus

Unit 1

Introduction: Computational material science, need for discrete computation. [2 hours]
Crystal lattice, Reciprocal lattice, symmetry elements, space groups, generation of crystals [10 hours]

Unit 2

Statistical Mechanics: Review of probability and statistics, quantum states of a system, equations of state, canonical and microcanonical ensemble, partition function, energy levels for molecules, equipartition theorem, minimizing the free energy, partition function for identical particles, Maxwell distribution of molecular speeds. [12 hours]

Unit 3

Molecular dynamics: basic machinery, running, measuring, and analyzing, interatomic potentials, LAMMPS, Examples. [15 hours]
Introduction to Intelligent Computational Nanotechnology – Data driven modeling and scientific computation. [6 hours]

Textbooks:

1. Ashcroft, N., and Mermin, N. D., Solid state physics, Cengage, 2003.
2. Pathria, R. K., and Beale, P. D., Statistical Mechanics, Academic Press Inc., 202221.
3. Haile, J. M., Molecular Dynamics Simulation: Elementary Methods, Wiley Interscience, 1997

Reference Books:

1. Ercolessi, F., A Molecular Dynamics Primer, Notes of Spring College in Computational Physics, ICTP, Trieste, June 1997.
2. Kutz, J. N., Brunton, S., Brunton, B., and Proctor, J., Data driven Modeling and Scientific Computation: Method for Complex Systems and Big Data, Oxford University Press, 2013.
3. Frenkel, D., and Smit, B., Understanding Molecular Simulation: From Algorithms to Applications, Academic Press, 2001

SPECIALIZATION

ELECTRIC VEHICLE TECHNOLOGY

SYLLABUS

23MEE470	ELECTRICAL DRIVES AND CONTROLLERS	L-T-P-C: 2-0-3-3

Course Objectives

The course will enable the students to

- To analyze the basic requirements of motors and controllers for EV.
- To understand suitability of electric motor & their control
- To apply speed control of Induction motor
- To describe fundamentals of BLDC motor
- To understand PWM techniques of Inverter for Induction motor
- To design Electric vehicle drives and controls

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Analyze the requirements of EV motors	Analyze
CO02	Evaluate the suitability of electric motor & their control for EV	Evaluate
CO03	Apply the knowledge of speed control of Induction motor for EV design	Apply
CO04	Analyze performance of BLDC motor	Analyze
CO05	Design Electric vehicle drives and controls	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3	2					1	1	1		1	2			
CO02	3	2	1					1	1	1		1	2			
CO03	3	2	2					1	1	1		1	2			
CO04	3	3	2					1	1	1		1	2	1		1
CO05	3	3	2					1	1	1	1	1	2	1		1

Syllabus

Unit 1

Speed Torque Characteristics of EV and EV Motors, Suitability study of Electric motors for EV application. Fundamentals of magnetic circuits, Lorentz equation, Maxwell's Equation and Electromagnetic torque production. Types of motors: DC, AC, BLDC, PMSM and Switched Reluctance type.

Unit 2

Basics of DC Motor, Torque speed characteristics, DC Motor dynamics, Field Weakening Control, Four quadrant operation. Introduction to DC – DC converters: Buck, Boost and Buck Boost Converters, Two and Four Quadrant Choppers.

Unit 3

Induction Motor control: Rotating Magnetic Field, Basics of Induction motor, Speed-Torque Curve. Torque control for Induction motor. Introduction to Inverters for induction motor control - PWM and Inverter: Sinusoidal PWM

Unit 4

Permanent Magnetic Brush-Less DC motor Drives: Basic principles of BLDC Motor Drives, BLDC Machine construction, Classification properties of PM material, Alnico, Ferrites, Rare-Earth PMs

List of Experiments:

1. Demonstration of Wiring layout of Electric Vehicles
2. Current/Voltage control of Electric Vehicles
3. Control Circuit of Induction motor
4. Demonstration of controller s and actuators in Electric vehicles
5. V/f control of three phase induction motor
6. Speed control of BLDC motor in two-wheeler
7. Speed control of SRM motor in three wheeler
8. Simulation of Four quadrant operation of three phase induction motor
9. MOSFET based Step up and step down chopper
10. VI characteristics of SCR, IGBT and MOSFET
11. Three phase IGBT based PWM inverter control of Induction motor

Textbooks:

1. K Wang Hee Nam: AC Motor Control & Electrical Vehicle Application, CR Press, Taylor &FrancisGroup, 2019
2. C.C Chan, K.T Chau: Modern Electric Vehicle Technology, Oxford University Press Inc., New York2001

Reference Books:

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
2. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.
3. Power Electronics: Circuits, Devices and Applications- M.H Rashid, Pearson Education, PHI 3rdEdition, New Delhi 2004

23MEE471	ELECTRIC VEHICLE DESIGN	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- To familiarize with the basic electric components configuration for the Electric Propulsion unit.
- To expose utilization of different Energy storage system and Hybridization.
- To inculcate the knowledge while resolving issue of Energy management system

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Demonstrate the electric components in detail.	Understand
CO02	Apply controls of different motors for drive system efficiency.	Apply
CO03	Understand various energy storage devices including the Hybridization.	Understand
CO04	Apply energy management system strategies to solve problem	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3	2										2	1		
CO02	3	3	2	2								1	2	1		
CO03	3	3	2										2	1	1	
CO04	3	3	2									1	2	1	1	

Syllabus

Unit 1

Electric Propulsion unit: Introduction to Electric Vehicle Dynamics-Introduction to electric components used in electric vehicles. Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives. Configuration and control of Switch Reluctance Motor drives, drive system efficiency.

Unit 2

Energy Storage: Introduction to Energy Storage Requirements Electric Vehicles, Battery based energy storage and itsanalysis, Fuel Cell based energy storage and its analysis.

Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis. Hybridization of different energy storage devices.

Unit 3

Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles Classification of different energy management strategies, comparison of different energy management strategies Implementation issues of energy management strategies.

Textbooks:

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals", CRC Press, 2003.

Reference Books:

1. MehrdadEhsani, YimiGao, Sebastian Longo, KambizEbrahimi, "Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design", CRC Press, Third edition.
2. James Larminie, John Lowry, "Electric Vehicle Technology" Wiley, Second edtiion.2012.
3. Sandeep Dhameja, "Electric Vehicle Battery Systems", Newnes, 2001

23MEE472	VEHICLE ENERGETICS AND BATTERY MANAGEMENT SYSTEM	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- To understand the different types of energy storage system.
- To describe about the battery characteristic & parameters.
- To understand the energy requirement of an electric vehicles.
- To acquire the concepts of battery management system and design the battery pack.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Analyze different types of energy storage system and thermal loads in EVs.	Analyze
CO02	Understand the various parameters that forms the battery management system.	Apply
CO03	Model the thermal behavior battery packs with different cooling approaches.	Apply
CO04	Apply the concepts of battery management system and design the battery pack.	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3	2		1								2	1		
CO02	3	3	2		1		2						2	1		
CO03	3	3	2		1	1	2	1					2	1		2
CO04	3	3	2		1	1							2	1		2

Syllabus

Unit 1

Introduction: Lithium ion cell types, datasheet reading, dimensions, maximum charge and discharge currents, life cycle assessment – Lithium ion cell characteristics: Dependence of cycle life, state of charge (SOC) and state of health (SOH) on various parameters – Battery pack design: Electrical, mechanical and thermal considerations.

Unit 2

Thermal Loads and Comfort conditions: thermophysical properties of vehicle components (thermal transmittance, thermal bridges, thermal inertia, solar transmission). Energy balance of the vehicle. Calculation of winter and summer thermal loads. Basic concepts on Thermal Comfort: subjective and objective indices. dynamic behavior of HVAC system in combination of the battery thermal management.

Unit 3

Battery management system – Introduction – Types: Standalone and master - slaveconfiguration–- Functionality: Simple circuits for cell balancing(active and passive balancing), Protection: Cell voltage Protection, current in Charge /discharge Protection,–temperature in Charge/discharge Protection, Pre-charge and Pre-discharge circuits-High voltage architecture/safety-insulation protection, current measurement, stackable architectures, battery junction box. Contactors / relay selection.

Unit 4

Lithium-ion battery cells modelling. Principle of battery behavior from the thermal management point of view. Modeling of the thermal behavior of batteries. Comparison of different battery cooling approaches: air cooling, liquid cooling, and new approaches based on metal foams and Phase Change Materials (PCM).

Unit 5

SOC and SOH estimation techniques: Open circuit voltage tracking, Impedance tracking and Extended Kalman Filter - Commercially available battery monitors and protectors: Introduction of IC's from Texas Instrumentation, Renesas, Analog - Standards: AIS – 038 and AIS – 156.

Textbooks/Reference Books:

1. John Warner, "The Handbook of Lithium-Ion Battery Pack Design: Chemistry, Components, Types and Terminology", Elsevier 2015
2. Sandeep Dhameja, "Electric Vehicle Battery Systems", Newnes, 2002
3. Datasheets: BQ79652 (Texas Instrument)
4. Standards: AIS – 038, AIS – 156

23MEE473	MODELLING AND SIMULATION OF EHV	L-T-P-C: 3-0-3-4

Course Objectives

The course will enable the students to

- To understand the modeling of vehicle performance parameters.
- To model battery electric vehicles.
- To demonstrate the concepts of energy management system.
- To describe the vehicle dynamic control systems.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Understand the modelling of vehicle dynamics and performance parameters.	Understand
CO02	Model electric vehicles with battery.	Analyze
CO03	Describe the drive train characteristics.	Remember
CO04	Apply the concepts of energy management system.	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2	2						1	1			2	1		
CO02	2	3	2		1	1		1	1	1			2	1		1
CO03	2	3	2		1	1			1	1			2	1		
CO04	3	2	2		1	1			1	1			2	1		

Syllabus

Unit 1

Modelling Vehicle Acceleration - Acceleration performance parameters, modelling the acceleration of an electric scooter, modelling the acceleration of a small car.

Unit 2

Electric Vehicle Modelling - Tractive Effort, Rolling resistance force, Aerodynamic drag, Hill climbing force, Acceleration force, Total tractive effort, Modelling Electric Vehicle Range - Driving cycles, Range modelling of battery electric vehicles, Constant velocity range modelling, Range modelling of fuel cell vehicles, Range modelling of hybrid electric vehicles.

Unit 3

Modelling and Characteristics of EV/HEV Powertrains Components- ICE Performance Characteristics, Electric Motor Performance Characteristics - Battery Performance Characteristics-Transmission and Drivetrain Characteristics-Regenerative Braking Characteristics-Driving Cycles Modelling and Analysis of Electric and Hybrid Electric Vehicles Propulsion and Braking - Longitudinal Dynamics Equation of Motion - Vehicle Propulsion Modelling and Analysis - Vehicle Braking Modelling and Analysis. Handling Analysis of Electric and Hybrid Electric Vehicles - Simplified Handling Models Energy/Power Allocation and Management - Power/Energy Management Controllers - Rule-Based Control Strategies - Optimization-Based Control Strategies.

Unit 4

Control of Electric and Hybrid Electric Vehicle Dynamics - Fundamentals of Vehicle Dynamic Control (VDC) Systems, VDC Implementation on Electric and Hybrid Vehicles – Case Studies, Rechargeable Battery vehicles, Hybrid Vehicles, Fuel Cell Powered Bus.

List of Experiments: Simulation Tools: MATLAB/Simulink

1. Mathematical model of EV longitudinal dynamics
2. Motor and alternator model of EV
3. Engine modeling
4. Li-Ion battery pack modeling
5. Vehicle power train components modeling
6. Introduction to HIL setup using TI/
7. Peripheral programming TI/using Matlab/simulink
8. Introduction to lookup tables/optimization tool box in Matlab
9. Modeling and validation of engine
10. Modeling and validation of motor
11. Modeling and validation of Alternator
12. Modeling and validation of battery pack
13. HIL simulation of ECU
14. VIL testing of ECU

Textbooks:

1. James Larminie, John Lowry, “Electric Vehicle Technology Explained”, John Wiley & Sons Ltd, 2003.
2. Amir Khajepour, Saber Fallah and AvestaGoodarzi, “Electric and Hybrid VehiclesTechnologies, Modelling and Control: A Mechatronic Approach”, John Wiley & Sons Ltd, 2014.
3. Processor-in-the-Loop Simulation - MATLAB & Simulink - MathWorks India

Reference Books:

1. Antoni Szumanowski, “Hybrid Electric Power Train Engineering and Technology: Modelling, Control, and Simulation”, IGI Global, 2013.
2. MehrdadEhsani, Yimin Gao, Ali Emadi, “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles_ Fundamentals, Theory, and Design, Second Edition”, CRC Press, 2010.
3. Patankar, P., Kulkarni, S. (2022). MATLAB and Simulink In-Depth: Model-based Design with Simulink and Stateflow, User Interface, Scripting, Simulation, Visualization and Debugging. India: BPB Publications.

23MEE454	E-NOISE VIBRATION AND HARSHNESS	L-T-P-C: 2-0-3-3

Course Objectives

The course will enable the students to

- Learn measurement and analysis techniques of vehicle noise and vibration
- Expertise in the application of NVH refinement in vehicles and their systems
- Understanding of advanced techniques for reduction of NVH
- Process and analyze the signals using vibration and noise reduction techniques

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Analyse vibrations of SDOF, MDOF and Continuous systems, vibration measurement and analysis	Analyze
CO02	Measure vibration and noise signals and evaluate them applying signal processing and analysis techniques including modal analysis	Analyze
CO03	Evaluate acoustic materials and apply them for noise reduction	Evaluate
CO04	Apply Principles of NVH refinement in vehicles and their systems – power train, chassis, body, suspension, etc.,	Apply
CO05	Apply advanced Techniques – NVH simulation, Statistical Energy Analysis, Acoustic Holography, beam forming, etc.,	Apply

CO-PO Mapping: [affinity[#]: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2	2		1	1			1	1		1	2	1		1
CO02	3	2	1	2	1	1			1	1		1	2	1		1
CO03	3	2	2		1	1			1	1		1	2	1	1	1
CO04	3	2	2	2	1	1	1		1	1		1	2	1		1
CO05	3	2	2		1	1	1		1	1		1	2	1		1

Syllabus

Unit 1

Introduction to Automotive NVH-Fundamentals of vibrations –Vibration of Single degree of freedom, Multi degrees of freedom - Vehicle vibration measurement and analysis.

Unit 2

Fundamentals of acoustics, Vehicle noise measurement, Noise Standards for electric vehicle, Types of Signals, Signal conditioning and processing, Data Acquisition Systems, Analysis and presentation of data Ride Comfort – Sound Quality and psychoacoustics –Sound Quality Metrics, Subjective–objective correlation –Squeak and Rattle-Vibration isolation and Transmission.

Unit 3

Fourier series – Fourier Integrals –- Discrete Fourier Transforms – Fourier and Laplace Transforms - Filters - Windowing - Time Sampling and Aliasing - Random signal processing and analysis -Theory of modal analysis - Methods for performing modal analysis, Modal analysis of Electric motors, motor drive system, battery and battery management systems.

Unit 4

Refinement of e-Power train systems, Chassis and Suspension and Body –Vibro-acoustics – Aerodynamic noise and its refinement–Aeroacoustics Simulation methods in Automotive NVH – FEM, BEM, MBD, CFD, TPA, SEA, Vibro and Aero-acoustics,Acoustic shielding and sound packages for electronics system noise and motors – Acoustic materials and their characterization-Special issues related to EHV and NVH.

List of Experiments:

1. Sound Power evaluation using SPL measurements- ISO 3744
2. Motor SPL measurement as per SAE
3. Modal Testing and analysis
4. Signal Analysis using FFT
5. Demonstration of inverse square law
6. Demonstration of the effect of sound absorbing and insulating materials
7. Noise source identification by masking method
8. Motor vehicle pass-by noise- IS 3028/ISO 362
9. Motor vehicle Stationary noise (tail pipe noise)- ISO 10399
10. Sound Quality analysis - Jury Rating, Metrics and its correlation
11. Vibration measurement and Modal analysis

Textbooks:/Reference Books:

1. Xu Wang, “Vehicle Noise and Vibration Refinement”, CRC Press Publication, 2010.
2. J.M. KrodkiewskI, “Mechanical Vibration” Univ of Melbourne, 2008
3. Kihong Shin and Joseph K. Hammond “Fundamentals of Signal Processing for Sound and Vibration Engineers”, Johe Wiley, 2008.
4. S.S.Rao, “ Mechanical Vibrations”, Prentice- Hall, 2011

23MEE474	TESTING AND CERTIFICATION OF ELECTRIC HYBRID VEHICLES	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- To acquire knowledge in the field of E-vehicle certification.
- To analyze the data of static testing of E-vehicle.
- To understand the concept of dynamic testing of electric vehic1le.
- To describe about various E-vehicle component testing.
- To understand the fundamentals of charging station & hybrid electric vehicle testing

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Acquire knowledge in the field of E-vehicle certification.	Understand
CO02	Apply the concept of static testing of E-vehicle	Apply
CO03	Describe the concept of dynamic testing of electric vehicle.	Understand
CO04	Demonstrate about the various E-vehicle component testing	Understand
CO05	Acquire knowledge on the insight of charging station & hybrid electric vehicle testing	Remember

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2	1			1	1			1		1	2	1		
CO02	2	2	2			1	1			1		1	2	1		
CO03	2	2	1			1	1			1		1	2	1		
CO04	2	2	1			1	1			1		1	2	1		
CO05	3	2	2			1	1			1		1	2	1		

Syllabus

Unit 1

Need for testing and validation – Vehicle Classification vehicle development process - Types of testing –Objectives of testing- Measurement of Real world usage patterns and their analysis – design of test specifications. Homologation & its types, Regulations overview (EEC, ECE, FMVSS, AIS, CMVR), Type approval Scheme, Homologation for export, Conformity of Production, various Parameters, Instruments and Types of test tracks, Hardware in The Loop (HIL) concepts for EV/HEVs.

Unit 2

CMVR physical verification, Tyre Tread Depth Test, Vehicle Weighment, Horn installation, Rear view mirror installation, Tell Tales, External Projection, Wheel Guard, Arrangement of Foot Controls for M1 Vehicle, Angle & Dimensions Measurement of Vehicle, The requirement of temporary cabin for drive– away – Chassis, electric vehicle – Safety norms, Energy consumption and power test.

Unit 3

EMI/EMC/EMS testing and regulations-Safety and crash testing– Regulatory and NCAP tests – Injury criteria - Materials and material testing-Servo-hydraulics and fatigue testing-Testing of EHVs Hood Latch, Gradeability, Pass-by Noise, Interior Noise, Turning Circle Diameter & Turning Clearance Circle Diameter, Steering Effort, Constant Speed Fuel Consumption, Cooling Performance, Speedo-meter Calibration, Range Test, Maximum Speed, Acceleration Test, Coast-down test, Brakes Performance ABS Test, Broad band / Narrow band EMI Test, Electric vehicle – Range Test.

Unit 4
Horn Testing, Safety Glasses Test: Windscreen laminated and toughened safety glass, Rear View Mirror Test, Hydraulic Brakes Hoses Fuel Tank Test: Metallic & Plastic, Hinges and Latches Test, Tyre& Wheel Rim Test, Bumper Impact Test, Side Door Intrusion, Crash test with dummies, Demist test, Defrost Test, Interior Fittings, Steering Impact test (GVW).

Unit 5
Hybrid Electric Vehicles Tests (M and N category), Tests for Hybrid Electric System Intended for Retro-fitment on Vehicles of M and N Category (GVW < 3500 kg), Test for Electric Propulsion kit intended for Conversion, Test for Electric Vehicle Conductive AC Charging System, and Test for Electric vehicle conductive DC charging system.

Textbooks:

1. "Vehicle Inspection Handbook", American Association of Motor Vehicle Administrators
2. Michael Plint& Anthony Martyr, "Engine Testing & Practice", Butterworth Heinmenn, 3rd ed, 2007
3. Martyr and Plint, "Engine Testing – Theory and Practice", Butterworth Heinemann, 2007.
4. Douglas Montgomery, "Design and Analysis of Experiments", John Wiley, 2008

Reference Books:

1. Proceedings- Automotive Testing & Certification held on 20th to 24th July 2010 at ARAI, PUNE
2. Bosch Automotive Handbook, Robert Bosch, 7th Edition, 2007.
3. Jiju Antony, "Design of Experiments" Butterworth & Heinemann, 2003.
4. Hinkleman and Kempthone, "Design and Analysis of Experiments – Advanced Experimental Design", John Wiley& Sons, 2005
5. CMVR, TAPS document, Indian Standards, AISs, ISOs, etc

23MEE475	ELECTRIC AND HYBRID VEHICLES	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- To familiarize various types of hybrid drive-train topologies
- To introduce mathematical models to describe vehicle performance
- To categorize Electric Propulsion unit and the Energy storage system
- To understand the case studies of designing the Hybrid Electric Vehicle (HEV) and Battery Electric Vehicle (BEV)

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Compare and contrast different types of hybrid drive-train topologies	Understand
CO02	Solve mathematical models to describe vehicle performance	Apply
CO03	Categorizing electric propulsion unit and the energy storage system	Understand
CO04	Understand the case studies of designing the hybrid electric vehicle (HEV) and battery electric vehicle (BEV)	Understand

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2	1										2			
CO02	3	2	2			1	1					1	2			1
CO03	3	2	1			1	1					1	2			
CO04	3	2	1										2			

Syllabus

Unit 1

Electric Drive-trains and Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, Architecture – Basic architecture of hybrid drive train, power flow control in hybrid drive-train topologies, torque coupling and analysis of parallel drive train, architecture of electric drive-train, fuel efficiency analysis.

Unit 2

Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.

Unit 3

Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Hybridization of different energy storage devices. Sizing the drive system: Matching the electric machine and the internal combustion engine, Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology.

Unit 4

Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies.

Textbooks /Reference Books:

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals", CRC Press, Second Edition 2011.
2. Mehrdad Ehsani, Yimi Gao, Sebastian Longo, KambizEbrahimi, "Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design", CRC Press, third edition(Check) 2018
3. James Larminie, John Lowry, "Electric Vehicle Technology" Wiley, second ediion.2012.
4. "Electricand Hybrid Vehicles", Routledge, Second Edition 2020

23MEE476	MATERIALS FOR EVS	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- To acquire problem oriented in depth knowledge of automotive materials and manufacturing.
- To apply knowledge of Electric vehicle materials and selection of material in the field.
- To describe the integration of manufacturing and new technology applications in the EV industry.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Classify the materials used for EV applications	Understand
CO02	Identify the appropriate manufacturing processes of EV applications	Understand
CO03	Select the suitable materials for EHV applications	Apply
CO04	Develop new materials and process for advanced EV applications	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]											Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	1	1									1	2		2	
CO02	3	2	1									1	2		2	
CO03	3	2	1									1	2		2	
CO04	3	2	2									1	2		2	

Syllabus

Unit 1

Introduction to common engineering materials, Iron-carbon phase diagram: eutectic, pearlitic, eutectoid reactions, classifications of steels and cast irons, Strengthening mechanisms: Effect solid solutions, Heat treatment, surface engineering, High Strength Low Alloy Steels (HSLA), advanced high strength steels, copper base alloys, Ultra-light weight metallic materials: Aluminium base alloys, magnesium base alloys, titanium alloys, typical properties of alloy grades, methods of identification of alloy grades, standards for automotive materials. Manufacturing considerations for various lightweight automotive structures

Unit 2

Primary, secondary and advanced processes for automotive applications - Casting, forging, forming, fusion and solid state joining, powder metallurgy, 3D printing, instruction to unconventional and advanced metallurgical processes, Effect of alternate fuels on materials.

Selection, processing and design of materials for auto components: cylinder block, Cylinder head, piston, piston ring, connecting rod, crank shaft, crank case, cam, cam shaft, engine valve, gear wheel, clutch plate, axle, bearings, chassis, spring, shock absorber, propeller shaft, body panel, radiator, brake pads, fuel tank and seats.

Unit 3

Advanced polymers and composites: Properties and applications for automotives, elastomers, silicon rubbers. Polymer & carbonFiber reinforced plastics, metal matrix /composites and nano-composites. Other Materials - Electrical insulating materials. Gaskets, automotive glasses, Sound insulating materials, Protective coating materials, bulletproof glasses etc. Automotive ceramics- Novel material for automotive applications, Graphene, Battery materials and technology. Futuristic technology and material for automotive applications, hybrid materials-processes and applications.

Unit 4

Case studies on Li-ion battery, polymer composites and sensor materials. Chemical reactions between fuel and metals, environmentally induced degradation.

Textbooks /Reference Books:

1. Michel F Ashby, “Material Selection in Mechanical Design”, 4th edition, Elsevier, 2011.
2. Michel F Ashby, “Material and Design: The Art and Science of Material Selection in Product Design”, Butterworth Heinemann, 2008.
3. John Mortimer, “Advanced Manufacturing in the Automotive Industry” Springer, 1997.
4. Harry Peck, “Design for Manufacturing”, Pitman Publications, 1983.
5. Cantor B, Johnston, Colin Grant and Patrick, “Automotive Engineering: Lightweight, Functional and Novel Materials”, Taylor & Francis Ltd, 2008

23MEE477	**AUTOMOTIVE INFOTRONICS**	**L-T-P-C: 2-0-3-3**

Course Objectives

The course will enable the students to

- Understand the working of various peripherals of automotive controller S12XE
- Make use of Code Warrior IDE for programming S12XE for various automotive applications
- Introduce basics of modeling, simulation and Hardware in Loop testing of various automotive subsystems
- Introduce to OSEK/VDX Environment, AUTOSAR layered software architecture

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Analyze working of various peripherals of automotive controller Kinetics K40	Analyze
CO02	Make use of Code Warrior IDE for programming Kinetis K40 for various automotive applications	Apply
CO03	Apply basics of modeling, simulation and Hardware in Loop testing of various automotive subsystems	Apply
CO04	Introduced to OSEK/VDX Environment, AUTOSAR layered software architecture	Remember

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2	2		1	1	1		1	1		1	2	1		1
CO02	2	2	1		1	1	1		1	1		1	2	1		1
CO03	3	2	2		1	1	1	1	1	1		1	2	1		1
CO04	2	2	1		1	1	1		1	1		1	2	1		1

Syllabus

Unit 1

Introduction to Automotive Controllers –Kinetis K40: 32-Bit Automotive Microcontroller, Port Integration, Memory mapping control, memory protection, External bus interface, interrupts, clock and reset, ADC, Scalable Controller Area Network, periodic interrupt timer, PWM, serial peripheral interfaces, Timer module

Unit 2

Body Controller Application Example, Programming using code warrior IDE. Introduction to longitudinal and lateral vehicle control, Modeling and simulation study of ABS, Adaptive cruise control, Electronic stability control, Active suspension control

Unit 3

Basics of Rapid Control Prototyping and Hardware-in-the-Loop simulation. X-by-wire technology: Brake-by-wire, Steer-by-wire and Throttle-by-wire, Sensors, Actuators and Controllers, Fault-tolerant electronic sub-systems. Introduction to OSEK/VDX Environment, AUTOSAR layered software architecture.

Laboratory Components:

1. Modeling and Simulation Experiments using MATLAB & Simulink – Controller Design for ABS, Steer-by-wire system and Throttle-by-wire system
2. Rapid Control Prototyping and Hardware-in-the-Loop Simulation of Controllers for Steer-by-wire system and Throttle-by-wire system Using MATLAb& Simulink Embedded Coder, on Texas Instruments - C2000 Development Board and SpeedGoat Real-time Target Machines

Textbooks /Reference Books:

1. MC9S12XEP100 Reference Manual Covers MC9S12XE Family.
2. Rajesh Rajamani, "*Vehicle Dynamics and Control*", Springer, 2005.
3. UweKiencke and Lars Nielsen, "*Automotive Control Systems: For Engine, Driveline, and Vehicle*", Second Edition, Springer 2005.
4. Joseph Lemieux, "*Programming in the OSEK/VDX Environment*", CMP Books, 2001
5. OSEK/VDX Environment, AUTOSAR layered software architecture, 2009.

23MEE478	MEMS FOR EV APPLICATIONS	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- To acquire knowledge on various techniques involved in MEMS device fabrication
- To familiarize with transduction mechanisms and modeling in different energy domains
- To apply MEMS skills to integrate automotive and EV sensors and actuators
- To design and analyze MEMS using soft tools

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Describe the process and various techniques involved in MEMS device fabrication	Remember
CO02	Understand the transduction mechanisms and modelling in different energy domains	Understand
CO03	Understand the applications of MEMS in automotive sensors and actuators	Understand
CO04	Design and analyze MEMS based sensors/actuators using CAD	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2	2										2	1	1	
CO02	3	2	1										2	1	1	
CO03	3	2	2										2	1	1	
CO04	3	2	1		1								2	1	1	1

Syllabus

Unit 1

Micro electro mechanical systems (MEMS), devices, and technologies. Micro-machining and microfabrication techniques, including planar thin-film processing, silicon etching, wafer bonding, photolithography, deposition, and etching.

Unit 2

Transduction mechanisms and modeling in different energy domains. Electrostatic Sensing and Actuation, Thermal Sensing and Actuation, Piezoresistive Sensors, Piezoelectric Sensing and Actuation, Magnetic Actuation-demo on electro mechanical sensor.

Unit 3

Computer-aided design for MEMS layout, fabrication, and analysis. MEMS for passenger safety in automotive vehicles, MEMS sensors for EV stability control applications, MEMS for tire pressure monitoring systems, MEMS pressure and flow sensors for Electric and Hybrid vehicles, RF MEMS for EV radar sensors, MEMS for passenger comfort in electric vehicles.

Textbooks/Reference Books:

1. Michael Kraft and Neil White, MEMS for Automotive and Aerospace Applications, 1st Edition, Woodhead Publishing, 2013
2. Chang Liu, Foundations of MEMS, 2nd Edition, Pearson Education, 2011
3. Tai-Ran Hsu, MEMS and Microsystems: Design, Manufacture, and Nanoscale Engineering, 2nd Edition, John Wiley & Sons, 2008
4. Jiri Marek, Hans-Peter Trah, Yasutoshi Suzuki, IwaoYokomori, Sensors for Automotive Applications, WILEY-VCH, 2003
5. Jan Korvink and Oliver Paul, MEMS: A Practical Guide to Design, Analysis and Applications, William Andrew Publishing, 2006.

SPECIALIZATION

DIGITAL MANUFACTURING

SYLLABUS

23MEE455	INDUSTRIAL INTERNET OF THINGS	L-T-P-C: 2-0-3-3

Course Objectives

The course will enable the students to

- The fundamental knowledge of industrial trends and revolutions.
- The industry standards in communication technology and various communication protocols.
- The visualization and data types in communication for the Industrial Internet of Things (IIoT).
- The demonstration of different wireless communication schemes and experimental validation.
- Programming the edge or fog computing node and sensor data visualization.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Describe the concepts and characteristics of Industry 4.0.	Understand
CO02	Comprehend different enabling technologies and their role in establishing Industry 4.0.	Evaluate
CO03	Understand different communication technologies used in Industry 4.0.	Understand
CO04	Perform edge and cloud computing and visualize the data.	Analyze
CO05	Apply IoT for the given applications.	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2	1		2				1	1		1	2			2
CO02	3	2	1		2				1	1		1	2			2
CO03	3	2	2		2		1		1	1		1	2			2
CO04	3	2	3		2	2	2	1	1	1		1	2			2
CO05	3	2	2		2	2	2	1	1	1		1	2			2

Syllabus

Unit 1

Introduction: The various industrial revolutions, digitalization, and the networked economy, drivers, enablers, comparison of industry 4.0 factory and today's factory, challenges. Cyber-Physical Systems, Robotic Automation, Collaborative Robots, Support Systems for Industry 4.0, Mobile Computing, Cyber Security, Augmented / Virtual reality, Artificial Intelligence, System integration, and Digital Twins.

Unit 2

Communication Technologies of IIoT

Communication Protocols: IEEE 802.15.4, ZigBee, Z Wave, Bluetooth, BLE, NFC, RFID, Industry standards communication technology (LoRA, WAN, OPC UA, MQTT), connecting into existing Modbus and Profibus technology, wireless network.

Unit 3

Visualization and IIoT Communication

Front-end EDGE devices, Emerging descriptive data standards for IIoT, Cloud database, could computing, Fog or Edge computing, pushing data to the cloud. Grabbing the content from a web page, sending data on the web, and Troubleshooting. Applications of IIoT. Case study: Health monitoring, smart city, Smart irrigation, Robot surveillance.

List of Experiments:
1. Introduction to Arduino and ESP8266 (Node MCU)
2. Introduction to Raspberry Pi and Installation of OS
3. Measurement of temperature & pressure values of the process using Raspberry Pi/Node MCU
4. Modules and Sensors Interfacing (LM35, DHT 11, POT, IR sensor, Ultrasonic sensors) using Raspberry Pi/node MCU
5. Modules and Actuators Interfacing (Relay, Motor, Buzzer) using Raspberry Pi/Node MCU
6. Demonstration of MQTT communication
7. Demonstration of LoRa communication
8. Visualization of diverse sensor data using a dashboard (part of IoT's 'control panel')
9. Sending an alert message to the user (ways to control and interact with the environment)
10. Device control using mobile Apps or through Web pages
11. Machine to Machine communication

Textbooks:
1. Klaus Schwab, "The Fourth Industrial Revolution", Portfolio Penguin, 2017.
2. Bruno S.Sergi, Elena G.Popkova, Aleksei V. Bogoviz and Tatiana N. Litvinova, "Understanding Industry 4.0: AI, The internet of things, and the future of work", Emerald publishing limited, 2019.

Reference Books:
1. Alasdair Gilchrist, "Industry 4.0: The Industrial Internet of Things", Apress, 2016.
2. Kaushik kumar, DivyaZindani, J. Paulo Davim, "Digital manufacturing and assembly systems in Industry 4.0", CRC Press, Taylor and Francis group, 2020.
3. Antonio sartal, Diego Carou, J.PauloDavim, "Enabling technologies for the successful deployment of Industry 4.0, CRC press, 2020.
4. Alp Ustundag, Emrecavikcan, "Industry 4.0: Managing the digital transformation", Springer International publishing, 2018.
5. Christoph Jan Bartodziej, “The Concept Industry 4.0”, Springer Gabler, 2017.

23MEE421	ADDITIVE MANUFACTURING	L-T-P-C: 2-0-3-3

Course Objectives

The course will enable the students to

- To provide comprehensive knowledge of the wide range of additive manufacturing processes, capabilities, and materials.
- To familiarize with materials science for additive manufacturing, process evaluation, applications, and quality and reliability.
- To impart knowledge about the software tools and techniques used for additive manufacturing.
- To create physical objects that facilitate product development/prototyping requirements.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Illustrate the significance and principles of additive manufacturing	Understand
CO02	Select the suitable additive manufacturing process for a product/application and appropriate materials for the selected additive manufacturing process.	Evaluate
CO03	Demonstrate the methodology of CAD tools and CAD interface with additive manufacturing systems.	Apply
CO04	Design and develop 3D-printed physical prototypes.	Create

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2	1						1	1		1	3	1	3	1
CO02	3	2	2	1	2				1	1	2	1	3	1	3	1
CO03	3	2	2	1	3				1	1		1	3	1	3	1
CO04	3	2	3	2	3				1	1	1	1	3	1	3	1

Syllabus

Unit 1

Introduction: Methods and Systems

Introduction: Introduction to layered manufacturing, Importance of Additive Manufacturing, Introduction to reverse engineering: Traditional manufacturing vis Additive Manufacturing, Additive Manufacturing in Product Development, 3D Printers and Printable Materials, 3D Printer Workflow and Software. [3 hours]

Classification of additive manufacturing processes: Common additive manufacturing technologies: Fused Deposition Modeling (FDM), Selective Laser Sintering (SLS), Stereo Lithography (SLA), Selection Laser Melting (SLM), Digital Laser Processing (DLP), Jetting, Laser Engineering Net Shaping (LENS), Laminated Object Manufacturing (LOM), Electron Beam Melting (EBM),

Wire Arc Additive Manufacturing (WAAM), Ultrasonic Additive Manufacturing, 4D Printing Capabilities, materials, costs, advantages and limitations of different systems. [7 hours]

Unit 2

Material and Process Evaluation

Material science for additive manufacturing: Mechanisms of material consolidation: FDM, SLS and SLM technologies. Polymers coalescence, sintering, photopolymerization, solidification rates, Meso and macro structures. [3 hours]

Process evaluation: process-structure relationships, structure-property relationships. [3 hours]

Post-processing: Defects in FDM, SLS, and SLM, Residual stress and distortion, Heat treatment, shot peening, HIPS, Micro finishing of AM parts, Support material removal, surface texture improvements, property enhancement using thermal and non-thermal techniques; Critical process parameters: geometry, temperature, composition, phase transformation [4 hours]

Unit 3
CAD in Additive Manufacturing
CAD Modelling for 3D Printing: 3D Scanning and Digitization, data handling & Reduction Methods. [3 hours]
AM Software: data formats and standardization, Slicing algorithms: uniform flat layer slicing, adaptive slicing. [3 hours]
Process-path generation: Process-path algorithms, rasterization, part Orientation, and support generation. [4 hours]

Laboratory
CAD Modeling: Introduction to CAD environment, Sketching, Modeling and Editing features, Different file formats, Export/Import geometries, Part orientation, Slicing, Support generation-FDM/SLA, Process path selection, 3D Printing of prototypes using various technologies. [45 hours]

Session 1: Introduction to CAD package and basic sketching
Session 2: Introduction to basic 3D modeling
Session 3: Basic modeling exercise
Session 4: Complex modeling exercise
Session 5: CAD standard exchange formats and STL conversion
Session 6: Introduction to slicing software
Session 7: Support generation exercise
Session 8: Generation of G Code
Session 9: 3D Printing using FDM-exercise 1
Session 10: 3D Printing using FDM-exercise 2
Session 11: Demonstration of 3D printer – SLA and SLS

Textbooks:

1. Gibson, I., Rosen, D.W. and Stucker, B., “Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing”, Springer, 2015.
2. Ben Redwood, Filemon Schoffer, Brian Garret, “3D Printing Handbook, Technologies design and Applications” 3D Hubs B. V., 2018.

Reference Books:

1. Joan Horvath, Rich Cameron, “Mastering 3D Printing in the Classroom, Library and Lab”, Apress, 2018.
2. Chua, C.K., Leong K.F. and Lim C.S., “Rapid prototyping: Principles and applications”, 2/e, World Scientific Publishers, 2010.
3. Liou, L.W. and Liou, F.W., “Rapid Prototyping and Engineering applications: A tool box for prototype development”, CRC Press, 2011.
4. Kamrani, A.K. and Nasr, E.A., “Rapid Prototyping: Theory and practice”, Springer, 2006.
5. Hilton, P.D. and Jacobs, P.F., Rapid Tooling: Technologies and Industrial Applications, CRC press, 2000.

23MEE422	DIGITAL TWINS	L-T-P-C: 2-0-3-3

Course Objectives

The course will enable the students to

- To introduce digital twins concepts and their applications in industry.
- To familiarize with trends in discrete industry
- To be acquainted with digital twins in the process industry.
- To elaborate on the advantages and applications of digital twins.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Introduce the concept of Digital Twins in Manufacturing the industry.	Understand
CO02	Acquire knowledge of Digital Twins and their importance.	Apply
CO03	Design Digital Twins for discrete and process industries.	Apply
CO04	Analyze the performance of Digital Twins.	Analyze
CO05	Discover the advantages and applications of Digital Twins.	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3	3	2	1				1	1		1	2	1		2
CO02	3	3	3	2	1				1	1		1	2	1		2
CO03	3	3	3	2	1				1	1		1	2	1		2
CO04	3	3	3	2	1				1	1		1	2	1		2
CO05	3	3	3	2	1				1	1		1	2	1		2

Syllabus

UNIT 1

DIGITAL TWINS

Industrial Revolutions. Digital Twins: Definition, Types of Industry & its Requirements, Characteristics of Digital Twins, Importance, benefits, Impact, and Challenges. Conceptual design methodology of digital twins, Five-dimensional digital twins for the product, Application of Digital Twins in process, product, service industries, History of Digital Twins, Digital Transformation role in industry innovation, Technologies/tools enabling Digital Twins.

UNIT 2

DESIGN OF DIGITAL TWINS

Design of Digital Twins: Technological needs. Physics-based approach: Model identification, Model creation. Data-driven approach: Model development using ML/DL models. Digital twins for Prototype, Product, and Performance. Digital Twins validation.

UNIT 3

DIGITAL TWINS IN THE DISCRETE INDUSTRY

Discrete Industry: Trends in the Discrete Industry, control system requirements in a Discrete Industry, Digital Twins of a Product, Digital Thread in Discrete Industry, Data Collection & Analysis for Product & production improvements, Automation Simulation, and Digital Enterprise.

UNIT 4
DIGITAL TWINS IN THE PROCESS INDUSTRY
Process Industry: Basics of Process Industry, Trends in the process industry, control system requirements in a process industry, Digital Twins of a plant, Digital Thread in process Industry, Data collection & Analysis for process improvements, process safety, Automation simulation, and Digital Enterprise.

UNIT 5
APPLICATIONS OF DIGITAL TWINS
Improvement in product quality, production process, process Safety, identifying bottlenecks and Improve efficiency, achieve flexibility in production, continuous prediction, and tuning of the production process through Simulation, reducing the time to market.

List of Experiments:
1. Exercise on Model development using MATLAB Simulink, Simscape
2. Exercise on Model identification using MATLAB – System Identification
3. Model development using Simscape
4. Fault Diagnosis of rotating elements using Digital Twins
5. Parameter tuning of Digital Twins
6. Digital Twins modeling of the Drilling system
7. Validation and performance optimization of the Digital Twins model of the Drilling system
8. Digital Twins for fan speed control system
9. Develop Predictive Models using Digital Twins
10. Estimate the remaining useful life using Digital Twins

Textbooks:

1. Alp Ustundag and Emre Cevikcan, "Industry 4.0: Managing The Digital Transformation", Springer Series in Advanced Manufacturing., Switzerland, 2017.
2. Andrew Yeh Chris Nee, Fei Tao, and Meng Zhang, "Digital Twin Driven Smart Manufacturing", Elsevier Science., United States, 2019
3. Shyam Varan Nath, Pieter van Schalkwyk, Dan Isaacs, “Building Industrial Digital Twins Design, Develop, and Deploy Digital Twin Solutions for Real-world Industries Using Azure Digital Twins”, Packt Publishing, 2021

Reference Books:

1. Enis Karaarslan, Moharram Challenger, Ömer Aydin, Ümit Cali, “Digital Twin Driven Intelligent Systems and Emerging Metaverse”, Springer Nature Singapore, 2023
2. Christoph Jan Bartodziej, “The Concept Industry 4.0 An Empirical Analysis of Technologies and Applications in Production Logistics”, Springer Gambler., Germany, 2017.

23MEE423	SMART MANUFACTURING	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- Impart the knowledge of Smart Manufacturing and its components.
- Introduce the essentials of Digital Tread and its importance in manufacturing.
- Describe the conceptual framework of Intelligent Machining.
- Impart knowledge of Manufacturing data analytics and intelligent machining.
- Describe the various advanced manufacturing enterprise.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Describe the components of digital manufacturing and digital thread.	Apply
CO02	Implement digital thread in shop floor and manufacturing enterprise.	Apply
CO03	Apply data analytics on the different manufacturing settings.	Apply
CO04	Apply the process control strategies to manufacturing enterprises.	Apply
CO05	Implement the advanced manufacturing paradigms in the manufacturing enterprise.	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3	3		1							1	2	1	1	2
CO02	3	3	3		1							1	2	1	1	2
CO03	3	3	3		1							1	2	1	1	2
CO04	3	3	3		1							1	2	1	1	2
CO05	3	3	3		1							1	2	1	1	2

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Introduction: Digital Manufacturing and Design, Impact of Digital Manufacturing, Advantages. Components of Digital Manufacturing and Design, Closed loop approach, Integrated Information Systems in the Product Lifecycle. [6 Hours]

Digital Thread – Definition, Data Storage in the Digital Thread, Data Sharing, and The Digital Thread. Digital Thread: Implementation - Strategic issues in implementing the digital thread, Cyberinfrastructure Components of the Digital Thread, Technologies used in the Design Process, Digital Thread on the Shop Floor, and Manufacturing Enterprise. [8 Hours]

Advanced Manufacturing Process Analysis: Introduction. Data Analysis Process, Data Collection in Different Manufacturing Settings, Discrete Part Manufacturing, Continuous Manufacturing. Data Collection: Big Data, Data Collection Considerations, Data Storage, and Pre-processing.

Data Analysis: Computational Techniques and Platforms: Sensitivity Analysis, Anomaly Detection, Computational Platform: Cloud Computing. [9 Hours]

Intelligent Machining: Introduction. Evolution of Intelligent Machining, Components of Intelligent Machining. Sensors and Sensing Techniques: Sensors, Signal Processing, Transforming Data into Information, Practical Uses of Machine Learning. Process Control Strategies: Closed Loop Process Control Systems, Introduction to Adaptive Control, Commercially Available Software. Future Directions in Advanced Machining. [10 Hours]

Advanced Manufacturing Enterprise: Integrated Enterprise, Transparency of Product Life Cycle Data, Advanced Manufacturing: Levels of Approach, Product Life Cycle, Advanced Manufacturing Adoption, Information Sharing Infrastructures, Product Life Cycle Management, Material Requirements Planning, Manufacturing Process Management, Manufacturing Execution Systems, Enterprise Resource Planning, Infrastructure Performance, New Manufacturing Paradigms, Case studies. [12 Hours]

Textbooks:

1. Soroush, M., Baldea, M.M. and Edgar, T.F. eds., 2020. *Smart Manufacturing: Concepts and Methods*. Elsevier.
2. Sapsford, R. and Jupp, V. eds., 1996. *Data collection and analysis*. Sage.

Reference Books:

1. Journal of Intelligent Manufacturing, Springer
2. Masoud Soroush, McKetta Michael Baldea, Thomas F. Edgar eds., 2020, Smart Manufacturing Applications and Case Studies, Elsevier Science

23MEE424	COMPUTER INTEGRATED MANUFACTURING	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- Provide fundamental knowledge of CAD/CAM and CIM in the manufacturing system.
- Familiarize with computer application in process planning, cellular manufacturing, and flexible manufacturing systems.
- Provide exposure to different types of automatic material handling and storage systems for CIMS.
- Introduce the types of computer-aided inspection methods available for component inspection.
- Highlight the role of automation in the present manufacturing industries.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Explain the various elements of computer-integrated manufacturing using computers and their technology in the manufacturing sector.	Understand
CO02	Interpret steps to implement computer-aided process planning, including resource planning in CIM.	Understand
CO03	Analyze the material handling systems with the utilization of automation in materials handling.	Analyze
CO04	Choose a suitable Machine cell layout based on Group technology and FMS.	Apply
CO05	Decide an actual computer-aided inspection method for quality control in the CIM environment.	Evaluate

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	1	1									1	2			
CO02	3	2	1									1	2			
CO03	3	2	2									1	2			
CO04	3	2	2		1							1	2		1	1
CO05	3	2	2		1							1	2	1	1	1

Syllabus

Unit 1

Introduction: Brief introduction to CAD and CAM – Manufacturing Planning, Manufacturing control-Introduction to CAD/CAM – Concurrent Engineering - CIM concepts – Computerised elements of CIM system – Types of production - Manufacturing models and Metrics – Mathematical models of Production Performance – Manufacturing Control– Basic Elements of an Automated system – Levels of Automation – Manufacturing lead time - Lean Production and Just-In-Time Production.

Unit 2

Computerized process and resource planning: Process planning – Computer Aided Process Planning (CAPP) – Aggregate Production Planning and the Master Production Schedule – Material Requirement planning – Capacity Planning - Control Systems - Shop Floor Control - Inventory Control – Brief on Manufacturing Resource Planning-II (MRP-II) & Enterprise Resource Planning (ERP)

Automated material handling and storage: Material functions, types, and analysis of material handling system and equipment. System design: conveyor system, automated guided vehicle systems, automated storage/retrieval systems, caroused storage systems, work in process storage, interfacing handling & storage with manufacturing.

Unit 3

Cellular manufacturing and FMS: Group Technology (GT), Part Families – Parts Classification and coding – Simple Problems in Opitz Part Coding system – Production flow Analysis – Cellular Manufacturing – Composite part concept – Machine cell design and layout – Quantitative analysis - Arranging Machines in a GT cell – Hollier Method. FMS. Types of Flexibility – FMS Components, Application & Benefits – Planning and Control – Quantitative analysis in FMS.

Computer-aided quality control: Automated inspection principles and methods, Contact and Non-contact inspection methods, machine vision system, optical inspection method, sensors, coordinate measuring machine.

Textbooks:

1. Mikell.P.Groover "Automation, Production Systems and Computer Integrated Manufacturing", Prentice Hall of India, 2008.

Reference Books:

1. Kant Vajpayee S, "Principles of Computer Integrated Manufacturing", Prentice Hall India, 2003.
2. Gideon Halevi and Roland Weill, "Principles of Process Planning – A Logical Approach" Chapman & Hall, London, 1995.
3. Rao. P, N Tewari &T.K. Kundra, "Computer Aided Manufacturing", Tata McGraw Hill Publishing Company, 2000.
4. Radhakrishnan P, Subramanyan S.and Raju V., "CAD/CAM/CIM", 2nd Edition, New Age International (P) Ltd, New Delhi, 2000.

23MEE425	APPLIED ANALYTICS	L-T-P-C: 2-0-3-3

Course Objectives

The course will enable the students to

- Make students understand the importance of Data Analytics and Business Analytics for various manufacturing systems.
- Students will learn about fundamental data analytic techniques and tools used to analyze data.
- Empowering the students to perform experiments as a group using real-world data.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Classify and analyze data and propose business solutions based on the results.	Apply
CO02	Perform data analytics using modern tools.	Apply
CO03	Conduct independent Business analytics to provide solutions for a business problem.	Apply
CO04	Work as a team on a project and present the results as tangible action plans.	Analyze

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2		1	1				1	1		1	2			2
CO02	3	2	2	1	3				1	1		1	2			2
CO03	3	2	2	1	2			1	1	1	1	1	2			2
CO04	3	2	2	1	1			1	1	1	1	1	2			2

Syllabus

Business Analytics: Introduction-Elements of Business Analytics Consulting, Stakeholder Management-Team culture -Working with an Analytics company.

Python programming essentials: Variables and Data types – Control Structures. Data Structures: Lists, Dictionary, Tuples, Sets, Arrays, Bytearray, Stack, Queue, binary tree. Functions, Modules, File I/O. Libraries and packages: Pandas, NumPy, SciPy, SymPy, Matplotlib, Streamlit, Scikit-learn, TensorFlow.

Exploratory Data Analysis: Import Data, Data Preparation, Analysis, and Visualization. Data scraping, wrangling, web scraping, data parsing, and data ingestion. Cloud database and data modeling. SQL and RDBMS.

Business Intelligence: Setting up a Business Intelligence (BI) project, principles of decoding a business problem to an analytical problem. Dashboard in Excel, Matplotlib, and Power bi/Tableau. Basics of business presentation, Design thinking, technical tools, documentation, and project management.

List of Experiments:

1. Exercise in Python programming3
2. Exercise on Python packages
3. Data series and Data frame creation using Pandas
4. Exercise on data visualization
5. Data cleaning and preprocessing using Pandas
6. Perform correlation and covariance analysis on the given data
7. Exercise of data scraping
8. Exercise of web scraping
9. Develop a classifier for prediction problems using manufacturing data
10. Develop a classifier for classification problems using manufacturing data

Textbooks:

1. Allen B. Downey, "Think Python: How to Think like a Computer Scientist", 2^{nd} Edition, O'Reilly Publishers, 2016.
2. Karl Beecher, "Computational Thinking: A Beginner's Guide to Problem Solving and Programming", 1^{st} Edition, BCS Learning & Development Limited, 2017.

Reference Books:

1. Paul Deitel and Harvey Deitel, "Python for Programmers", Pearson Education, 1^{st} Edition, 2021
2. John V Guttag, "Introduction to Computation and Programming Using Python: With Applications to Computational Modeling and Understanding Data ", 3^{rd} Edition, MIT Press, 2021
3. Maisel, Lawrence. Cokins, Gary. Predictive Business Analytics: Forward Looking Capabilities to Improve Business Performance. United Kingdom: Wiley, 2013.
4. Business Analytics: An Introduction. United States: CRC Press, 2013.
5. Sharda, Ramesh. Delen, Dursun. Turban, Efraim. Business Intelligence and Analytics: Systems for Decision Support. United Kingdom: Pearson, 2014.

23MEE426	DESIGN FOR ADDITIVE MANUFACTURING	L-T-P-C: 2-0-3-3

Course Objectives

The course will enable the students to

- To provide knowledge about additive manufacturing
- To make the students capable of designing various cellular manufacturing concepts
- To provide knowledge about reverse engineering

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Identify the need for Design for Additive Manufacturing.	Understand
CO02	Apply Design for Additive Manufacturing guidelines in designing mass-customized products.	Apply
CO03	Create an optimal 3D model using a generative design approach.	Create
CO04	Develop lattice structures using topology optimization.	Apply
CO05	Create the 3D model using Reverse Engineering.	Create

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2	2						1	1		1	2	2	2	2
CO02	3	2	2	1	2				1	1		1	2	2	2	2
CO03	3	2	2	1	3				1	1		1	2	2	2	2
CO04	3	2	2	1	3				1	1		1	2	2	2	2
CO05	3	2	2	1					1	1		1	2	2	2	2

Syllabus

Unit 1

Introduction: Need and Economics of Additive Manufacturing, Basic design guidelines for 3D printing, Design guidelines for Fused Filament Fabrication: Part dimension, Part orientation, Part location, Support Generation: Overhang Geometrical features, Location and size of features. [8 hours]

Unit 2

Design guidelines for resin-based AM system: Part orientation, Support Generation, Geometrical features.
Design guidelines for Powder Bed Fusion process: Part orientation, Support Generation, Geometrical features, Comparison of polymer and metal process [8 hours]

Unit 3

Generative Design: Design optimization, Topology Optimization, Cellular structures, Auxetic Patterns, and Lattice structures. [7 hours]

Unit 4

Reverse Engineering: 3D scanning, Laser scanning, CT Scanning, CMM, File formats, Model correction, surface modeling, Sculpting, [7 hours]

Laboratory Session:

CAD modeling, Surface modeling, 3D scanning, File conversion, OBJ files, DICOM to STL, Generative design, Topology optimization, 3D printing.
Session 1: Advanced modelling exercise
Session 2: 3D scanning exercise
Session 3: Surface modelling exercise

Session 4: 3D printing of scanned object
Session 5: Generative design-exercise
Session 6: 3D printing of generative designs
Session 7: Generation of lattice structures
Session 8: 3D printing of lattice structures
Session 9: Topology optimization
Session 10: 3D printing of optimized structure

Textbooks:

1. Gibson, I., Rosen, D.W. and Stucker, B., “Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing”, Springer, 2015.
2. Ben Redwood, Filemon Schoffer, Brian Garret, “3D Printing Handbook, Technologies design and Applications” 3D Hubs B. V., 2018.

Reference Books:

1. Joan Horvath, Rich Cameron, “Mastering 3D Printing in the Classroom, Library and Lab”, Apress, 2018.
2. Chua, C.K., Leong K.F. and Lim C.S., “Rapid prototyping: Principles and applications”, 2/e, World Scientific Publishers, 2010.
3. Liou, L.W. and Liou, F.W., “Rapid Prototyping and Engineering applications: A tool box for prototype development”, CRC Press, 2011.
4. Kamrani, A.K. and Nasr, E.A., “Rapid Prototyping: Theory and practice”, Springer, 2006.
5. Hilton, P.D. and Jacobs, P.F., Rapid Tooling: Technologies and Industrial Applications, CRC press, 2000.

23MEE427	SUSTAINABLE MANUFACTURING	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- Familiarize the concept of sustainability manufacturing with tools and techniques.
- Inculcate knowledge on performing life cycle analysis.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Understand the concept of sustainable manufacturing	Understand
CO02	Utilise tools and techniques of sustainable manufacturing	Apply
CO03	Perform life cycle assessment and assess environmental impacts of the manufacturing process	Analyze
CO04	Perform sustainability analysis using software packages	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3				1		3					2	2	1	1	1
CO02	3				1		3					2	2	1	1	1
CO03	3				1	2	3					2	2	1	1	1
CO04	3				1	2	3					2	2	1	1	1

Syllabus

Unit 1

Concept of sustainability, manufacturing operations, resources in manufacturing. Concept of the triple bottom line, environmental, economic, and social dimensions of sustainability. Relation between green, lean, and sustainable manufacturing.

Unit 2

Environmental conscious: Quality Function Deployment-R3 and R6 cycles. Environmental impact assessment methods: CML, EI 95 and 99, ISO 14001, EMS and PAS 2050 standards, environmental impact parameters. Sustainability assessment-concept models and various approaches, product sustainability and risk assessment-corporate social responsibility.

Unit 3

Life cycle analysis (LCA): Remanufacture and disposal, tools for LCA, optimization for achieving sustainability in manufacturing, value analysis, analysis for carbon footprint-software packages for sustainability analysis.

Textbooks:

1. Atkinson G, Dietz S, Neumayer E, "Handbook of sustainable manufacturing" Edward Elgar Publishing limited, 2007
2. Rodick, D, " Industrial Development for the 21 st century: Sustainable development perspectives" UN New York,2007

Reference Books:

1. Lawn.P, " Sustainable development indicators in ecological economics", Edward Elgar Publishing limited,2006
2. Asefa, " The economics of sustainable development", WE Upjohn institute for employment research, 2005
3. Dornfeld, David (Ed), " Green manufacturing : fundamentals and applications", Springer Science & Business Media,2012
4. Klemes J, "Sustainability in the process industry", McGraw Hill, 2011.

23MEE428	CYBER SECURITY IN MANUFACTURING	L-T-P-C: 3-0-0-3

Course Objectives
The course will enable the students to

- To understand key terms and concepts in Cyber security, Policies, Governance and Compliance.
- To exhibit knowledge to secure corrupted systems, protect personal data, and secure computer networks in an Organization.
- To understand principles of cyber security and to guarantee a secure network by analyzing the nature of attacks through cyber forensics software or tools.

Course Outcomes:
After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Analyze and evaluate the cyber security needs of a manufacturing industry.	Analyze
CO02	Analyze the security issues in networks and computer systems to secure infrastructure.	Analyze
CO03	Design operational cyber security strategies and policies.	Apply
CO04	Apply various techniques to detect current and future attacks on an organization's computer systems and networks.	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3	2		2	1						1	2			2
CO02	3	3	2		2	1						1	2			2
CO03	3	3	2		2	1						1	2			2
CO04	3	3	2		2	1						1	2			2

Syllabus

Introduction:
Cyber Security- Layers of security, Vulnerability, Assets and Threat, Challenges and Constraints - Computer Criminals - CIA Triad - Motive of attackers - Spectrum of attacks - Taxonomy of various attacks – Cryptography - Security Governance – Challenges and Constraints, Legacy Cyber security systems – Transformations in Cyber security.

Cyber Security In Manufacturing: Importance of Cyber Security, Cyber Security Domains, Threats and Vulnerabilities, Information Security Framework, Operational Technology and Informational Technology, Risk Management, Application of Information Security,

Guidance on Securing Digital Manufacturing Operations: Securing all Aspects of a Digital Manufacturing Operation. Human-Machine and M2M Interactions, Securing End to End Processes via Security Development Life Cycle, Software Security Flaws and Threats, Network Security, and Authentication.
Protecting Operational Technologies and Intellectual Property: Supply Chain Security, Shipping, RFID tags, Mobile Device Security and Wireless Communication, Data/Applications, and Cloud Security Intellectual Property Protection from Threats.

Breach Response: Reliability versus Security, Intrusion Prevention Techniques and Data Leak Prevention Tools, Monitoring, Intrusion Detection, and Network Hardening, Intrusion Response, Recovery, and Forensics

Textbooks:

1. Yuri Diogenes, Erdal Ozkaya, Cyber security - Attack and Defense Strategies, Packt, Publishers, 2018.
2. Charles J. Brooks, Christopher Grow, Philip A. Craig, Donald Short, Cybersecurity Essentials, Wiley Publisher, 2018

Reference Books:

1. William Stallings, Effective Cybersecurity: A Guide to Using Best Practices and Standards, 1st edition, 2019
2. Nina Godbole, Sunit Belapure, Cyber Security - Understanding cybercrimes, Computer Forensics and Legal Perspectives, Wiley, 2011

SYLLABUS

PROFESSIONAL ELECTIVES

DESIGN

23MEE331	FAILURE ANALYSIS AND DESIGN	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- Familiarize yourself with various failure modes and examine the failed components.
- Impart knowledge of vibration analysis for early fault detection

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Recognize and describe common engineering failure mechanisms.	Understand
CO02	Appreciate the condition monitoiring for detecting the failure.	Apply
CO03	Predict the remaining useful life of the components using fatigue, fracture, and creep.	Analyze
CO04	Analyze the failed engineering components	Analyze

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3	3	1									2			
CO02	3	2	3	1		1	1	1	1			1	2		1	
CO03	3	3	3	1	1								2		1	1
CO04	3	3	2	1	1	1							2		1	1

Syllabus

Unit 1

Introduction, causes of failures, classification, steps in failure analysis, tools, sample selection and treatment, materials analysis, equipment, Metallography, and commonly used NDT methods. Condition monitoring techniques using sensors fror engineering applications.

Unit 2

Failure mechanisms, overload failure, ductile and brittle fracture, ductile to brittle transition, stress concentration approach. Fracture mechanics approach, Fatigue mechanisms, classical fatigue prevention and prediction, fractography, and damage tolerant fatigue approach. Wear failures, adhesive, abrasive, erosive, corrosive wear. Elevated temperature failures, creep, creep crack branching. Corrosion failures, types, and their identification.

Unit 3

Application and case studies on Failure analysis: Failures of the cast and welded components, failures of rotating components-shaft, bearing, and gears.

Textbooks:

1. Jones D. R. H., "Engineering Materials 3–Materials Failure Analysis: Case Studies and Design Implications", Pergamon Press, 1993.
2. ASM Handbook, Vol. 11, "Failure Analysis and Prevention" Edited by, ASM Publications, 2002.

Reference Books:

1. ASM Handbook, Vol. 11, "Failure Analysis and Prevention" Edited by, ASM Publications, 2002.
2. Colangelo Vito J. and Heiser F., "Analysis of Metallurgical Failures", Second Edition, John Wiley & Sons, Inc., 1987.
3. Jones D. R. H., "Failure Analysis and Case Studies", Elsevier Publications, 1998.
4. Robert Bond Randall, "Vibration-Based Condition Monitoring: Industrial, Aerospace and Automotive Applications", John Wiley & Sons, 2011.

23MEE332	OPTIMIZATION TECHNIQUES IN ENGINEERING	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- Impart knowledge on the theory of optimization and conditions for optimality for unconstraint and constraint optimization problems.
- Inculcate modeling skills necessary to describe and formulate optimization problems in design and manufacturing.
- Familiarize with optimization algorithms' working principles for solving linear and non-linear problems.
- Train the students to solve optimization problems using software tools

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Formulate engineering problems as optimization problems	Apply
CO02	Apply necessary and sufficient conditions for a given optimization problem for optimality.	Apply
CO03	Select appropriate solution methods and strategies for solving an optimization problem and interpret and analyze the solution obtained by optimization algorithms.	Analyze
CO04	Justify and apply modern heuristic algorithms to solve optimization problems	Apply
CO05	Solve Engineering Design and Manufacturing related optimization problems using software tools.	Apply

CO-PO Mapping: [affinity[#]: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3	1	1	1				1	1	1	1	3	1	1	
CO02	3	3	2	1					1	1	1		3	1	1	
CO03	3	3	2	1	1				1	1	1		3	1	1	
CO04	3	3	2	2	2				1	1	1		3	1	1	1
CO05	3	3	3	2	3				1	1	1	1	3	1	1	1

Syllabus:

Unit 1

Introduction - Engineering applications - Statement of an optimization problem – Classifications of Optimization problems - Optimal problem formulation: Problems involving design and manufacturing - Optimality criteria - Classical optimization techniques - Kuhn-Tucker (KT) optimality conditions.

Unit 2

Non-linear programming: One-dimensional minimization methods - Unconstrained optimization techniques - Constrained optimization techniques - Transformation methods - Interior and exterior penalty function method - Convergence and divergence of optimization algorithms - Complexity of algorithms.

Unit 3

Modern Methods in Optimization: Genetic Algorithm - Simulated Annealing - Particle Swarm Optimization – Neural Network based optimization - Optimization of Fuzzy systems - Multi-objective optimization - Data Analytics and optimization using Machine learning approach.

Unit 4

Implementing optimization algorithms in MATLAB / R / Python environment and solving linear, non-linear, multi-objective unconstrained, and constrained optimization problems.

Textbooks:

1. S.S. Rao, Engineering Optimization: Theory and Practice, New age international, 3rd edition, 2013.
2. K. Deb., Optimization for Engineering Design: Algorithms and Examples, PHI, 2nd Edition, 2012.
3. J. S. Arora, Introduction to Optimum Design, Academic Press, 4th Edition, 2017.

23MEE333	EXPERIMENTAL METHODS	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- Analyse experimental data based on various statistical methodologies, analyze the data, and extract the detailed information.
- Understand the dynamics characteristics of the Instruments, which an engineering student is liable to use.
- Familarisation of common instruments used for measurements of important parameters such as Displacement, force, Pressure, flow rate.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Understand the various measurement techniques and measuring device for given application	Understand
CO02	Apply the principles of dynmics measurement techniques	Apply
CO03	Analyse experimental data based on various statistical methodologies.	Analyze
CO04	Devolop experimental setup for a given engineering application	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3	1	1					1	1	1	1	3	1	2	
CO02	3	3	2	1					1	1	1		3	1	2	
CO03	3	3	2	1	1				1	1	1		3	1	2	
CO04	3	3	2	2	1				1	1	1		3	1	2	1
CO05	3	3	3	2	1				1	1	1	1	3	1	2	1

Syllabus

Unit 1

Types of measurements and errors, Internal and external estimates of errors, Relative frequency distribution, Histogram, True value, Precision of measurement, Best estimate of true value and precision, Methods of calculating best estimate of true value and standard deviation. Combination of measurements, accuracy of the mean, Significant digits. Method of least squares and its application to the calculation of best estimate of true value, the curve fitting.

Unit 2

General linear regression, Comparison and combination of measurements. Extensions of least square method. Theory of errors, Binomial and Gaussian distribution, Confidence limits, Significance test, principle of maximum likelihood and goodness of fit, Chi-square test.

Unit 3

Displacement measurement: Dial Gauge, Microcator, Optical Method, Pneumatic Transducer, Strain Gauges, Variable Inductance and Capacitance Transducer, Piezo-Electric, Electro-Kinetic, Photo-Electric, Ionization, Vibrating Wire And Vacuum Tube Transducer. Force and Torque Measurement: Elastic Type, Fluid Load Cell, Dynamometers. Temperature Measurement: Bi-Materials, Pressure and Resistance Thermometers, Thermocouples and Pyrometers. Pressure Measurement: McLeod Gauge, Pirani Gauge, Ionization Gauge, Manometers, Bourdon Tube, Resistance Gauges. Fluid Velocity Measurement: Pitot tube and Hot Wire Anemometer, LDA. Flow Measurement in Confined Passages and Open Channels.

Unit 4
Dynamic Response of a Measuring Instrument, Response to Transient and Periodic Signals, First and Second order systems as well as their Dynamic Response Characteristics.

Textbooks:

1. Instrumentation, Measurement and Analysis by B C Nakra and K K Chaudhary, Tata McGraw Hill, 1985.
2. Principles of Measurement, Precision, Error and Truth by N C Barford, Addison Wesley, 1967.
3. Physical Measurement and Analysis by N N Cook and E Rabinowicz, Addison Wesley, 1963.
4. Experimental Methods for Engineers by J P Holman and W J Gajda, McGraw Hill Co., 1978.

23MEE334	THEORY OF VIBRATIONS	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- Familiarize students with the mathematical modeling and analysis of mechanical vibration systems
- Make students understand the importance of vibration analysis in the design of dynamical systems

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Classify different types of vibrations and develop mathematical models of vibratory systems.	Apply
CO02	Analyze free and forced vibrations of single degree of freedom systems.	Analyze
CO03	Estimate the natural frequencies and mode shapes of multi degree of freedom systems.	Apply
CO04	Analyze free vibrations of continuous systems	Analyze

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3	1	1								1	3	1		
CO02	3	3	1	1	1							1	3	1		
CO03	3	3	1	1	1							1	3	1		
CO04	3	3	1	1	1							1	3	1		

Syllabus

Unit 1

Vibration of sdf systems- Free vibration of sdf systems – undamped and damped free vibration-underdamped overdamped and critically damped systems-estimation of damping by logarithmic decrement.
Forced vibration of sdf systems- Harmonically excited sdf systems-rotating unbalance-support harmonic excitation- vibration isolation-sdf system as a vibration measuring instrument- Half power point method for the estimation of damping- Response to periodic excitation - method of Fourier series.
Types of damping - viscous, Coulomb, structural and material damping models- Equivalent viscous damping. Response of sdf system to arbitrary excitation (Transient Vibration)- Convolution integral - method of Fourier transforms.

Unit 2

Vibration of two dof systems-Undamped free vibration of the two dof systems -matrix eigenvalue problem - natural frequencies and natural modes - elastic and inertial coupling - coordinate selection to remove coupling- beat phenomenon - response to harmonic excitation- vibration absorbers - orthogonality of natural modes
Vibration of multi dofsystems-Equations of motion - formulation and solution of matrix eigenvalue problem - computational methods for the solution of matrix eigenvalue problem - decoupling of equations of motion by modal analysis.

Unit 3

Vibration of continuous systems Transverse vibration of a string - axial vibration of a rod - torsional vibration of a shaft - bending vibration of a beam - formulation and solution of differential eigenvalue problem.

Textbooks:

1. Theory of vibrations, W T Thomson, M D Dahleh and C Padmanabhan, Pearson Education,2018.
2. Fundamentals of vibrations, Leonard Meirovitch, McGraw Hill International edition,2010
3. Elements of vibration analysis, Leonard Meirovitch, Tata McGraw Hill, 2010. Mechanical vibrations, S.S Rao.Pearson Education, 2018.
4. Engineering Vibrations, D.J Inman, Pearson International Education, 2011.

23MEE335	MODELING AND SIMULATION OF ENGINEERING SYSTEMS	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- Provide a generalized framework for modeling engineering systems through lumped parameter elements.
- Introduce and apply different mathematical tools to analyze models of engineering systems.
- Familiarize the use of software tools for solving engineering problems.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Develop mathematical models for engineering systems in different domains and derive analogies.	Apply
CO02	Analyze first and second-order linear and nonlinear systems in the time and frequency domain.	Apply
CO03	Perform system identification for linear time-invariant systems.	Apply
CO04	Simulate mathematical models of engineering systems using simulation software.	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3	2	1	1							1	3	1		
CO02	3	3	1	1	1							1	3	1		
CO03	3	3	1	1	1							1	3	1		
CO04	3	3	2	1	1							1	3	1		

Syllabus

Unit 1

Fundamental concepts in mathematical modeling: Abstraction-linearity and superposition-balance and conservation laws and the system boundary approach. Lumped element modeling: Mechanical systems-Translational, rotational. Hydraulic systems. Thermal systems. RLC electrical systems. Modeling analogies.

Unit 2

Modeling of the first order and second order systems: Governing equations for free and forced responses – transient response specifications - experimental determination of time constant and damping coefficient. Laplace Transforms. State space formulation. Frequency response of Linear Time-Invariant (LTI) systems: Frequency response of first-order and second-order systems - Transfer function - mathematical features - Bode Plots-Relating time domain, frequency domain, and state space. Introduction to modeling and analysis of nonlinear engineering systems.

Unit 3

Introduction to linear system identification – time and frequency domain identification – discrete-time input-output models for LTI systems – linear least square parameter estimation.

Textbooks:

1. Cha P.D, Rosenberg J.J, and Dym C.L, Fundamentals of Modeling and Analyzing Engineering Systems, Cambridge University 2000
2. Keesman, Karel J. System identification: an introduction. Springer Science & Business Media, 2011

23MEE336	TOOL DESIGN	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- Familiarize with location and clamping principles for design of a jig or a fixture
- Elucidate design of jigs and fixtures for any given component
- Elucidate design of a die-set for a given sheet metal component

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Select standard components, clamping and locating devices using basic principles of jigs and fixtures	Understand
CO02	Formulate the design procedure and select the materials used for manufacture	Analyze
CO03	Design jigs and fixtures for a given component	Evaluate
CO04	Identify and choose the types of presses for a given sheet metal component	Evaluate
CO05	Design a die-set for a given sheet metal component using the design procedure for various sheet metal working processes	Analyze

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	1										1	2	1		
CO02	2	2	1									1	2	1	2	
CO03	3	3	3	2					1		1	1	2	1		
CO04	2	2	1									1	2	1	2	
CO05	3	3	3			1		1	1	1	1	1	2	1	2	

Syllabus

Unit 1

Design of Jigs: Introduction - Location Principles – Six Point Location Principle – Locators – Clamping Principles – Clamping Devices – Drill Jigs – Drill Bushes – Drill Jig Types – Design and Development of Jigs for given components.

Unit 2

Design of Fixtures: Milling Fixtures – Milling Methods – Milling Fixture Types – Turning fixtures – Broaching Fixtures – Grinding Fixtures – Assembly, Inspection and Welding Fixtures – Modular Fixtures – Design and Development of Fixtures for given components.

Unit 3

Design of Dies: Power presses types and construction details, die cutting operation, cutting action in die and punch, center of pressure, clearance and its significance, cutting forces, methods of reducing cutting forces, methods of punch support, strippers, stock stops, guide pilots, knockout, design of blanking and piercing dies. Design Concepts and description of the components of progressive dies. Design of progressive dies. Design of compound dies. Design of combination dies.

Unit 4

Drawing Dies: Metal flow and factors affecting drawing, blank size calculations, drawing force, single and double acting drawing dies, design and development of drawing dies for different components.

Unit 5

Bending and Forming Dies: Spring back, bend allowance; calculation of development length, bending force calculations types of bending dies. Curling dies. Forging process and forging dies. (Introductory Treatment)

Textbooks:

1. P. H. Joshi – ‘Jigs and Fixtures Design Manual’ - McGraw Hill - 2002
2. Kempster M. H. A. - ‘An Introduction to Jig and Tool Design’ - Viva Books Pvt. Ltd. - 2002
3. P. H. Joshi – ‘Press Tools Design and Construction’ – S. Chand and Company Ltd. – Revised edition, 2008

Reference Books:

1. John G. Nee - ‘Fundamentals of Tool Design’ - Society of Manufacturing - 1998 - 4th Edition
2. E. K. Henriksen – ‘Jig and Fixture Design Manual’ - Industrial Press, New York - 1973
3. Paquin and Crowley – ‘Die Design Fundamentals’ - Industrial Press, New York – 1979
4. Donaldson, Lecain and Goold – ‘Tool Design’ - McGraw Hill, New York - 1976.

23MEE337	NVH FOR AUTOMOTIVE APPLICATIONS	L-T-P-C: 2-0-3-3

Course Objectives

- Introduce the importance of NVH analysis and associated standards in automobile industry
- Familiarize students with the different sources of noise and vibration in automobiles
- To enable the students to provide solutions to NVH problems through theoretical and experimental knowledge.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Identify and characterize different sources of vibration and noise in automobiles.	Analyze
CO02	Perform steady state and transient vibration and sound analysis.	Analyze
CO03	Apply various passive and active noise control strategies to NVH problems.	Create
CO04	Acquire hands-on experience of sound and vibration measurements and their application in automobiles.	Understand

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3	2	1	1							1	3	2	2	
CO02	3	3	2	1	1							1	3	2	2	
CO03	3	3	2	1	1		1					1	3	2	2	
CO04	3	3	2	1	1		1					1	3	2	2	

Introduction to acoustics : Acoustic Terminology, Sound Fundamentals, Plane Wave, Spherical Wave Propagation, Theories of Monopole & Di pole source, Sound Source, Transmission & Absorption, Absorption thru multiple walls, Sound transmission through ducts, Structure Radiation, Sound level, sound field, sound wave equations, Octave bands, Helmholtz equation, Source path receiver models. (6 hrs)

Basics of vibration and vibration analysis: Damping, Resonance, Transmissibility, Vibration Measurements, Theory of Modal Analysis Quarter car, half car and full car models for automobiles. Transient and steady-state response of quarter car model. Modes of vibration. Vibration absorption analysis of different materials. (6 hrs)

Automotive NVH: Sources of noise and vibration from automobiles. Noise ratings and standards, human tolerance levels and weighting factors, Pass – by noise requirement, Target vehicles and objective targets, engine noise, transmission noise, Air Borne & Structure Borne Noise, tyre noise, aerodynamic noise, exhaust system noise, inlet manifold noise, combining sound sources, acoustical resonances. Rols of NVH engineer. (6 hrs)

NVH analysis and Control strategies: Digital Signal Processing, Time & Frequency Analysis, FFT Analysis, Sampling & Nyquist Criterion**,** Noise control, noise rating and standards related to NVH, noise path analysis. Human tolerance levels. Vibration absorbers and Helmholtz resonators. Passive noise control – micro-perforated panels (MPP), resonators, passive sound absorbing foam materials. Active control techniques. Noise reduction in automobiles – vehicular noise and control – environmental noise control. Noise control through barriers, enclosures and absorbent linings – sound absorbing materials. (10 hrs)

Lab exercises (10 hrs)

1. Theoretical and experimental modal analysis of structural elements (beams, plates etc.)
2. Use of sound level meter to measure cabin noise, radiated noise etc + Calibration
3. Free and forced vibration analysis using the experimental setup.
4. Sound transmission loss analysis using MATLAB/ COMSOL
5. Noise source identification by masking method
6. Sound quality analysis – Jury rating, metrics and its correlation.

Text/ Reference Books

1. Norton M P, Fundamentals of Noise and Vibration, Cambridge University Press,1989
2. M. L. Munjal, 2014, Noise and Vibration Control, World Scientific Press: Singapore
3. István L. Vér, Leo L. Beranek, Noise and Vibration Control Engineering: Principles and Applications, John Wiley, 2006.
4. Anton FuchsEugenius NijmanHans-Herwig Priebsch, Automotive NVH Technology, springer, 2016.

23MEE338	**SYSTEMS ENGINEERING**	**L-T-P-C: 3-0-0-3**

Course Objectives

The course will enable the students to

- To familiarize with systems engineering as a crucial discipline pertaining to creation of multi-disciplinary solutions to complex systems and practice for successfully realizing many complex systems.
- To build an appreciation and provide insights into key systems engineering practices.
- To provide an overview of various development lifecycle activities pertaining to systems engineering of complex systems.
- To give an insight to modelling and simulation of different models to study the system behavior.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Apply different holistic approaches to the study of complex systems.	Apply
CO02	Understand properties of complex system like hierarchy, auto-organization and emergence.	Understand
CO03	Model and analyze complex systems using dynamical system approach.	Evaluate
CO04	Analyze complex systems using causal loop and stock flow diagrams.	Analyze
CO05	Apply agent-based modeling to analyze complex systems.	Analyze

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2	1	2	1							1	3	1		
CO02	3	2	1	2	1							1	3	1		
CO03	3	2	1	2	1							1	3	1		1
CO04	3	2	1	2	1							1	3	1		1
CO05	3	2	1	2	1							1	3	1		1

Syllabus

Unit 1

Introduction to concepts of system – systems science & engineering - fundamental ideas, principles, and methods, as well as the systems engineering procedure and its function in the creation of complex systems. System requirements analysis, functional analysis and design, system architecture, and system modelling are all examples of system analysis and design. Integrating, testing, and verifying complex systems, including requirements validation, system testing, integration testing, and verification. Design definition – system analysis – interface management - system integration –Systems definition of complexity, examples, structural and functional hierarchies, formation of complex systems, auto-organisation, emergent phenomena, systems and network, multiple and spatial time scales, evolution of systems, adaptive systems and systems of systems. System dynamics-system modelling, types of models.

Unit 2

Decision-making tools, risk management, and configuration management are all examples of systems engineering tools and techniques. The phases of the system lifetime, including as development, testing, deployment, operation, and maintenance, as well as the function of systems engineering at each phase, are referred to as the system lifecycle. – life cycle stages – requirement definition – architecture definition – design definition – system analysis – interface management project planning – project management & control – Principles of project management, project planning, scheduling, budgeting, and team building, as well as communication, cooperation, and teamwork in systems engineering projects.

Unit 3

Introduction to system modeling & simulation – System Modelling: modelling and simulation techniques, modelling notation, and model-based design. Emerging Topics in Systems Engineering: exploration of current and emerging topics in systems engineering, such as artificial intelligence, cybersecurity, and autonomous systems. Causal loop diagrams, feedback loops, examples. Stock and flow diagrams, governing difference equations, stock and flow with delay, examples. Introduction to MBSE: basic concepts, principles, and techniques of model-based systems engineering, including the use of models to represent system behaviour, structure, and performance. Lean & Agile systems engineering – specialty areas (interoperability/ logistics/ safety/ reliability/ maintainability/ security/ usability).

Case Studies: analysis and discussion of real-world systems engineering problems and challenges, including examples from aerospace, transportation, energy, and other industries.

Textbooks:

1. G.E Mobus and M .C Kalton, Principles of systems science, Springer Science, New York, 2015.

Reference Books:

1. Kossiakoff, Alexander and William N. Sweet; Systems Engineering: Principles and Practice
2. INCOSE Systems Engineering Handbook, Ver. 4
3. System Engineering Book of Knowledge, www.sebokwiki.org
4. NASA Aeronautics and Space Administration, NASA Systems Engineering Handbook, Rev1, December 2007)
5. Faul Conbridge, R.I. and Ryan, M. J., Systems Engineering Practice, Canberra: Argos Press, Revised Edition 2018.
6. ISO/IEC/IEEE 15288 - Systems and software engineering — System life cycle processes
7. Blanchard, Benjamin S., and Wolter J. Fabrycky. Systems Engineering and Analysis. 3rd ed.

23MEE339	MACHINE CONDITION MONITORING	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- Familiarize with the concept of condition-based maintenance for effective utilization of machines
- Impart knowledge of signal processing techniques for machinery fault diagnosis

Course Outcomes

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Select the proper maintenance strategies and condition monitoring techniques for identification of failure in a machine.	Understand
CO02	Acquire and process sound and vibration signals in a dynamic mechanical system	Evaluate
CO03	Predict the faulty component in a machine by analyzing the acquired vibration signals	Analyze
CO04	Apply the signal analysis techniques in fault diagnosis of rotating machine.	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2	1	1								1	2	1		1
CO02	3	2	1	1	1	1						1	2	1		1
CO03	3	2	1	1	1	1						1	2	1		1
CO04	3	2	1	1	1							1	2	1		1

Syllabus

Unit 1

Basic Concepts: Machinery failures, basic maintenance strategies, factors influencing maintenance strategies, machine condition monitoring, condition monitoring methods: vibration analysis, sound analysis, acoustic emission analysis, wear debris analysis, ultrasonic detection and infra-red thermography [8 Hours]

Unit 2

Instrumentation and Signal Processing: Vibration transducers, piezo electric accelerometer, mounting methods, data acquisition. Signal Processing – time domain analysis, Fast Fourier transform: Nyquist sampling theorem and windowing, spectrum analysis, cepstrum analysis, order analysis, envelope analysis, time synchronous averaging, spectral kurtosis and kurtogram, orbit plot, polar plot, operational deflectional shape analysis, time frequency analysis: short time fourier transform and wavelet analysis. [18 Hours]

Unit 3

Vibration Analysis: Detection and diagnosis of faults in rotating machines – vibration criteria, unbalancing shaft, shaft misalignment, bent shaft, cracked shaft; gear faults – tooth wear, gear backlash, gear misalignment, rolling element bearing faults. [12 Hours]

Unit 4

Application and case studies of condition monitoring: gear boxes, centrifugal pumps, turbines and tool wear monitoring. Machine learning based bearing fault diagnosis. IoT based real time monitoring system. [7 Hours]

Textbooks:

1. Robert Bond Randall, “Vibration-Based Condition Monitoring Industrial, Aerospace and Automotive Applications, John Wiley & Sons, 2011.
2. Cornelius Scheffer and Paresh Girdhar, “Practical Machinery Vibration Analysis and Predictive Maintenance”, Elsevier, 2004

Reference Books:

1. Clarence W.de Silva “Vibration Monitoring, Testing and Instrumentation (Mechanical and Aeropace Engineering Series)”, CRC Press, Taylor & Francis, 2007.
2. A. R. Mohanty, “Machinery Condition Monitoring: Principles and Practices” , CRC Press, Taylor & Francis, 2015
3. Collacot, “Mechanical Fault Diagnosis and Condition Monitoring”, Chapman- Hall, 1987.
4. Davies, “Handbook of Condition Monitoring - Techniques and Methodology”, Springer, 1998.

23MEE340	EXPERIMENTAL STRESS ANALYSIS	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- Familiarize with the fundamentals of experimental stress analysis
- Elucidate the basic concepts of Interferometers, DIC, Strain gauges and Digital Photoelasticity
- Clarify the experimental data sets and suitable experimental techniques for industrial applications.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	To understand the relation between the fundamental theories of solid mechanics and experimental stress analysis	Understand
CO02	To be able to implement the electrical resistance strain gauge measurement systems for measuring strain tensors in industrial applications	Evaluate
CO03	To understand and evaluate the significance of basic concepts of interferometers and fundamentals of Digital Image Correlation	Understand
CO04	To Understand the principles and techniques of Digital Photoelasticity to evaluate the whole field stress and strain measurements.	Apply
CO05	To demonstrate the ability to develop logical, appropriate conclusions based on the experimental data.	Analyze

CO-PO Mapping: [affinity[#]: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	1										1	2	1	1	
CO02	2	2	1							1	1	2	2	1	1	
CO03	3	3	3	2					3	1	1	3	2	1	1	
CO04	2	2	1							1	1	2	2	1	1	
CO05	3	3	3						3	1	1	3	2	1	1	

Syllabus

Unit 1

Basic Concepts: Stresses, stress-strain relationships, basic equations, elasticity theory, elementary concepts of fracture mechanics

Unit 2

Review of strain measurement by strain gauges: Electrical resistance strain gauges, Strain-gauge circuits and parameters affecting their performances, instrumentation for strain measurement, strain analysis.

Unit 3

Interferometric Methods: Holographic interferometer, Moiré interferometry, Speckle interferometry and electronic speckle interferometry, Fundamentals of Digital Image Correlation

Unit 4

Photoelastic Theory: Two-Dimensional and three-dimensional stress analysis, photoelastic method of determining fracture parameters, Concepts on Digital Photoelasticity for whole field stress measurements.

Textbooks:

1. James W. Dally and William F. Riley, Experimental Stress Analysis, McGraw-Hill Inc., 1991

Reference Books:

1. Garry Cloud, Optical Methods of Engineering Analysis, Cambridge University Press, 1998.
2. A. S. Kobayashi, handbook on Experimental Mechanics, Wiley, John & Sons, Inc., 1993.
3. James F. Doyle, Modern Experimental Stress Analysis: Completing the Solution of Partially Specified Problems, Wiley, John & Sons, Inc., 2004.

23MEE341	NONLINEAR DYNAMICS AND CHAOS	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- Familiarize with nonlinear dynamics concepts for better understanding of physical systems
- Demonstrate analytical and numerical tools to analyse systems with nonlinear effects
- Characterize chaotic motion using analytical and numerical tools.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Apply the qualitative approach to the study of dynamical systems to analyse nonlinear systems.	Apply
CO02	Develop theoretical and computational tools for the analysis of one-dimensional, two-dimensional and multi-dimensional nonlinear systems.	Analyze
CO03	Analyse different bifurcations of practical nonlinear systems and to use them in design.	Analyze
CO04	Differentiate chaotic and non-chaotic systems and to analyse mechanical engineering systems exhibiting chaotic behavior.	Analyze
CO05	Solve interdisciplinary problems in engineering, ecological, electronic, biological and financial systems using nonlinear dynamics tools.	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2	1		1							1	2	1		
CO02	3	2	1		1							1	2	1		
CO03	3	2	1		1							1	2	1		
CO04	3	2	1		1							1	2	1		
CO05	3	2	1		1							1	2	1		

Syllabus

Unit 1

Introduction and Motivation - Examples of Nonlinear and Chaotic Systems, definition of dynamical system, state space, vector field and flow One Dimensional Flows – Flows on the line, fixed points and their stability, linear stability analysis, impossibility of oscillations, bifurcations in one dimensional case, saddle-node , transcritical and pitchfork, flows on the circle, examples. [15 Hours]

Unit 2

Two Dimensional Flows - Planar linear systems, solving linear systems, eigenvalues and eigen vectors, dynamical classification based on eigenvalues, planar nonlinear systems, phase portraits, linearisation, hyperbolic fixed points and Hartman – Grobman theorem, stable, unstable and centre manifolds, limit cycles, van der pol equation, Poincare - Bendixson theorem, saddle-node, transcritical, pitchfork and Andronov-Hopf bifurcations in planar case. [15 Hours]

Unit 3

Chaotic Dynamics - One dimensional maps, fixed points and cobwebs, logistic map, bifurcations in iterated maps and chaos, Feigenbaum universality. Three dimensional systems, Poincare sections, quasiperiodicity, routes to chaos. Quantifying chaos -Lyapunov exponents, Kolmogorov Sinai entropy, fractal dimensions. Analytical methods for nonlinear systems -Perturbation method, Secular terms, Lindsted - Poincare method, averaging method, method of multiple scales. [15 Hours]

Textbooks:

1. Steven H. Strogatz, “Nonlinear Dynamics and Chaos”, Reading, Addison-Wesley, 1994.
2. Robert C. Hilborn, “Chaos and Nonlinear Dynamics”, Second Edition, Oxford University Press, 2000.

Reference Books:

1. Ali Hasan Nayfeh, “Introduction to Perturbation Techniques”, John Wiley, 1993.
2. Robert L. Devaney, “An Introduction to Chaotic Systems”, Second Edition, West View Press, 2003.
3. Edward Ott, “Chaos in Dynamical Systems”, Cambridge University Press, 1993

23MEE342	MATERIALS SELECTION IN MECHANICAL DESIGN	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- To impart the basics of mechanical properties of engineering materials
- To understand the different failure modes of materials
- To understand the basis of materials selection through case studies
- To understand basis of process selection through case studies

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Identify the suitable materials and its properties for various application.	Understand
CO02	Select the processing method and testing procedure for a given application.	Apply
CO03	Determine the properties, features, and applications of different light weight material.	Evaluate
CO04	Design suitable hybrid material for a given application.	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3	1										1	1	3	
CO02	3	3	1				1						1	1	3	
CO03	3	3	1			2	1			1			1	1	3	
CO04	3	3	1			2	1						1	1	3	

Syllabus

Unit 1

Overview of materials properties- modulus, tensile. Fatigue, creep strengths, toughness, hardness, fracture toughness, damping capacity, thermal, oxidation, corrosion, and wear resistances.

Materials property charts. Materials families and classes- metals, ceramics, glasses, polymers, elastomers, composites, foams, natural. [15 hours]

Unit 2

Basis of materials selection. Design of components- functions, constraints, objectives and free variables. Selection process-translation, screening, ranking, supporting information. Illustration of the principles with examples- heat sink, overhead electrical transmission line, tie rod, light stiff beam. [10 hours]

Unit 3

Case studies in materials selection for various applications- oar, table leg, flywheel, kiln walls, passive solar heating, heat exchangers, bearings, springs, pressure vessel.

Principles of process selection and classification-casting, forging, moulding, fabrication, welding, joining, machining, powder processing, composite processing. Illustration of the principles with case studies.

Multiple constraints and objectives- case studies. Design of hybrid materials- case studies. [20 hours]

Textbooks:

1. Jones D.R.H. and Ashby M.F. 'Engineering Materials 1: An Introduction to properties, application and design', - Elsevier Publication - 2018, 5th Edition.
2. Ashby M.F., 'Materials selection in Mechanical Design' - Butterworth Heinemann - 2010 - 3rd Edition.

Reference Books:

1. ASM Handbook – 'Materials Selection and Design'-1997.
2. Ashby M.F. and Johnson K. 'Materials and Design', Butterworth Publication, 2002.
3. Askeland D. R and Phule P. P., 'The Science and Engineering of Materials', Thomson Brooks/Cole Publication, 4th edition, 2006.

23MEE343	GEOMETRIC MODELLING AND COMPUTER GRAPHICS	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- Impart knowledge on principles, methods and techniques of computer graphics and geometric modelling.
- Familiarize modelling and manipulation of curves and surfaces.
- Develop models and manipulate solids.
- Learn and apply various geometric transformations and projections

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Understand the basics, needs and applications of computer graphics and geometric modeling.	Understand
CO02	Apply fundamental mathematical knowledge to generate and manipulate curves and surfaces.	Apply
CO03	Develop and manipulate geometric models for solids.	Analyse
CO04	Implement geometric transformation and projection of geometric model.	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	1	2	2	1				1	2		1	2	2		
CO02	3	2	2	2	1				1	2		1	2	2		
CO03	3	2	2	3	1				1	2		1	2	2		
CO04	3	2	2	3	1				1	2		1	2	2		

Syllabus

Unit 1

Introduction, conventional and computer aided design, features, requirements and applications of modelling, CAD tools- hardware and software, Input & output devices, Graphics standard, functional areas of CAD. Data interoperability, challenges, data transfer. Neutral formats (DXF, IGES, PDES, STEP, ACIS, Parasolid, STL, etc). [15 Hours]

Unit 2

Introduction, representation of curves, analytic curves, synthetic curves, curve conversions, curve manipulation; Surface representation – Analytic and synthetic surfaces, surface manipulations, design examples. Fundamentals of solid modeling, properties and techniques Boolean operations, boundary representation, constructive solid geometry, solid manipulations, solid modeling based applications. [15 Hours]

Unit 3

Introduction, Translation, Scaling, Reflection, Rotation in 2D and 3D. Homogeneous representation of transformation, Concatenated transformations. Geometric co-ordinate systems, Coordinate systems– Global, Local, View and Screen coordinate systems. Orthographic, Isometric, and Perspective projections of Geometric Models. Transformation matrices, Implementations. [15 Hours]

Textbooks:

1. Zeid, I and Sivasubramanian, R., "CAD/CAM: Theory and Practice", 2nd edition, McGraw Hill Education, Special Indian Edition ISBN-13: 978-0070151345,2009
2. M. Groover, E. Zimmers, "CAD/CAM computer aided design and manufacturing", Pearson India, 1998.
3. Donald D. Hearn, M. Pauline Baker, Warren Carithers, "Computer Graphics with OpenGL", 4th Edition, Pearson Education, 2015.

Reference Books:

1. Michael E. Mortenson, "Geometric Modelling", Third edition, Industrial Press, 2006.
2. Foley, Wan Dam, Feiner and Hughes – Computer graphics principles & practices, 3rd edition, Pearson Education, 2003.
3. Rogers, D. and Adams, J. A., “Mathematical Elements for Computer Graphics”, 2nd edition, McGraw Hill Education, ISBN-13: 978-0070486775,2 017.

23MEE344	ROBUST DESIGN	L-T-P-C: 2-0-3-3

Course Objectives

The course will enable the students to

- The course presents the theory of modeling with a variation using physical models and methods for practical applications on designs more insensitive to variation.
- Provides a comprehensive understanding of optimization and robustness for probabilistic design

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Familiarize with the statistical theories required for implementing robust design concepts in product development	Understand
CO02	Create designs that have minimal sensitivity to input variation	Apply
CO03	Perform sensitivity analysis and determine design parameters that have the largest impact on variation	Analyze
CO04	Optimize design with multiple outputs	Analyze
CO05	Create empirical models to estimate system outputs	Analyze

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	1	2	1					1	1		1	3	2		
CO02	3	1	2	1	1	1		1	1	1		1	3	2		
CO03	3	1	2	1	1	1		1	1	1		1	3	2		
CO04	3	1	2	1	1	1		1	1	1	1	1	3	2		
CO05	3	1	2		1	1		1	1	1	1	1	3	2		

Syllabus

Unit 1

New product development process: Phases, Patterns, Design for Six Sigma – Statistical background for new product design: Statistical distributions, Probability plotting – Process capability – Robustness Concept. [3 Hours]

Unit 2

Introduction to variation in Engineering Design: Propagation of error, protecting design against variations, Estimation of statistical parameters, statistical bias, robustness, determining the variation of inputs using simulation approach - Modelling variation of complex systems – Desirability: Requirements and scorecards, determining desirability. [9 Hours]

Unit 3

Optimization and sensitivity: Optimization procedure, Statistical outliers, Process capability, Sensitivity, and cost reduction – Modelling system cost and multiple outputs - Case studies and problem-solving - Tolerance analysis: Tolerance analysis methods, Tolerance allocation, Drift, Shift and Sorting – Case Studies and problem-solving. [9 Hours]

Unit 4

Empirical Modelling: Screening, Response Surfaces, Central Composite Design, Taguchi approach – Logistic regression and customer loss function – Case studies - Engineering model verification and validation: Introduction, Design verification methods, and tools, Process validation procedure, Case study and Problem-solving using software tools. [9 Hours]

Laboratory Practice:
Practical Examples using software tools on
Design of Experiments
Desirability and Sensitivity Analysis
Robust Design
Multi Response Robust Design
Design Optimization [15 Sessions 45 Hours]

Textbooks:

1. Dodson, Bryan, Patrick C. Hammett, and Rene Klerx. "Probabilistic design for optimization and robustness for engineers". Hoboken, NJ: Wiley, 2014

Reference Books:

1. Arner, Magnus. "Statistical robust design", Wiley, 2014.
2. Roy, Ranjit K., "Design of experiments using the Taguchi approach: 16 steps to product and process improvement". John Wiley & Sons, 2001.

23MEE345	INDUSTRIAL TRIBOLOGY	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- To familiarize the various types of engineering surfaces in contact.
- To provide comprehensive knowledge of friction, wear, lubrication between various engineering surfaces and bearings.
- To provide comprehensive knowledge of various surface modifications and coatings techniques.
- A wealth of real world engineering problems and examples towards gaining the experience for how the knowledge of tribology is applied in engineering practice.
- The effective use of the knowledge of tribology to various engineering problems to enhance the performance of the mechanical elements.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Analyze the failures due to friction in engineering surfaces	Analyze
CO02	Analyze the failures due to wear in engineering surfaces	Analyze
CO03	Apply the knowledge of lubrication and bearings in engineering applications	Apply
CO04	Apply the knowledge of surface engineering to engineering applications	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3	3	3	3								3	1	3	
CO02	3	3	3	3	3								3	1	3	
CO03	3	3	3	3	3								3	2	3	
CO04	3	3	3	3	3								3	2	3	

Syllabus:

Unit 1: Friction and its types

Introduction to tribology, engineering surfaces, fundamentals of contact between the surfaces, surface roughness, stick slip phenomenon, friction of metals and non-metals, friction mechanisms – ploughing and adhesion, friction of ceramic materials, friction of polymers, friction measurement. [12 hours]

Unit 2: Wear and wear mechanisms

Introduction to wear, abrasive wear, abrasivity of particles, abrasive resistance of engineering materials, adhesive wear, adhesion mechanisms, effects of adhesion between mating surfaces, controlling adhesive wear, erosive wear, cavitation, corrosive wear, tribo-corrosion and tribochemical polishing, oxidative wear in various engineering environments, controlling oxidative wear, fretting, fatigue wear during sliding, fatigue wear during rolling, wear of metals, wear of polymers, wear of ceramics, wear of non-metals. Wear measurements. [12 hours]

Unit 3: Lubricants, lubrication mechanisms and bearings

Types of lubricants and their properties, Stribeck curve and regimes of lubrication, Greases, Solid lubricants, Reynolds equation, Hydrodynamic lubrication, Pad bearings, Journal bearings, Porous bearings, Elastohydrodynamic lubrication, Boundary and extreme pressure lubrication [12 hours]

Unit 4: Surface Engineering

Surface treatments, Wear resistant coatings and surface treatments, Physical vapor deposition, chemical vapor deposition, ion implantation, surface welding, thermal spraying, laser surface hardening and alloying, diamond like coatings, carbon based composite coatings, multi-layered coatings, nano-engineered coatings, Thick coatings. [9 hours]

Textbooks:

1. GwidonStachowiak, Andrew W Batchelor., "Engineering tribology", Elsevier Butterworth –Heinemann, USA, 2005.

Reference Books:

1. Hutchings.I.M and Shipway P, "Tribology, Friction and Wear of Engineering Material, Elsevier Butterworth –Heinemann , UK, 2017.
2. Bharat Bhushan, "Introduction to tribology", Wiley Publication, 2013.
3. Williams.J.A, "Engineering Tribology", Oxford University Press, 2005.
4. Stolarski.T.A, "Tribology in Machine Design", Industrial Press Inc., 1990.
5. Cameron.A, "Basic Lubrication Theory", Longman, U.K., 1981.
6. Neale.M.J., "Tribology Handbook", Newnes Butter worth, Heinemann, U.K., 1975.
7. Tomasz Liskiewicz and Daniele Dini, Fretting Wear and Fretting Fatigue, Elsevier UK, 2023.

23MEE346	PRODUCT DESIGN AND DEVELOPMENT	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- Understand and describe the product development process and its various tools and methods.
- To make students be able to apply methods for gathering of consumer requirements in order to formulate product specific requirements.
- Give an overview about the importance of DFM (Design for Manufacturing) and DFE (Design for the Environment) in product development process

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Apply methods for collection of customer requirements and for formulating product requirements.	Apply
CO02	Select an appropriate product design and development process for a given application.	Evaluate
CO03	Choose an appropriate ergonomics for the product.	Evaluate
CO04	Create methods to minimize the cost of product development.	Create
CO05	Apply the concepts of design for manufacturing.	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2	2	2	2	2	2	1	1				2	2	2	
CO02	3	2	2	2	2	1	2	1			1		2	2	2	
CO03	3	2	1	1	2	2	1	1				1	2	2	2	
CO04	3	2	1	2	3	2	2	2	2		3	1	2	2	2	
CO05	2	2	1	1	2	2	1	1	1				2	2	2	

Syllabus

Unit 1

Introduction: Classification/ Specifications of Products. Product life cycle. Product mix. Introduction to product design. Modern product development process. Innovative thinking. Morphology of design.

Conceptual Design: Generation, selection & realization of concept. Product architecture. Industrial design: Need and process. Robust Design: Taguchi Designs & DOE. Design Optimization.

Unit 2

Ergonomics and Aesthetics: Gross human anatomy. Anthropometry. Man-Machine interaction. Concepts of size and texture, colour. Comfort criteria. Psychological & Physiological considerations. Creativity Techniques: Creative thinking, conceptualization, brain storming, primary design, drawing, simulation, detail design.

Value Engineering and Value Analysis: Definition and basic concepts only. Economic analysis (Basic concepts): Qualitative & Quantitative. Product costing.

Unit 3

Design for Manufacturing & Assembly: Methods of designing for Manufacturing & Assembly. Designs for Maintainability. Designs for Environment. Legal factors and social issues. Engineering ethics and issues of society related to design of products.

Basic concepts of Concurrent Engineering, Rapid prototyping techniques including Additive manufacturing. Tools for product design – Drafting / Modelling software. QFD. CAM Interface. Overview of Patents & IP Acts. Report generation.

Textbooks:

1. Anita Goyal, Karl T Ulrich, Steven D Eppinger, “Product Design and Development “, 4th Edition, 2009, Tata McGraw-Hill Education, ISBN-10-007-14679-9
2. Chakrabarti, Debkumar. “Indian Anthropometric Dimensions for Ergonomic Design Practice”, National Institute of Design. (1997).

Reference Books:

1. Kemnneth Crow, “Concurrent Engg./Integrated Product Development”, DRM Associates, 26/3,Via Olivera, Palos Verdes, CA 90274(310) 377-569, Workshop Book.
2. Stephen Rosenthal, “Effective Product Design and Development”, Business One Orwin, Homewood, 1992, ISBN 1-55623-603-4.
3. Staurt Pugh, “Tool Design –Integrated Methods for Successful Product Engineering”, Addison Wesley Publishing, New york, NY

MANUFACTURING AND MATERIALS

23MEE351	COMPOSITE MATERIALS AND DESIGN	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- To introduce various types of reinforcements and matrices for composites
- To impart knowledge on the fundamentals of design of composites and structure property relations
- To familiarize with suitable tools and methods for manufacturing of composites
- To understand advance composite materials and processes

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Perceive the importance of base matrix and reinforcements of composites for different applications	Understand
CO02	Select the mould, tool, matrix and reinforcements for composites	Analyze
CO03	Identify suitable processes and parameters for the manufacture of various composites	Evaluate
CO04	Select appropriate composite materials, design of composites for real time applications.	Analyze

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	1											2	1	3	
CO02	2	2	2										2	1	3	
CO03	2	3	3	1			1				1		2	1	3	
CO04	1	3	3			1	1	1		1	1	1	2	1	3	

Syllabus

Unit 1

Types of reinforcements, their mechanical properties and functions -ceramics, glass, carbon, boron.silicon carbide, metal, aramid.Forms of reinforcements- particulate, fibre, filaments, whiskers, flakes. Pre-fabricated forms-preforms, prepegs, fabrics, honeycomb. Type of matrix, its mechanical properties and functions- polymers (thermosets and thermoplastics), metals, ceramics, glass and carbon.Basic principles in the design of composites and selection of matrix and reinforcement. Bonding mechanisms.

Unit 2

Anisotropic behaviour and relationship between structure-mechanical properties.Mechanical testing- tensile, compressive, Intra-laminar shear, Inter-laminar shear and fracture. Polymer Matrix Composites: Types of thermoset and thermoplastic resins. Principles in the selection of matrix and the reinforcements.Process selection criteria.Mould and tool making.Basic manufacturing steps- impregnation, lay-up, consolidation and solidification.

Unit 3

Manufacturing processes for polymer composites- lay-up, compression moulding, extrusion, injection moulding, sheet forming, pultrusion, hot press & autoclave techniques and filament winding. Metal and ceramic matrix composites wettability of reinforcement to matrix and bonding, methods of manufacturing reinforcements with intermediate wetting layer. Manufacturing processes for metal matrix composites: casting methods- gravity & low pressure die, investment, squeeze, spray forming, compression moulding and thixo-moulding. Manufacturing processes for ceramic matrix composites: reaction sintering, electro-deposition, spray forming, infiltration.
Applications of composites: daily usages- industrial, automotive and aerospace, advanced composites, design selection and process of composite for new application, case studies.

Textbooks:

1. Clyne, T.W. and Withers, P.J., 'An Introduction to Metal Matrix Composites', Cambridge Univ. Press 1993.
2. Matthews, F.L., and Rawlings, R.D, 'Composite Materials: Engineering and Science', Chapman & Hall, London 1994.

Reference Books:

1. Suresh, S., Martensen, A., and Needleman, A., 'Fundamentals of Metal Matrix Composites', Butterworth, Heinemann, 1993.
2. Mallick, P. K., 'Fiber-reinforced Composites: Materials, Manufacturing and Design', Marcel Dekker, 1993.
3. Mazumdar, S.K., 'Composites Manufacturing-Materials, Product, & Process Engineering', CRC Press, 2002.

23MEE352	FUNDAMENTALS OF NANOMATERIALS	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- To understand fundamentals of nanotechnology and nanomaterials
- To understand and relate quantum and statistical mechanics fornano technology
- To impart knowledge on nano structures, properties and characterization techniques
- To demonstrate bulk nano material and nano tribology for various applications

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Understand fundamentals of nanomaterials	Understand
CO02	Understand quantum and statistical mechanics and its relation to nanotechnology	Understand
CO03	Understand nano structures and properties	Understand
CO04	Select the characterization technique specific to nanomaterials	Analyze
CO05	Apply the appropriate processes for bulk nano materials and nano tribology	Analyze

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3												1		1	
CO02	3			1	2								1		1	
CO03	2		1										1		1	
CO04	2	1		1	1		1				1	1	1		1	
CO05	2	2	2	2	1	1	1				1	1	1		1	

Syllabus

Unit 1

Introduction to advanced material science, basic principles of nano material and its relation with properties, Examples of nanomaterials in daily life (GMR read heads, NEMS goniometers, health care, energy materials, etc), Foundations of quantum and statistical mechanics for nanomaterials, idea of tunneling, bound state and scattering, notion of quasiparticles, light matter interaction; DOS, bose-einstein and Fermi-dirac statistics.

Unit 2

Properties of individual nanostructures; bulk nanostructured materials; selection rules and spectroscopic techniques; Introduction to characterization of nanomaterials ,size and dimensionality effects; quantum confinement; properties dependent on density of states; single electron tunneling; current-induced forces, current-induced heating and electromigration in nanowires.

Unit 3

Nanotribology; carbon based nanomaterials; biological materials and biomimetic strategies for nanosynthesis; magnetic nanomaterials; nanodevices and nanomachines, Nano structured bulk material, amorphous Vs crystalline nano material.

Text books:

1. Introductory Nanoscience, by MasuroKuno, Garland Science (2011).
2. Introduction to Nanotechnology, by Poole and Owen, Wiley Indian Edition (2010).
3. Nanophysics and Nanotechnology, by Edward L. Wolf, Wiley-VCH (2006).

Reference Books:

1. Nanotechnology, By Lynn E. Foster, Pearson (2011).
2. Quantum Mechanics, by J. J. Sakurai.
3. Statistical Mechanics, by Kerson Huang.
4. Fundamentals and Applications of Nanomaterials, by Z. Guo and Li Tan.
5. Nanoelectronics and Information technology, by Rainer Waser, Wiley-VCH (2005)

23MEE353	INDUSTRIAL ROBOTICS	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- To familiarize robot structures and their workspace and distinguish between different sensors and drives.
- To develop skills in performing spatial transformations and kinematic analysis of robot manipulator.
- To develop knowledge in the Industrial applications of robots using image processing concepts.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom’s Taxonomy]
CO01	Identify the components of a robot and distinguish the types of robot configurations	Understand
CO02	Compare, evaluate and choose sensors/drives for robots	Evaluate
CO03	Construct a kinematic model of a given manipulator and evaluate whether the inverse kinematic model is solvable	Evaluate
CO04	Choose and apply appropriate image processing techniques for object recognition in robotic systems	Analyze
CO05	Familiarize with robot cell design and robot programming	Analyze
CO06	Design and develop a robotic system for a given industrial application	Analyze

CO-PO Mapping: [affinity[#]: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	2	3										1	3			1
CO02	3	3									2	1	3			1
CO03	3	3	3	3						2		1	3			1
CO04	3	2	2		3							1	3			1
CO05	3	2	3	3	3							1	3			1
CO06	3	3	3	3	3	2	2		3	3	3	1	3			1

Syllabus

Unit 1

Evolution of robotics. Robot anatomy- Co-ordinate Systems, Work envelope, types and classification – Specifications – Pitch, Yaw, Roll, Joint Notations, Speed of Motion: Accuracy, Resolution, Repeataility. Pay Load – Basic robot motions - Point to point control, Continuous path control. Robot Parts and Their Functions – Need for Robots Different Applications.

Robot drive systems: Pneumatic Drives – Hydraulic Drives – Mechanical Drives – Electrical Drives – D.C. Servo Motors, Stepper Motor, A.C. Servo Motors – Salient Features, Applications. Harmonic drives. End Effectors – Grippers – Mechanical Grippers, Pneumatic and Hydraulic Grippers, Magnetic Grippers, Vacuum Grippers; Two Fingered and Three Fingered Grippers; Internal Grippers and External Grippers; Selection and Design Considerations.

Unit 2

Coordinate frames. Mapping: Mapping between rotated frames - Mapping between translated frames- Mapping between rotated and translated frames-Description of objects in space-Transformation of vectors – Rotation translation combined with rotation-translation of vectors-composite transformation - Inverting a homogenous transform- Fundamental rotational matrices.

Direct Kinematic Model – Mechanical structure and notations-Description of links and joints-Kinematic modeling of manipulator-Denavit-Hartenberg Notation-Kinematic Relationship between adjacent links-Manipulator Transformation Matrix.

Inverse Kinematic Model – Manipulator Workspace-Solvability-Solution techniques-Closed form solution.

Unit 3

Imaging components-image representation-picture coding-object recognition and categorization-visual inspection. Robot cell-design and control layouts. Robot programming Languages –VAL Programming – Motion Commands, Sensor Commands, End effecter commands, and Simple programs. Industrial Applications – Material Handling, Process, Assembly, Inspection.Non-Industrial Applications.

Textbooks:

1. Fu, K.S., Gonzalez, R.C. and Lee C.S.G. – 'Robotics: Control, Sensing, Vision, and Intelligence' – McGraw Hill, New York, NY – 1987

Reference Books:

1. R K Mittal and I J Nagrath, 'Robotics and Control', Tata McGraw-Hill Publishing Company Limited, New Delhi, 2003.
2. J Craig, 'Introduction to Robotics: Mechanics and Control', Addison-Wesley, Reading, MA, 1989 (second edition).

23MEE354	NANOTECHNOLOGY AND SURFACE ENGINEERING	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- To impart knowledge of basic nanomaterials for surface engineering.
- To introduce various nano-surface coating techniques and properties.
- To facilitate the material design and hard coatings based on nano techniques.
- To familiarize with characterization techniques used for nano-surface engineering.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Understand various nanomaterials for surface engineering	Understand
CO02	Understand surface engineering techniques and identify the appropriate manufacturing processes for nano-coatings	Understand
CO03	Understand ion-based surface coatings, gases, and environment for coatings	Understand
CO04	Analyze the processes behavior for hard and nano coatings	Analyze
CO05	Select appropriate characterization techniques for nano-surface engineering.	Analyze

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	2												2	1	2	
CO02	2			1			1						2	1	2	
CO03	2		1			1	1					1	2	1	2	
CO04	2	1		1	1			1			1		2	1	2	
CO05	2	1	1		1	1		1			1		2	1	2	

Syllabus

Unit 1

Introduction to tribology and conventional surface engineering, outlines of conventional surface modification methods-physical vapour depositions, chemical vapour deposition, Introduction to nanofilms, glancing angle deposition (GLAD) technique. Transparent polymer nanocomposites, silane coating, silica coating, Nanocomposite processing, melt blending, In situ synthesis, Optical, Thermomechanical and mechanical properties of the nano coatings.

Unit 2

Nanostructures by Ion Irradiation- Introduction, Implantation, Sputtering , Cleaning, roughening of surface for improving the adhesion of coatings, Ion beam assisted deposition (IBAD) and ion beam deposition (IBD) of monoatomic ions or clusters, microencapsulation, decorative and golden PVD coatings, concept of color, reactive gas flow, Influence of oxygen in the layers.

Ion bombardment, TiN (ZrN) + Au coatings, nanostructured TiN/ZrN coatings, hardness and nanostructure of coatings, chromium nitride coatings, tantalum nitride (TaN) coatings, TiAl (N, C, O) coatings.

Unit 3

Introduction to nanolayered hard coatings, nanostructuring of transition-elements nitrides obtained by cathodic arc evaporation, plasma enhanced chemical vapor deposition, pulsed current in nano coatings.

Nanopowders- instructions for use, defining the working conditions.

Characterization of coatings- hardness, adherence and internal stresses, mechanical behavior and machining performances.

Determining internal stresses by radius of curvature measurements (Stoney's method), determining residual stresses using x-ray diffraction, high temperature oxidation resistance of nanocomposite coatings

Textbooks:

1. Nanomaterials and Surface Engineering, Edited by Jamal Takadoum, publisher: ISTE Ltd and John Wiley & Sons, Inc. 2009. ISBN 978-1-84821-151-31.

Reference Books:

1. Nanomaterials and Surface Engineering, Jamal Takadoum (Editor), March 2010, Wiley.

23MEE355	ADVANCED CASTING TECHNOLOGY	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- To understand the advanced casting processes and equipment
- To facilitate the usage of software packages in design and application for advanced casting methods
- To impart knowledge on the characterization and inspection methods for advanced casting.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Design the basic tooling requirements for the advanced casting process.	Understand
CO02	Select a suitable process for manufacturing casting components.	Understand
CO03	Analyze the liquid metal flow and solidification characteristics using casting software.	Analyze
CO04	Identify the defects in castings and suggest improvements	Analyze

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	1	2			1	1					1	3		1	
CO02	3	2	2			1	1					1	3		1	
CO03	3	3	2	1	1	1	1			2		1	3		1	
CO04	3	3	2	1	1	1	1			2		1	3		1	

Syllabus

Unit 1

Melt processing techniques for ferrous and non-ferrous alloys such as stainless steels, nickel, titanium alloys. Vacuum melting equipment and practice.

Elementary aspects of pattern and mould design using CAD software. Resin-bonded mould and core making processes and machines. Special casting processes and their applications- low-pressure die casting, investment casting, and squeeze casting, thixo-forming. Illustrations of automotive and aerospace applications.

Unit 2

Gating and riser design - principles of fluid flow, governing equations, heat transfer applied to casting solidification, governing equations, boundary conditions for different casting methods, the concept of directional solidification, gating, and risers, and application of simulation methods. Use of casting software in solving practical problems.

Unit 3

Casting defects and remedies. Inspection methods - visual, penetrant, magnetic, metallurgical, X-ray and Gamma ray radiography and Mechanization and Automation.

Textbooks:

1. Jain P. L. - 'Principles of Foundry Technology' - Tata McGraw Hill, New Delhi - 2011 - 3rd Edition

Reference Books:

1. Heine R. W., Loper C. R., and Rosenthal P. C. - 'Principles of Metal Castings' - Tata McGraw Hill, New Delhi - 1997 - 2nd Edition
2. Beeley- P. R.- 'Foundry Technology' - Butterworth Scientific, London - 2001

23MEE356	ADVANCED MANUFACTURING PROCESSES	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- To impart knowledge on process parameters for nonconventional and micromachining
- To understand high-speed machining and its characteristics.
- To impart an understanding of advanced grinding and various laser material processing techniques.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Select appropriate nonconventional processes for machining and micromachining for specific applications.	Understand
CO02	Understand the requirements for high-speed machining processes	Understand
CO03	Choose the applications of modern grinding technology.	Analyze
CO04	Assess the process parameters and capabilities of laser material processing techniques.	Analyze

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	1	1									1	2		3	
CO02	3	1										1	2		3	
CO03	3	1										1	2		3	
CO04	3	1										1	2		3	

Syllabus

Unit 1

Non-traditional manufacturing processes - chemical machining – electro chemical machining - ultrasonic machining - physical setup, metal removal rate, process parameters, process capabilities, and applications. Electrical discharge machining - wire EDM - abrasive flow machining - physical setup, metal removal rate, process parameters, process capabilities, and applications.

Unit 2

High-speed machining: high-performance machining of components. Application of HSM, improved material removal rate, surface finish and integrity, accuracy, and economic considerations.

Unit 3

Modern grinding technologies, high speed, and high-performance grinding.Hard machining using single-point tools. Laser applications in manufacture: Cutting, welding, surface treatment, automation and in-process sensing**.**

Textbooks:

1. Serope Kalpakjian and Steven R. Schmid - 'Manufacturing Engineering and Technology' - Prentice Hall – 2013 - 7th Edition0

Reference Books:

1. Benedict G. F. - 'Non-Traditional Manufacturing Processes' - Marcell Dekker Inc., NY – 1987 Krar S. F. and Gill A. - 'Exploring Advanced Manufacturing Technologies' -Industrial Press - 2003

23MEE357	ADVANCED MATERIALS AND PROCESSES	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- To introduce composites and advanced materials and their applications.
- To familiarize manufacturing and characterization of composite and aerospace alloys.
- To provide knowledge about the behaviour and applications of smart and nano-materials.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Interpret the properties and structure of composite and advanced material.	Understand
CO02	Identify the appropriate fabrication technique for composite and aerospace alloys	Understand
CO03	Examine the different behaviour of materials for aerospace applications	Analyze
CO04	Summarize the properties and applications of smart and nano-materials	Analyze

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	1	2			1							2		2	
CO02	3	1	2			1							2		2	
CO03	3	1	2			1							2		2	
CO04	3	1	2			1							2		2	

Syllabus

Unit 1

Composite Materials: Types of metal matrices and reinforcements and their properties, bonding mechanisms, structure-property relationships, preforms, and design of composites. Physical and Mechanical properties. Characterization of microstructures and macrostructures. Fabrication techniques - metal infiltration, pressure and vacuum casting methods. Case studies.

Unit 2

Aerospace Alloys: High strength Aluminium and Magnesium alloys, Nickel and Cobalt-based Superalloys, Titanium alloys, their structures, structure-property relationships, and heat treatment. Directional solidification and single crystal turbine blades. Case studies.

Unit 3

Smart Materials: Concept of shape memory, crystal structure, phase transformation mechanism and characteristics, properties, classification, and applications.

Nanomaterials: properties, classification, characterization, materials behaviour, fabrication and applications.

Textbooks:

1. Clyne T. W. and Withers P. J. - 'An Introduction to Metal Matrix Composites' - Cambridge University Press - 2003
2. Duerig T. W, Melton K. N., Stöckel D. and Wayman C. M. - 'Engineering Aspects of Shape Memory Alloys' - Butterworth Heinemann – 1990

Reference Books:

1. Handbook of Nanostructured Materials and Nanotechnology' - Academic Press - 2000
2. Wang Z. I., Liu Y. and Zhang Z. - 'Handbook of Nanophase and Nanostructured Materials: Vol 1. Synthesis' - Kluwer Academic/Plenum Publishers – 2002
3. Sinha A. K. - 'Physical Metallurgy Handbook' - McGraw Hill - 2002

23MEE358	**ADVANCED WELDING TECHNOLOGY**	**L-T-P-C: 3-0-0-3**

Course Objectives

The course will enable the students to

- Elucidate the concepts of continuity, mechanism, physics, and design elements in welding process
- Comprehend the characteristics of weldable materials and welding technologies
- Demonstrate the importance of modelling and simulation of welding process
- Develop intellectual skills for correlating the microstructural evolution with the defects and properties of weldments

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Describe welding processes, welding symbols, joint configurations, and heat source characteristics	Understand
CO02	Formulate governing equations and boundary conditions to simulate the thermal phenomenon in the course of a welding process	Evaluate
CO03	Evaluate the microstructural evolution on the properties of weldments	Evaluate
CO04	Identify appropriate techniques for detecting the welding defects	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3											1	2		1	
CO02	3	3	2	2					1	1	1	1	2	1	1	
CO03	3	3	2	2								1	2	1	1	
CO04	3	3	2	2								1	2		1	

Syllabus

Unit 1

Overview of welding processes and their classification, types of joints, edge preparation, weld symbols, weld nomenclature, bead geometry, power density, heat sources - Gaussian distribution of heat flux, welding techniques - linear and orbital. Arc characteristics. Voltage-current characteristics. Types of welding manipulators and their applications. Advanced welding processes: submerged arc, TIG, MIG, electro-slag, ultrasonic, electron beam and laser beam welding. Case studies and applications - industrial, automotive and aerospace.

Unit 2

Thermal modeling and simulation of welding processes - governing heat transfer equations and boundary conditions for various types of welding processes. Estimation of cooling rates. Prediction of mechanical properties, micro/macro-structures of weldments and heat-affected zone. Prediction of weld defects such a crack, segregation, lack of fusion. Modeling and simulation of pulsed arc processes. Use of softwares for simulation. Solidification behaviour of fusion weld: structural zones, epitaxial growth, weld pool shape and columnar grain structures. Weldability of metals- steels, stainless steels, aluminium, copper, nickel and titanium alloys.

Unit 3

Microstructures of weldment.Segregation of alloying elements.Impact of micro/macro-structures and segregation on mechanical properties.Pre- and post-treatment. Effects of heat flow on residual stresses and distortion. Weldability tests. Welding defects - causes and remedies.Methods of testing weldments - mechanical, pressure and leak testing.Inspection methods - visual, penetrant, magnetic, ultrasonic, x-ray and gamma radiography.Use of imaging techniques for online monitoring.

Textbooks:

1. Khanna O. P. - ‘A Text Book on Welding Technology’ – Dhanpat Rai and Sons, New Delhi - 2013
2. Parmar R. S. - ‘Welding Process and Technology’ - Khanna Publishers, Delhi – 1992

Reference Books:

1. Little R. L. - ‘Welding and Welding Technology’ - Tata McGraw Hill Publishing Company Limited, New Delhi – 1989
2. Grong O. - ‘Metallurgical Modelling of Welding’ - The Institute of Materials - 1997 - 2nd Edition
3. Kou S. - ‘Welding Metallurgy’ - John Wiley Publications, New York - 2003 - 2nd Edition.

23MEE359	MICRO-MANUFACTURING	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- To impart knowledge on principles and working of various micro-machining processes and its applications
- To facilitate an understanding of micro-fabrication, micro metrology and its applications

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Understand the basic concepts of micro-machining processess	Understand
CO02	Select the suitable micro-machining process for a given application	Apply
CO03	Apply various micro fabrication process for a given component	Apply
CO04	Appreciate the requirement of various micro-mterological instriments	Understand

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	2	1	1									1	2	1	1	
CO02	2	1	1									1	2	1	1	
CO03	2	1	1									1	2	1	1	
CO04	2	1	1									1	2	1	1	

Syllabus

Unit 1

Micromachining – definition - principle of mechanical micromachining - Classification of micromachining and nanofinishing processes - Molecular dynamics simulations of machining at atomic scale. Diamond Turn Machining (DTM) - components of DTM – requirements of DTM - material removal mechanism – molecular dynamics - tool geometry. Abrasive Jet Micromachining - erosion mechanism - powder feeding - microstructure fabrication. Ultrasonic micromachining – basic elements - mechanism of material removal - microhole drilling, contour machining, micro-de-burring, machining of ceramic materials. Electrochemical micromachining.

Unit 2

Micro-electric discharge micromachining – principle - Micro EDM system development - process parameters - Analytical Modeling. Laser micromachining techniques and their applications. Focused Ion Beam machining. Electro chemical spark micromachining – mechanism - equipment. Electron beam micromachining – mechanism- process parameters - applications.

Unit 3

Microfabrication - Materials for Microsystems manufacture - Substrates and Wafers, active substrate materials, silicon and silicon components. Photolithography based micro fabrication processes - Photo resist development. Additive and subtractive techniques – CVD –PVD – etching - chemical, plasma - resists removal. Large aspect ratio micro manufacturing - LIGA, Deep Reactive Ion Etching (DRIE). Micro Metrology - Scanning Electron Microscopy, optical microscopy, atomic force microscope, molecular measuring machine, Micro-CMM, Transmission electron microscope – principles - applications.

Textbooks:

1. Madou M. J. - 'Fundamentals of Microfabrication' - CRC Press - 2009 - 2nd Edition
2. Jain V. K. - 'Introduction to Micromachining' - Narosa Publishing House – 2010

Reference Books:

1. Ran Hsu, T. R. 'MEMS & Microsystems: Design and Manufacturing' - Tata McGraw- Hill - 2002
2. Mohamed Gad-el-Hak - 'The MEMS Handbook' - CRC Press – 2002

23MEE360	NON-DESTRUCTIVE TESTING	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- To impart knowledge on various NDT methods
- To describe appropriate techniques to detect the defects in components
- To impart knowledge on quantification and calibration of equipment

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Apply the various NDT techniques to identify the defects	Apply
CO02	Select the suitable NDT techniques for various defects	Apply
CO03	Identifying the nature and quantifying the defects	Apply
CO04	Understand the instruments and interpretation on techniques	Understand

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2	2										2		1	
CO02	3	2	2										2		1	
CO03	3	2	2										2		1	
CO04	3	2	2		2								2		1	

Syllabus

Unit 1

Introduction: Non-Destructive testing - Relative Merits and Limitations - NDT vs Mechanical testing. Dry technique and Wet technique – Principle – Applications - Advantages and Limitations. Dyes - Developers – Cleaners. Fluorescent penetrant test. Liquid penetrant inspection. Radiography: X-rays and Gamma rays, Properties of X-rays relevant to NDT - Absorption of rays - scattering. Types and use of Filters – screens - Geometric factors, Film type and Processing. Characteristics of films graininess, Density, Speed, Contrast. Characteristic curves. Characteristics of Gamma rays - fluoroscopy – X-ray – Radiography. Safety with X-rays and Gamma rays.

Unit 2

Ultrasonic Testing: Types of Ultrasonic Waves - Principles of wave propagation - Characteristics of ultrasonic waves - Attenuation. Production of ultrasonic waves - Couplants. Inspection methods - pulse echo, Transmission and Resonance techniques. Thickness measurement. Types of scanning. Test block - Reference blocks.

Unit 3

Techniques for Specific Purposes: Magnetic particle inspection - Principles – Applications - Magnetization methods - Magnetic particles, demagnetization. Eddy current testing - Thermal inspection Principle, Application - Instrumentation of Thermal Inspection. Holography. Acoustic Emission. Pressure and Leak Testing. Chemical Spot Testing. Spark Testing.

Textbooks:

1. Cartz L. - 'Non-Destructive testing' - ASM International, Metals Park Ohio, US - 1995
2. Raj B., Jayakumar T., and Thavasimuthu M. - 'Practical Non-Destructive Testing' - Narosa, New Delhi – 1997

Reference Books:

1. ASM Metals Hand Book, 'Non-Destructive Evaluation and Quality Control' - American Society of Metals, Metals Park Ohio, USA - 1989.

23MEE361 QUALITY CONTROL AND RELIABILITY ENGINEERING L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- To introduce the principles and techniques of statistical quality control and their applications
- To familiarize with basic concepts and techniques of reliability engineering

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Apply the knowledge of statistics and probability to attain the quality improvement in industries	Apply
CO02	Analyze the product quality using statistical tools	Analyze
CO03	Determine the reliability and maintainability of systems	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2		2	1	1	1				1	1	2		1	
CO02	3	2		2	1	1	1				1	1	2		1	
CO03	3	2		2	1	1	1	1			1	1	2	2	1	

Syllabus

Unit 1

Introduction: Review of statistics and probability. Quality related costs, contemporary quality engineering philosophy, Quality systems and international standards and 6 Sigma. Control charts for variables: X-bar and R charts, X-bar and S charts; Control charts for individual measurements; Exponentially Weighted Moving Average (EWMA) and Deviation (EWMD) charts.

Unit 2

Control charts for attributes: p, np, c, and u charts Interpretation of control charts. Average Run Length (ARL) Study. Multivariate quality control. Control charts for short production runs, Modified acceptance control charts. Sensitivity analysis- Process capability analysis. Introduction to Reliability: Concepts and definition of Reliability – Reliability mathematics – failure distributions.

Unit 3

Hazard models – hazard rate function – failure density function – conditional reliability – exponential, Rayleigh, Weibull, Normal and Lognormal distributions – two-parameter exponential and three-parameter Weibull distributions – MTTF, MTBF – design life. Reliability of simple Systems – Series and parallel configurations – Reliability improvement – redundancy – combined series and parallel systems – High level and low level redundancy – k-out of n system – standby redundancy. Maintainability – Factors affecting maintainability of systems – Design for maintainability - MTTR – Maintenance – spare provisioning.

Textbooks:

1. Montgomery D. C. - 'Introduction to Statistical Quality Control' - John Wiley – 2010
2. Ebeling C. - 'An Introduction to Reliability and Maintainability Engineering' - Tata McGraw Hill Publishing Company Ltd. – 2004

Reference Books:

1. Eugene G. L. - 'Statistical Quality Control' - McGraw-Hill - 1996
2. Srinath L. S. - 'Concept in Reliability with an Introduction to Maintainability and Availability' - Associated East-West - 1998
3. Rao S. S. - 'Reliability Based Design' - McGraw Hill – 1992
4. O'cconer P. D. T. - 'Practical Reliability Engineering' - John Wiley & Sons Ltd. – 2003

23MEE362	SIMULATION MODELING OF MANUFACTURING SYSTEMS	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- To impart knowledge in the field of modern methods for simulation and modelling of production systems for industrial needs
- To focus on technological processes and manufacturing systems and applies the principles of discrete simulation for their modeling using software tool.
- To familiarize with discrete event simulation for modelling & simulation of manufacturing systems

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Understand the basic concepts and applications of discrete event simulation	Understand
CO02	Analyze the simulation input data	Analyze
CO03	Verify and validate simulation models using statistical techniques	Analyze
CO04	Analyze and interpret the simulation output results	Analyze
CO05	Build credible simulation models for real-time applications	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2		2	1				1		1	1	2		1	1
CO02	3	2	2	1	1				1	1	1	1	2		1	1
CO03	3	2	2	3	1				1	1	1	1	2		1	1
CO04	3	2	2	3	1				1	1	1	1	2		1	1
CO05	3	2	2	3	1				1	1	1	1	2		1	1

Syllabus

Unit 1

Introduction: Introduction to manufacturing systems – Introduction to simulation – applications – System and System Environment – Types of Simulation - Simulation procedure – Examples of simulation. Probability distributions: Review of basic probability and statistics – Probability distributions – Random number generators – Testing of Random numbers.

Unit 2

Analysis of Simulation input data: Data Collection – Statistical analysis of numerical data – Tests for Independence and Identically distributed data - Distribution fitting – selecting a distribution in the absence of data – Modelling discrete probabilities – Demonstration of input modelling using Arena Simulation package. Model Building of Discrete systems: Modelling Paradigms - Modelling of Structural elements and Operational elements – Modelling issues – Model Verification and Validation.

Unit 3

Applications of Simulation in Manufacturing – Manufacturing Modelling Techniques – Modelling Material Handling system – Model building exercises using Arena - Case study.

Simulation output analysis: Design of Simulation Experiments: Determination of warm up period, Run length, Number of replications - Statistical analysis of simulation output – Terminating and Non-Terminating Simulations – Comparing alternative system designs – Variance reduction Techniques – Simulation Optimization.

Textbooks:

1. Law A. W. and Kelton D. W. - ‘Simulation Modeling and Analysis’ - McGraw Hill - 2010 - 5th Edition
2. Kelton D. W., Sadowski R. P. and Sasowski D. A. - ‘Simulation with ARENA’ - McGraw Hill – 2009

Reference Books:

1. Banks J., Carson J. S., Nelson B. L. and Nicol D. M. - ‘Discrete Event System Simulation’ - Pearson Education - 2001 - 3rd Edition
2. Viswanathan N. and Narahari Y. - ‘Performance Modeling of Automated Manufacturing Systems’ - Prentice Hall - 1998

23MEE363	ENVIRONMENTAL ENGINEERING AND MANAGEMENT	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- To study the different types of environmental pollution
- To learn about the various treatment methods for water and wastewater treatment
- To impart basic concepts of solid waste management

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Learn about the characteristics of water and wastewater	Understand
CO02	Study and design the primary, secondary, and tertiary treatment processes for water and wastewater treatment	Understand
CO03	Evaluate the air quality and design control equipment for air pollution	Apply
CO04	Study the processing and management of different types of solid waste like municipal waste, biomedical waste, hazardous waste, and electronic waste	Understand

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	2			1		3	3	2				2	1			
CO02	3	2	3			3	3	2	1			2	1			
CO03	3	2	3	1		3	3	2	1			2	1			
CO04	2					3	3	1				2	1			

Syllabus

Unit 1: Water and Wastewater treatment

Specifications of drinking water (physical, chemical, and bacteriological) by BIS and WHO. Water treatment processes-primary, secondary and tertiary. Physical, chemical, and biological characteristics of wastewater. Wastewater treatment processes. Primary treatment: Screening, grit removal, oil and grease removal, sedimentation-coagulation. Secondary treatment: Activated Sludge Process, Rotating Biological Contactor. Tertiary treatment methods.

Unit 2: Air pollution and control

Sources of air pollutants. Monitoring of air pollutants. Evaluation of Air Quality Index and prediction of air quality using machine learning techniques. Air pollution control equipment: scrubber, bag filter, settling chamber, cyclone separator, electrostatic precipitator. Process design of air pollution control equipment.

Unit 3: Solid Waste Management

Classification of solid waste. Waste processing techniques: Biochemical and Thermochemical conversion techniques. Waste disposal methods. Biomedical waste management. Hazardous waste management. Electronic waste management. Application of Geographical Information System (GIS) in SWM. Scope of artificial intelligence in solid waste management

Textbooks:

1. Jayarama P. 2011. Municipal Solid Waste Management: Processing, energy recovery global examples, BSP Books Pvt Ltd. Hyderabad

Reference Books:

1. Bhatia, S.C. 2007. Solid and hazardous waste management. Atlantic Publishers and distributors.
2. Liu. H.F and Liptak. G.B. 2000. Environmental Engineer's Handbook, Second Edition, Lewis Publishers, New York
3. Ramachandra. T.V.2006. Management of Municipal Solid Waste, Capital Publishing Company
4. Tchobanoglous G and Kreith. F. 2002. Handbook of Solid Waste Management, Second Edition, McGraw, Hill Companies.
5. Tchobanoglous G, Rowe. R.D and Peavy. S.H. 1985. Environmental Engineering, International Edition, McGraw –Hill Book Co. Singapore
6. C S Rao. 2018. Environmental Pollution Control Engineering, Third Edition, New Age International Publishers
7. S K Garg Sewage Waste Disposal and Air Pollution

23MEE364	DESIGN FOR MANUFACTURING AND ASSEMBLY	L-T-P-C: 3-0-0-3

Course Objectives
The course will enable the students to

- Familiarize students with the concept and application of Design for Manufacturing and Assembly (DFMA) and its impact on product cost and quality.
- Inculcate design guidelines for various manufacturing processes such as casting, welding, metal forming, machining, and additive manufacturing to ensure manufacturability and quality of the final product.
- Develop an understanding of the impact of manufacturing processes on the environment and identify how the application of DFMA can reduce their impact.
- Encourage students to apply sustainable manufacturing practices in their designs and develop an appreciation for the importance of sustainability in the manufacturing industry.

Course Outcomes:
After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Apply principles of DFMA during product design to improve manufacturing efficiency, reduce production costs, and ensure the quality of the final product.	Apply
CO02	Design products using various manufacturing processes such as casting, welding, metal forming, machining, and additive manufacturing.	Evaluate
CO03	Design products with sustainable manufacturing practices to meet environmental standards.	Evaluate
CO04	Develop a case study demonstrating the effective implementation of DFMA principles in product design, manufacturing, and assembly.	Create

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3	3	1			2					1	3	1	2	
CO02	3	3	3	1	1	1	2					1	3	1	2	
CO03	3	3	3	1	1	1	3					1	3	1	2	
CO04	3	3	3	2	1	1	3					1	3	1	2	

Syllabus

Unit 1
Introduction to Design for Manufacturing and Assembly (DFMA): Principles for applying DFMA during design stage, Advantages of applying DFMA during product design. Design features-GD&T**,** Material selection for product design. [4 hours]
Design for Manufacturing (DFM): Casting Processes- Design principles of sand casting, die-casting, investment casting. Design for welding: Design principles for arc welding, gas welding, resistance welding, soldering and brazing. [7 hours]

Unit 2
Design for metal forming: Design principles for blanking, punching, rolling, tube forming, metal extrusion and deep drawing. [4 hours]
Design for subtractive and additive manufacturing: Machining Processes -Design principles of tuning, drilling, milling, grinding and broaching. Design principles for additive manufacturing - FDM, SLS, SLA and SLM processes. [7 hours]

Unit 3

Design for Assembly (DFA): Introduction, Design consideration, Design for Fasteners: Introduction, Design recommendation for fasteners. [4 hours]

Design for Sustainability (DFS): Design for disassembly and Environmental– Design for recyclability- Design for remanufacturing- Design for energy efficiency- Design to regulations and standards. [6 hours]

Case studies on product design for manufacturing and assembly. [3 hours]

Textbooks:

1. Boothroyd G., Dewhurst P. and Knight W. - 'Product Design for Manufacture and Assembly' - Marcel Dekker, New York - 2016 - 4th Edition
2. Peck H. - 'Designing for Manufacture' - Pitman Publications - 1983

Reference Books:

1. Spotts M. F. - 'Dimensioning and Tolerance for Quantity Production'- Prentice Hall Inc. -1983
2. Wade O. R. - 'Tolerance Control in Design and Manufacturing' - Industrial Press Inc., New York - 1967
3. Creveling C. M. - 'Tolerance Design - A Hand Book for Developing Optimal Specifications' - Addison Wesley Longman, Inc, - 1997

23MEE365	GEOMETRIC DIMENSIONING AND TOLERANCING	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- To be familiar with GD&T glossary and resource symbols, feature control frame, modifiers, and notes in a blueprint.
- To understand the various types of tolerances such as location, position, orientation, and other form tolerances.
- To identify the different types of datum, axis and center plane and its applications in typical machine component feature specifications.
- To know the use of employing parallelism, perpendicularity, angularity, straightness, flatness in a typical engineering drawing and to understand the inspection methods of the same.
- To apply the concept of Tolerance of position (TOP) and Regardless of Feature Size (RFS) to control the feature tolerances.
- To understand the fundamentals of Maximum Material Condition (MMC), Least Material Condition (LMC), and Profile Controls for the perfect boundary system.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Understand the use of various GD & T symbols in an engineering drawing of a precision machined component.	Understand
CO02	Apply various types of tolerances such as location, position, orientation, and other form tolerances to achieve the functional requirement of the component.	Apply
CO03	Select the different types of datum, axis and center plane to satisfy the need of the component feature specification.	Select
CO04	Apply the parallelism, perpendicularity, angularity, straightness, flatness tolerances of the various surface of the component with respect to the requirement.	Apply
CO05	Select the appropriate Tolerance of position (TOP) and Regardless of Feature Size (RFS) to control the feature tolerances.	Select
CO06	Analyze the Maximum Material Condition (MMC), Least Material Condition (LMC), and Profile Controls for a perfect boundary system	Analyze

CO-PO Mapping: [affinity[#]: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2	2	1	1	1			1	1		1	3	2		
CO02	3	2	2	1	1	1			1	1		1	3	2		
CO03	3	2	2	1	1	1			1	1		1	3	2		
CO04	3	2	2	1	1	1			1	1		1	3	2		
CO05	3	2	2	1	1	1			1	1		1	3	2		
CO06	3	2	2	1	1	1			1	1		1	3	2		

Syllabus

Unit 1

GD & T Fundamental: Importance of Geometric Dimensioning and Tolerancing (GD&T); advantages of using GD&T on engineering drawings and product data sheets; GD&T Glossary and Resource Symbols and Terms; Feature Control Frame; Fundamentals of Limits, Fits and Tolerances: Designation of Holes & shafts.

Hole basis system/shaft basis system. [6 hours]

Different types of tolerances: Dimensional Tolerances, Form Tolerances, Position Tolerances, Surface Roughness values & Combination Tolerances. Interpretation of axial/radial runout, Eccentricity, circularity &

cylindricity control. Total Runout tolerance zone; Difference between Concentricity and Total Runout; Inspecting concentricity; Orientation tolerances: flatness & straightness control, Angularity, Perpendicularity and Parallelism. [6 hours]

Unit 2

Datum systems: Planar datums; Importance and benefits of Datum systems. Datum reference in the feature control frame. Primary, Secondary and Tertiary Datum's. Datum selection; Multiple datum reference frames, datum targets and its applications; Datum Axis & Center Plane; 3 Ways for representing an axis as datum, 2 Ways for representing a centre plane as datum. Datum feature applications. [5 hours]

Position & Location system: Application of perpendicularity, Parallelism and, angularity. Perpendicularity tolerance zones and its applications. Perpendicularity with multiple datums. Angularity tolerance zones and its applications. Angularity applied to a surface. Inspection of Angularity. Parallelism Tolerance Zones and its applications. Inspection of parallelism. [5 hours]

Fundamental concepts of tolerance of position; Zone of Tolerance-Cylinder-Position, Co-axiality, Symmetry, Tolerance of position (TOP) control-True position tolerance; Advantages of TOP; Tolerance of Position (top) - Special applications: TOP Locating Holes that are Non-Parallel; Bi-Directional TOP (Locating a Hole in Two Directions): Using TOP to locate an elongated hole: Concentricity control and its applications; Regardless of Feature Size (RFS). Datum axis RFS Primary and secondary. Datum Center plane RFS Primary; [7 hours]

Unit 3

Boundary system & Tolerance stack analysis: Maximum Material Condition (MMC), Least Material Condition (LMC). Profile Controls; Profile of any line, Profile of any surface, Profile tolerance zone specification. Advantages of Profile Control. Profile Used to tolerance a polygon, conical feature, coplanar surfaces. Tolerance stack analysis: Pattern Shift, Bonus Tolerance, Virtual Condition and Zero Positional Tolerances. [9 hours]

Example applications of GD&T Case study: [4 hours]

- Perpendicularity, Parallelism, Straightness, control.
- Concentricity, Eccentricity, Circularity and Cylindricity. Runout-Axial, radial & total.
- Datum reference in the feature control frame. Primary, Secondary and Tertiary Datums.
- Angularity tolerance zones and its applications and Location Tolerances.

Project work: Fabrication of feasible components using GD & T techniques. [5 hours]

Textbooks:

1. Gene R. Cogorno, "Geometric dimensioning and tolerancing for Mechanical Design" McGraw Hill Third Edition, 2020
2. James D. Meadows – "Geometric Dimensioning and Tolerancing Applications, Analysis & Measurement [per ASME Y14.5-2009]" – ASME Press 2010

Reference Books:

1. Alex Krulikowski – "Fundamentals of Geometric Dimensioning and Tolerancing 2018" – SAE International 2019
2. PS Gill - "Geometric Dimensioning and Tolerancing" 2013 S.K. Kataria & Sons
3. Bipinkumar singh- "Advanced Geometric Dimensioning and Tolerancing" – 2021, Blue Rose publishers

23MEE366	ADVANCED FORMING TECHNOLOGY	L-T-P-C: 2-0-3-3

Course Objectives

The course will enable the students to

- To understand the fundamental concepts of different types of forming processes, plasticity theories, and material selection methods to optimize tooling design and improve formability.
- To inculcate the practical implications of advanced forming processes in real-world manufacturing scenarios.
- To attain the design skills required for forming processes to manufacture complex parts with quality assurance.
- To gain skills and hands-on experience with various forming processes through laboratory exercises and projects.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Analyze material behavior during forming processes using plasticity theories	Analyze
CO02	Design optimized parts and tooling for forming processes using CAD software and simulation tools	Create
CO03	Apply advanced forming processes to produce complex parts	Apply
CO04	Evaluate formability using testing methods and formability limit diagrams	Evaluate
CO05	Conduct laboratory exercises and solve practical manufacturing problems with design considerations using advanced forming technology	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2	2	1					1	1		1	3		2	
CO02	3	2	2	1	1				1	1		1	3	2	2	
CO03	3	2	2	1					1	1		1	3		2	
CO04	3	2	2	1					1	1	1	1	3		2	
CO05	3	2	2	1					1	1	1	1	3		2	

Syllabus

Unit 1: Fundamentals of Forming Processes

Overview of forming processes - Plasticity theories for forming processes - Material selection and material flow analysis - Tooling design and selection - Formability testing methods - Forming limit diagrams – Spring back effect. [8 Hours]

Unit 2: Advanced Forming Processes

High-energy rate-forming processes - Incremental forming processes - Hydroforming processes - Powder metallurgy forming – Flow forming - Innovative and hybrid forming processes. [8 Hours]

Unit 3: Design for Forming Processes and Manufacturing of Complex Parts

Design considerations for forming processes - Part and die design principles - Tolerance analysis and control - Computer-aided design (CAD) for forming processes - Simulation and modeling for forming processes - Design for manufacturing (DFM) principles - Manufacturing of complex parts and quality assurance. [14 Hours]

Unit 4: Laboratory Exercises and Projects

Laboratory exercises on various forming processes - Design and optimization of tooling for forming processes - Project on the application of advanced forming technology to solve a practical manufacturing problem with design considerations.

Textbooks:

1. Advanced Forming Technology: Principles, Applications, and Manufacturing Processes by Ming Wang Fu

Reference Books:

1. Fundamentals of Metal Forming Technology by Taylan Altan, Gracious Ngaile, and Gangshu Shen
2. Introduction to Materials Science for Engineers by James F. Shackelford
3. Metal Forming: Mechanics and Metallurgy by William F. Hosford and Robert M. Caddell
4. Advances in Metal Forming: Expert System for Metal Forming by Taylan Altan, M. Akif Ezan, and Faruk Birol
5. Fundamentals of Metal Forming" by Harold W. Paxton and Frank W. Koehler

23MEE367	THEORY OF METAL CUTTING	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- Understand the mechanisms of chip formation and the forces involved in metal cutting
- Learn about the geometry of cutting tools and how cutting variables affect tool geometry and force
- Gain knowledge of different tool materials and their recommended cutting speeds, wear mechanisms, and tool life equations.
- Study the thermal aspects of metal cutting, including heat sources, temperature distribution, and cutting fluid properties and selection.
- Explore advanced topics such as cryo machining, high-speed machining, surface finish, machine tool vibration, and the economics of machining processes.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Analyze and predict the forces and power involved in metal cutting, and apply this knowledge to select appropriate cutting parameters for different applications.	Apply
CO02	Understanding the Geometry of single and multipoint cutting tools and tool force measurement	Understand
CO03	Understand the mechanisms of tool wear and failure, and use this knowledge to optimize tool life and reduce costs.	Understand
CO04	Determine the appropriate cutting fluid for a given application, and understand its properties and how to apply and filter it properly.	Apply
CO05	Understand advanced machining techniques to improve surface finish, reduce vibrations, and optimize machining economics.	Understand

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2	1	1									2		2	
CO02	3	2	1	1		1							2		2	
CO03	3	2	1	1		1							2		2	
CO04	3	2	1	1	3								2		2	
CO05	3	2	1	1	3								2		2	

Syllabus

Unit 1*

Mechanics Of Metal Cutting: Mechanism of chip formation, Orthogonal & Oblique cutting, types of chips, built-up edge, Determination of shear plane angle, forces on the chips, forces in orthogonal cutting, Merchant circle diagram and analysis, Theory of Lee & Shaffer, coefficient of friction, power & energy relationship, velocity relationship, shear-strain, factors affecting forces and power, problems. [10 Hours]

Unit 2*

Geometry of cutting tools and force measurement: Single-point and multipoint cutting tools, tools nomenclature, tool point reference systems, tool signature, Recommended tool angles, and effect of cutting parameters on tool geometry. Effect of Cutting variables on Forces, Force measurement using Dynamometers. [8 Hours]

Unit 3*

Tool Characteristics: Characteristics of tool materials, types of tool materials, recommended cutting speeds, discussion on hardening of tools and their applications. Mechanisms of tool wear, Sudden & gradual wear, crater wear, flank wear, tool failure criteria, tool life equations, the effect of process parameters on tool life, tool life tests, conventional & accelerated tool wear measurement, machinability index. [10 Hours]

Unit 4*

Thermal Aspects In Metal Cutting: Heat sources in metal cutting, the temperature in chip formation, temperature distribution, and experimental Determination of tool temperatures. Basic actions of cutting fluids, properties of cutting fluids, selection of cutting fluids, application of cutting fluids, filtration of fluids, recommended cutting fluids. [8 Hours]

Unit 5

Cutting tool aspects: Cryo machining & high-speed machining, Surface Finish and Surface Integrity, Machine Tools Vibration, and Economics of Machining Processes. [8 Hours]

Textbooks:

1. Metal Cutting Theory and Practice, A. Bhattacharya, Central Publishers, 2014.
2. Fundamentals Of Metal Cutting & Machine Tools, by Bl Juneja, Gs Sekhon, Nitin Seth, New Age International (P) Ltd, 2017

Reference Books:

1. Metal Cutting Principles, M.C.Shaw, Second Edition, Oxford Publications, 2004.
2. Fundamentals of Metal Machining and Machine Tools by Winston A. Knight, Geoffrey Boothroy, 3rd Edition, CRC Press, 2005
3. Metal Cutting, Paul K. Wright, E M Trent, Butterworth-Heinemann, 2000

23MEE368	ELECTRONIC MATERIALS SCIENCE	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- To understand the behavior of electrons in crystals, band theory and electron distribution statistics.
- Understand the difference between electronic structures and physical properties of semiconductors, metals, and dielectrics.
- Understand the physics of magnetic materials and superconductivity.
- Measure and analyze transport characteristics, and optical parameters of semiconductors.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Understand the mechanisms and models of electrical and thermal conduction in metals and semiconductors based on classical and quantum models	Understand
CO02	Apply the classical and quantum models to junctions involving metals, insulators and semiconductors	Evaluate
CO03	Understand the origin of magnetism and magnetic properties of materials, and analyse their behaviour in different applications	Understand
CO04	Select properties of materials and analyse their application in electronic devices; Understand thermal properties and their origins	Analyze

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3	1	1	1							1	2		1	
CO02	3	1	1	1	1							1	2		1	
CO03	3			1								1	2		1	
CO04	3			1	2							1	2		1	

Syllabus

Unit 1

Types of bonding in solids, Crystallography and crystalline defects: Crystallography, Directions and planes, Crystalline defects, line defects, Planar defects, Volume defects; Binary and Ternary Phase Diagrams: Lever rule and phase rule, Eutectic, peritectic and Eutectoid systems, Applications of Phase diagrams; Electrical Conduction in Solids – Metals, Semiconductors, Ionic Solids; Drude Model, Factors Affecting Resistivity: Temperature and Impurities, Alloys, Mattheissen and Nordheim Rules, Resistivities of Mixed Solid Phases, Hall Effect.

Unit 2

Basic Quantum Physics – atomic structure, Molecular Orbital Theory, Fermi Level; Use of band theory and occupation statistics to explain the existence and basic properties of metals and nonmetals. Conductivity of Metals; Metal-Metal Junction: Contact Potential, Seebeck and Peltier Effects; Thermocouples; Intrinsic and Extrinsic Semiconductors; Temperature Dependence of Conductivity; Recombination and Trapping; Drift and Diffusion Currents; Working of Semiconductor Devices using band diagrams and their electrical characteristics: pn junctions, BJT, MOSFET.

Unit 3

Use of band theory to explain optoelectronic properties of materials and optoelectronic devices: LEDs, Solar Cells, Lasers, pin diodes, photodiodes; Magnetic properties and Superconductivity: Magnetic moments and Magnetic Permeability, types of magnetism, saturation magnetization, magnetic domains, soft and hard magnetic materials, superconductivity and its origin, Giant Magneto Resistance, Josephson effect, Energy band diagrams and Magnetism, Applications of magnetic materials – Magnetic recording materials.

Textbooks:

1. S. O. Kasap, Principles of Electronic Materials and Devices, 2006, 3rd edition, Tata McGraw Hill

Reference Books:

1. D. Jiles: Introduction to the Electronic Properties of Materials, Chapman & Hall. 1994.
2. W. D. Callister, Jr., "Materials Science and Engineering", 2006, Sixth Edition, Wiley India.

23MEE369	REVERSE ENGINEERING AND ADDITIVE MANUFACTURING	L-T-P-C: 2-0-3-3

Course Objectives

The course will enable the students to

- To provide comprehensive knowledge on additive manufacturing technologies
- To familiarize the terminologies of reverse engineering
- To demonstrate the functionality and interactions between the subsystems of any product
- To create digital CAD model of physical object using reverse engineering approach

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Illustrate the significance and principles of additive manufacturing	Understand
CO02	Demonstrate the methodology of reverse engineering a product using different technologies	Apply
CO03	Apply various geometric modelling concept to handle the reverse engineering data	Apply
CO04	Develop CAD model of the reverse engineered product suitable for additive manufacturing	Analyze

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2	1						1	1		1	3	1	3	
CO02	3	2	2	1	2				1	1		1	3	1	3	
CO03	3	2	2	1	3	1			1	1		1	3	1	3	
CO04	3	2	3	2	3	1			1	1		1	3	1	3	

Syllabus

Unit 1

Reverse Engineering: Introduction to Reverse Engineering, Need of reverse engineering, Methodologies for Reverse Engineering, Phases of Reverse Engineering, Reverse engineering for different field and application: artefact/ product/ component/ process/ system. [8 hours]

Unit 2

Reverse Engineering Technologies: Existing technologies, Contact & Non-contact systems, Co-ordinate Measuring Machine-Types, Probe, 3D scanning and Digitizing Devices Laser scanning, Computed Tomography (CT) Scanning, Basic Components of CT, Magnetic Resonance Imaging (MRI), Ultrasound imaging, Imaging Systems, issues with Light-based Approaches, Accuracy issues in different approaches. [15 hours]

Unit 3

Geometric Modelling: Data handling for Reverse Engineering – Post processing the Captured Data, Handling Data Points, Cloud data handling, reduction methods. Point Cloud acquisition, Surface Modelling from a point clouds, Meshed or Faceted Models, Planar Contour Models, Points to Contour Models, Surface Models, Segmentation and Surface Fitting for Prismatic objects and Free Form Shapes. Conversion of Point Cloud Data into .stl file, Curve and Surface Creation, Inspection, Digital Communication in Medicine (DICOM) format, DICOM to STL creation. [15 hours]

Unit 4

Additive Manufacturing: Introduction, Different Technologies of Additive Manufacturing, Process parameters, CAD for additive manufacturing, Slicing algorithm, Adaptive slicing, Basic Principles of Additive Manufacturing, Design for Additive Manufacturing. [7 hours]

Textbooks:

1. Product Design: Techniques in Reverse Engineering and New Product Development, K. Otto and K. Wood, Prentice Hall, 2001.
2. Reverse Engineering: An Industrial Perspective, Raja and Fernandes, Springer, 2008.

Reference Books:

1. Reverse Engineering, Linda Wills, Kluiver Academic Publishers, 1996
2. Co-ordinate Measurment and reverse engineering, Donald R. Honsa, ISBN 1555897, American Gear Manufacturers Association
3. Gibson, I., Rosen, D.W. and Stucker, B., "Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing", Springer, 2015.

23MEE370	MATERIALS CHARACTERIZATION	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- Introduce the quantitative and semi-quantitative instrumental analysis of materials
- Illustrate the structure-property correlation to select apposite material for critical service environment
- Develop comprehensive knowledge on the advanced instrumental characterization of materials for analyzing the microstructure, texture, elemental composition, phase composition, and surface topography/roughness
- Enable effective use of software for indexing and interpretation of graphical data

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Describe the influence of microstructural features and crystallographic structure on the properties of materials	Understand
CO02	Construe the imaging, diffraction, and composition analysis of materials using analytical instruments	Understand
CO03	Determine the suitable analytical instrument for characterization of materials	Apply
CO04	Index and interpret the graphical data that were obtained from the analytical instruments	Analyze

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3												2		1	
CO02	3	2											2		1	
CO03	3		2	2									2		1	
CO04	3	3		1	3				1			1	2		1	

Syllabus

Unit 1

Introduction to instrumental analysis, quantitative – semi-quantitative analysis, and material identification; Concept of microstructure; Microstructure features and parameters (grains, grain boundary, dislocations, phases, grain size, phase fraction); Microstructure – Property relationship (mechanical, fatigue, creep, corrosion, and tribological); Crystallography (overview); Interaction of electro-magnetic waves with matter; Diffraction analysis of crystal structures – scattering of radiation, reciprocal space, Bragg's law, atomic scattering factors, scattering by unit cell, interpretation of diffraction density; X-ray diffractometer – powder diffraction (particles, polycrystals), single crystal Laue diffraction, rotating single crystal methods; Interpretation and indexing of x-ray diffraction graph (phase composition)

Unit 2

Crystallographic texture of materials – micro texture, macrotexture, stereographic projection, interpretation of pole figure and inverse pole figure; Crystallography of deformation; X-Ray Photoelectron Spectroscopy (including spectrum analysis); X-Ray Fluorescence Spectroscopy; Field-Emission Scanning Electron Microscopy (electron beam and sample interactions, origin of signals from sample, secondary electrons – SE1 & SE2, back scattered electrons BSE1 & BSE2); Energy Dispersive X-Ray Spectroscopy (SDD Detector); Wavelength-Dispersive X-Ray Spectroscopy; Electron Back Scattered Diffraction;

Unit 3

Transmission Electron Microscopy (specimen preparation, bright field, dark field, phase contrast, electron diffraction, Ewald's sphere, interpretation and indexing of ring patterns, spot patterns, Laue zones) Surface topography and roughness (2D and 3D parameters); Atomic Force Microscopy (operation modes) – Scanning Kelvin Probe Microscopy, AM-FM Viscoelastic Mapping Mode, Electrostatic Force AFM; Non-Contact Optical Profilometry; Electron Probe Micro Analyzer; UV-Visible Spectroscopy, Fourier Transform Infrared Spectroscopy; Introduction to Thermo Gravimetric Analysis, Differential Thermal Analysis, Differential Scanning Calorimetry

Textbooks:

1. David G. Rethwisch and William Callister, Materials Science and Engineering: An Introduction, 10^{th} Edition, Wiley, 2018
2. David Brandon and Wayne D. Kaplan, Microstructural Characterization of Materials, Wiley, 2008
3. Satyam Suwas and Ranjit Kumar Ray, Crystallographic Texture of Materials, Springer, 2014.
4. Richard Brundle, Charles A. Evans and Shaun Wilson, Encyclopedia of Materials Characterization: Surfaces, Interfaces, Thin Films, Butterworth-Heinemann, 1992

Reference Books:

1. Helmut Günzler and Alex Williams, Handbook of Analytical Techniques, WILEY-VCH Verlag GmbH, 2001
2. Yang Leng, Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, , Wiley VCH, 2013.
3. B. D. Cullity and S R Stock, Elements of X-ray diffraction, Prentice Hall, 2001

23MEE373	CORROSION SCIENCE AND ENGINEERING	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- Introduce thermodynamic and electrochemical aspects of corrosion
- Illustrate the correlation between themicrostructure and corrosion mechanism of engineering materials
- Develop comprehensive knowledge on the testing and characterization of advanced engineering materials operating under severe and harsh environmental conditions
- Enable effective use of software for analyzing the corrosion mechanism of materials
- Explicit the necessity of corrosion protection of materials for prevention of failures and sustainable material usage

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Describe the forms, thermodynamic and electrochemical corrosion kinetics of metallic materials	Understand
CO02	Construe the influence of microstructure on the corrosion and corrosion mechanism of the engineering materials	Understand
CO03	Determine the suitable methodology for characterizing the corrosion mechanism of materials	Apply
CO04	Interpret the microstructure and graphical data that were obtained from the analytical instruments	Analyze
CO05	Comprehend the effective corrosion protection methodologies for prevention of failures and sustainable material usage	Evaluate

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3												2		2	
CO02	3	2											2		2	
CO03	3		2	2									2		2	
CO04	3	3		1	3				1	1		1	2		2	
CO05	3	2	2	2					1	1		1	2		2	

Syllabus

Unit 1

Basics of corrosion: Thermodynamics and electrochemical aspects of corrosion; EMF and galvanic series; Pourbaix diagram; Evans diagram; Corrosion mechanism – kinetics of activation polarization, kinetics of passivation polarization, mixed potential theory, diffusion, limiting current tendency; Corrosivity and passivity.

Unit 2

Forms of Metallic Corrosion: Uniform, pitting, crevice, intergranular, stress corrosion, corrosion fatigue, dealloying, biological, liquid metal attach, and exfoliation; Atmospheric corrosion of metallic materials: Steel (marine environment, nuclear power plants), aluminum alloy (marine environment), and magnesium alloys (biological medium); nickel alloy (severe and harsh environment); High-temperature corrosion – mechanisms and kinetics

Unit 3

Corrosion Testing: Surface preparation, measuring and weighing, exposure techniques; Cleaning of specimens after exposure test; Methodologies to evaluate galvanic, erosion, crevice, intergranular, stress, and pitting corrosion; Huey, Warren, Streicher, in vivo, and slow-strain rate tests; Electrochemical corrosion analysis – linear polarization, AC impedance, cyclic voltammetry, Tafel; Corrosion Prevention: Materials selection, alternation of environment, cathodic and anodic protection, and coatings

Lab Experiments

1. Immersion Corrosion Test
2. Cyclic Corrosion Test
3. Potentiodynamic Polarization Test
4. Hot-Salt Corrosion Test (Demonstration on Nickel-based Superalloy and Nuclear Grade Steel)

Textbooks:

1. Mars G Fontana, Corrosion Engineering, McGraw Hill (3rdEdition)
2. Pierre R. Roberge, Corrosion Inspection and Monitoring, Wiley (2006)

Reference Books:

1. Uhlig's Corrosion Handbook, Wiley (3Edition, 2011)
2. Nastor Perez, Electrochemistry and Corrosion Science, Kluwer Academic Publishers (2ndEdition, 2004)
3. Philip A. Schweitzer, Fundamentals of Corrosion, CRC Press (1stEdition, 2009)
4. R. Winston Revie and Herbert H. Uhlig, Corrosion and Corrosion Control: An Introduction toCorrosion Science and Engineering, Wiley (4thEdition, 2008)
5. Research Opportunities in Corrosion Science and Engineering, National Academic Press,Washington D.C. (2011)

23MEE374	AUTOMOTIVE MATERIALS AND ENGINEERING	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- To understand the construction and working of automotive engines.
- To understand the properties of engineering materials.
- To impart knowledge on materials used in automobile components.
- To discuss case studies and material failures in auto industry.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Identify the functional requirements of automobile systems and components.	Understand
CO02	Identify the material property requirements in automotive systems.	Understand
CO03	Enabling students to design materials for auto components.	Apply
CO04	Realize the advancements in the future of automotive materials and technologies.	Understand

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3	1			1	1					1	3		2	
CO02	3	3	1			1	1					1	3		2	
CO03	3	3	1			1	1					1	3		2	
CO04	3	3	1			1	1					1	3		2	

Syllabus

Unit 1

Automotive engines –Operation, types, Construction– Piston, Cylinder blocks, Cylinder heads, Crankshaft, Camshaft and Valves, Fuel system – Fuel injection, carburetors, starting system, Charging system, Lubricating system, Cooling system, Exhaust systems, Electronic system, Clutches, Transmissions and Differentials, Suspensions, Steering and Brakes. Electric engines –construction, parts and working.

Engineering Materials – Basics of atomic structures, Mechanical properties, Failure analysis, Thermal, electrical, magnetic properties, corrosion, and wear.

Unit 2

Reciprocating engine – Materials for cylinder, piston, piston ring, camshaft, valve systems, crankshaft and connecting rod, Materials used in electric vehicles – Motors, batteries, Smart materials, Electronic materials, High temperature materials.

Unit 3

Light weight materials in automobiles – Al alloys, MMCs, fiber reinforced composites, carbon fiber, glass fiber, magnesium and alloys, rubbers, thermoplastic and thermo set foams. Failures and case studies, Future vehicles andmaterial technologies.

Textbooks:

1. Hiroshi Yamagata. -'The Science and Technology of materials in Automotive Engines'–Wood head publishing Limited, 2005.
2. Omar Faruk, Jimi Tijong, Mohini sain, 'Lightweight and sustainable materials for automotive applications', CRC press, 2017.

Reference Books:

1. William H. Crouse, Donald Anglin–'Automotive Mechanics'- McGraw Hill Education (India) Private Limited-2006-10thEdition.
2. Callister W.D. -'Materials Science and Engineering'- John Wiley & Sons–2010-8th Edition.

23MEE375	COMPUTER AIDED MANUFACTURING	L-T-P-C: 2-0-3-3

Course Objectives

The course will enable the students to

- Fundamental Concepts in computer aided design / manufacturing.
- Working principles of NC machines CNC control and part programming.
- Computer Aided Part programming of CNC turning and machining centers.
- Understand concept of computer aided process planning, inspection, and reverse engineering

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Able to understand the role of computers from the design stage to the production of final product.	Understand
CO02	Demonstrate and explain various CNC control, constructional features and establish the technological data for CNC machining.	Apply
CO03	Develop process plan, manual part program, part program using CAM package for any given, manufacture and inspect.	Apply
CO04	Develop the 3D model of an existing industrial component using reverse engineering tools.	Analyze

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	2	1	1	1					1	1		1	3		2	
CO02	3	1	2	1					1	1		1	3		2	
CO03	3	1	2	1	2	1			1	1		1	3		2	1
CO04	2	1	1	1	2	1			1	1		1	3		2	1

Syllabus

Unit 1

Computer Aided Manufacturing: Introduction- elements of CAM- examples- product design and manufacturing using CAM, Automation in manufacturing, programmable automation. [3 Hours]

Unit 2

CNC Machines: NC Machines, CNC Machines, CNC Machine Components, Co-ordinate System, Working Principle of Various CNC Systems, Direct Numerical Control and Adaptive Control Constructional Features of CNC Machines: Introduction-Machine Structure-Guideways-Ball Screws-Accessories of Machining Centre-Spindle Drives and Feed Drives-Control System of NC Machine Tools , Tooling and Work Holding Devices: Cutting Tool Material-Pre-set and Qualified Tools-ISO Specification of Tools, Chip Breakers, Principle of Location-Clamping-Work Holding Devices. [10 Hours]

Unit 3

CNC Part Programming: Part Programming Fundamentals- G and M Codes-Interpolation Systems-Methods of CNC Part Programming, Manual Part programming for CNC Lathe, Turning Centre- programming of machining centre, CNC Part Programming CAM software – approaches for developing part program in CAM software, procedure, example. [10 Hours]

Unit 4

Computer aided process planning- Generative, Variant, Retrieval, computer aided inspection-CMM. Reverse Engineering (RE) - RE as design methodology, procedure, hardware, and software for RE, RE of assembled product. [7 Hours]

Lab Practice:

Process Planning Exercises for Complex Geometries
Exercises on Turning and Machining Centre programming both manual and using CAM software.
Multi axis machining exercises
Exercises on programming and operation of high-speed machining centre, EDM
Generation of production drawing from the component/assembly using reverse engineering tools

[15 Sessions 45 Hours]

Group Project:

Generation of process plan, CNC part program using CAM software and production of components of industry requirements.

Textbooks:

1. P. N. Rao, 'CAD/CAM, Principles and Applications', Tata McGraw Hill Publishers, 2004.

Reference Books:

1. P.Radhakrishnan, 'Computer Numerical Control Machines and Computer Aided Manufacture, 2nd Edition, New Academic Science Limited, 2015.
2. Zhuming Bi, Xiaoqin Wang, 'Computer Aided Design and Manufacturing', John Wiley and Sons, 2020.

INDUSTRIAL ENGINEERING
AND
MANAGEMENT

23MEE431	FINANCIAL MANAGEMENT	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- Understand the overview of financial management
- Inculcate methods and concepts on valuation
- Familiarize with working capital management, financial analysis and planning

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Understand and apply time value concept of money and use this for investment criteria decisions.	Understand
CO02	Evaluate the risk and return for various alternatives of investment	Evaluate
CO03	Apply the capital budgeting techniques and evaluate the investment decisions.	Apply
CO04	Understand working capital management, cash and liquidity management and financial statements.	Understand

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3					1	1		3	3	1	2		2	
CO02	3	3				1	2	1		3	3	1	2		2	
CO03	3	2					1	1		3	3	1	2		2	
CO04	3	2					2	1	2	3	3	1	2		2	

Syllabus

Unit 1

Introduction: Financial Management an overview – Financial Decisions in a firm – Goal of FM – Function of the financial system. [10 hours]

Unit 2

Fundamental Valuation Concepts: Time value of money – Risk and Return. Capital Budgeting: Techniques of capital budgeting investment criteria– NPV – Benefit Cost Ratio – IRR – Payback Period – ARR – Investment appraisal in Practice – Estimation of Project cost flows. [14 hours]

Unit 3

Working Capital Management: Current Assets – Financing Ruling – Profit Criterion. Cash and Liquidity Management. Working Capital Financing. Financial Analysis and Planning**:** financial instruments, sources of long-term, intermediate term and short term finance. Analyzing Financial Performance – Break – even analysis and Leverages – Financial Planning and Budgeting. Mergers and Takeovers-International trade. [15 hours]

Textbooks:

1. Chandra, P., 'Financial Management: Theory and Practice', 9e, TMH, 2017.
2. Denzil Watson & Antony Head, 'Corporate Finance- Principles and Practice', 2e, Pearson Education Asia, 2016.
3. R L Varshney& K L. Maheshwari, 'Managerial Economics', S Chand & Sons, 22e, 2014.

Reference Books:

1. Stephen Blyth, 'An Introduction to Corporate Finance ', McGraw Hill Book Company, 2014.
2. Eugene F. Brigham & Louis C.Gapenski, 'Financial Management – Theory and Practice', 14e, 2015.

23MEE432	SUPPLY CHAIN MANAGEMENT	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- Understand the complexity and key issues in supply chain management.
- Describe logistics networks, distribution planning, routing design and scheduling models.
- Familiarize dynamics of supply chain and the role of information in supply chain.
- Understand the issues related to strategic alliances, global supply chain management, and procurement and outsourcing strategies.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Analyze the complexity and key issues in supply chain management	Analyze
CO02	Evaluate single and multiple facility location problems, logistics network configuration, vehicle routing and scheduling models	Evaluate
CO03	Analyze inventory management models and dynamics of the supply chain	Analyze
CO04	Develop the appropriate supply chain through distribution requirement planning and strategic alliances	Analyze
CO05	Identify the issues in global supply chain management, procurement and outsourcing strategies	Analyze

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	1	1								1	1	3			
CO02	2	2	3	1							1	1	2			
CO03	3	3	3	3							1	1	2			
CO04	2	2	1	1							1	1	2			
CO05	3	3	3	1							1	1	2			

Syllabus

Unit 1

Introduction: Introduction to SCM-the complexity and key issues in SCM – Location strategy – facility location decisions – single facility and multiple location models.

Logistics: Logistics Network Configuration – data collection-model and data validation- solution techniques-network configuration DSS – Transport strategy – Service choices: single service and inter modal services – vehicle routing and scheduling models – traveling salesman problems – exact and heuristic methods.

Unit 2

Inventory: Inventory Management and risk pooling-managing inventory in the SC. Value of Information-bullwhip effect-lead time reduction.

Supply Chain Integration: Supply chain integration-distributed strategies-push versus pull systems. Distribution Requirements Planning – DRP and demand forecasting, DRP and master production scheduling. DRP techniques – time-phased order point – managing variations in DRP – safety stock determination-Strategic alliances-third party logistics-distribution integration.

Unit 3

Issues in SCM: Procurement and outsourcing strategies – framework of e-procurement. International issues in SCM-regional differences in logistics. Coordinated product and supply chain design-customer value and SCM.

Textbooks:

1. Simchi-Levi, D., Kaminsky, P., Simchi-Levi, E., Shankar, R., 'Designing and Managing the Supply Chain: Concepts, Strategies, and Cases', Tata McGraw Hill, 2008.

Reference Books:

1. Christopher, M., 'Logistics and Supply Chain Management: Strtegies for reducing Cost and Improving Service', PH, 19199.
2. Ballou, M., 'Business logistics / Supply chain management', Pearson Education, 2003.
3. Vollmann, T.E., 'Manufacturing Planning and Control for Supply Chain Management', 5e, McGraw Hill, 2005.

23MEE433	PROJECT MANAGEMENT	L-T-P-C: 3-0-0-3

Course Objectives
The course will enable the students to

- To discuss the project life cycle and build a successful project from pre-implementation to completion.
- To introduce different project management tools and techniques

Course Outcomes:
After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Appraise the selection and initiation of individual projects and its portfolios in an enterprise.	Understand
CO02	Analyze the project planning activities that will predict project costs, time schedule, and quality.	Analyze
CO03	Develop processes for successful resource allocation, communication, and risk management.	Evaluate
CO04	Evaluate effective project execution and control techniques that results in successful project completion	Evaluate

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	2	3	2	2					2		3	1	2	3	2	
CO02	2	3	3	2					3		3	1	2	3	3	
CO03	1	2	3	2					3		3	1	1	2	3	
CO04	1	1	2						3		3	1	1	1	2	

Syllabus

Unit 1
Overview of Project Management: Verities of project, Project Features, Project Life Cycle – S-Curve, J-C
Project Selection: Project Identification and Screening – New ideas, Vision, Long-term objectives, SWOT Analysis (Strength, Weakness, Opportunities, Threats). Project Appraisal – Market Appraisal, Technical Appraisal, Economic Appraisal, Ecological Appraisal, and Financial Appraisal – Payback, Net Present Value (NPV), Internal Rate of Returns (IRR). Project Selection – Decision Matrix, Technique for Order Preference using Similarity to Ideal Solution (TOPSIS), Simple Additive Weighting (SAW).

Unit 2
Project Presentation: WBS, Project Network – Activity on Arrow (A-O-A), Activity on Node (A-O-N).
Project Scheduling: Gant Chart, Critical Path Method (CPM), Project Evaluation & Review Technique (PERT). [6 Hours]
Linear time cost trade-offs in project - Direct cost, indirect cost, Project crashing
Resource Consideration - Profiling, Allocation, Levelling.
Introduction to project management software: Primavera/ Microsoft project

Unit 3
Project Execution: Monitoring control cycle, Earned Value Analysis (EVA), Project Control – Physical control, Human control, financial control.
Organizational and Behavioral Issues: Organizational Structure, Selection-Project Manager, Leadership Motivation, Communication, Risk Management.
Project Termination: Extinction, Addition, Integration, Starvation.

Textbooks:

1. Jack R. Meredith and Samuel J. Mantel, Jr. - ‘Project Management- A Managerial Approach’ Eighth Edition - John Wiley & Sons Inc - 2012.
2. Arun Kanda – ‘Project Management-A Life Cycle Approach’ PHI Learning Private Limited – 2011

Reference Books:

1. ‘A Guide to Project Management Body of Knowledge’ PMBOK GUIDE, Sixth edition, Project management Institute – 2017
2. Ted Klastrorin - ‘Project Management, Tools, and Trade-Offs’ - John Wiley – 2011

23MEE434	MANAGERIAL STATISTICS	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- To impart the knowledge of basic statistical tools for analysis and interpretation of qualitative and quantitative data for decision making

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Apply basic probability and statistics concepts for various business problems	Understand
CO02	Perform test of hypothesis	Evaluate
CO03	Compute and interpret the result of regression and correlation analysis for forecasting	Analyze
CO04	Solve real time problems by applying different decision-making methods.	Evaluate

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3	1	1	1						2	2	3			
CO02	3	3	1	1	1						2	2	3			1
CO03	3	3	1	1	1						2	2	3			1
CO04	3	3	1	1	1						2	2	3			1

Syllabus

Unit 1

Quantitative methods: Basic terminology in probability, probability rules, conditions of statistical dependence and independence, Bayes Theorem, Discrete Random Variables review of probability distributions, measure of central tendency.

Sampling and sampling distributions: Introduction to sampling, random sampling, design of experiments, introduction to sampling distributions

Estimation: point estimates, interval estimates and confidence intervals, calculating interval estimates of mean from large samples, using t test, sample size estimation.

Unit 2

Testing hypothesis: Introduction, basic concepts, testing hypothesis, testing when population standard deviation is known and not known, two sample tests. Chi-square and analysis of variance: introduction, goodness of fit, analysis of variance, inferences about a population variation

Unit 3

Regression and correlation: Estimation using regression line, correlation analysis, finding multiple regression equation, modelling techniques,

Non-parametric methods and time series and forecasting: Sign test for paired data, rank sum test, rank correlation, Kolmogrov – Smirnov test, variations in time series, trend analysis, cyclic variation, seasonal variation and irregular variation. Decision theory: Decision tree analysis.

Textbooks:

1. Levin R. I. and Rubin D. S. - 'Statistics for management' - Pearson Education – 2007 - 5th Edition
2. Montgomery D. C. and Runger G. C. - 'Applied Statistics and Probability for Engineers' - John Wiley & Sons - 2002 - 3rd Edition

Reference Books:

1. Bain.L. J. and Engelhardt M. - ‘Introduction to Probability and Mathematical Statistics’ - Duxbury Press - March 2000 - 2nd Edition
2. Hinkelmann K. and Kempthorne O. - ‘Design and Analysis of Experiments : Volume I’ - John Wiley & Sons, Inc. - December 2007 - 2nd Edition
3. Johnson R. A. and Wichern D. W. - ‘Applied Multivariate Statistical Analysis’ - Prentice-Hall, Inc. - December 2001 - 5th Edition
4. Myers R. H. - ‘Classical and Modern Regression with Applications’ - PWS-Kent Publishing Company - March 2000 - 2nd Edition
5. Devore J. L. - ‘Probability and Statistics for Engineering and the Sciences’ - Brooks/Cole Publishing Company - December 1999 - 5th Edition
6. Freund J. E. and Walpole R. E. - ‘Mathematical Statistics’ - Prentice-Hall Inc. - October 1986 - 4th Edition

23MEE435	TOTAL QUALITY MANAGEMENT	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- Impart knowledge on quality management principles, tools, techniques and quality standards for real life applications

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Evaluate the principles of quality management and to explain how these principles can be applied within quality management systems.	Evaluate
CO02	Evaluate the performance measures using various quality and management tools	Evaluate
CO03	Apply the Quality Function Deployment, Taguchi principles, Total Productive Maintenance and Failure Mode and Effect Analysis concepts to solve industrial problems.	Analyze
CO04	Practice the various quality system in industry.	Understand

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2				1	1	1				1	2			
CO02	3	2				1	1	1				1	2			
CO03	3	2	2			1	1	1				1	2			
CO04	3	2	2	2		1	1	1				1	2			

Syllabus

Unit 1

Definition of quality - dimensions of quality. Quality planning - quality costs. Total Quality Management: historical review and principles –leadership - quality council - quality statements - strategic planning - Deming philosophy. Barriers to TQM implementation

Unit 2

Customer satisfaction – Customer retention - Employee involvement - Performance appraisal - Continuous process improvement - Supplier partnership - Performance measures. Seven tools of quality.Statistical fundamentals - Control Charts for variables and attributes - Process capability - Concept of six sigma - New seven management tools - Benchmarking.

Unit 3

Quality function deployment (QFD) - Taguchi quality loss function - Total Productive Maintenance (TPM) - FMEA. Need for quality systems - ISO 9000:2000 – Elements of quality systems (such as ISO 9000:2000). Implementation of quality system – documentation - quality auditing - QS 9000-ISO 14000.

Textbooks:

1. Besterfiled D. H. - 'Total Quality Management' - Pearson Education Asia – 2015-4th Edition

Reference Books:

1. Evans J. R, and Lidsay W. M. - 'The Management and Control of Quality' - Southwestern (Thomson Learning) - 2002 - 5th Edition
2. Feigenbaum A. V. - 'Total Quality Management - Vol I &II ' – McGraw Hill - 1991

23MEE436	**INDUSTRIAL SAFETY**	**L-T-P-C: 3-0-0-3**

Course Objectives

The course will enable the students to

- To develop an understanding of the principles of safety, terminologies in accident prevention and its theories.
- To understand the theory and practice of occupational health, ergonomics and hygiene, principle of fire engineering and fire-fighting.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Understand the need, basic principles and components of industrial safety	Understand
CO02	Select the proper accident prevention method for the concerned industry	Apply
CO03	Understand the classification of industrial fire and choose an appropriate extinguishing method	Understand
CO04	Create methods to minimize the risk at the work environment.	Analyze

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2	2	2	2	2	2	1				1	2			
CO02	3	2	2	2	2	1	2	1				1	2			
CO03	3	2	1	1	2	2	1	1				1	2			
CO04	3	2	1	2	3	2	2	2				1	2			

Syllabus

Unit 1

Development of safety movement: - Need for safety-safety and productivity- role and qualification of safety professional. Accident prevention: - Basic philosophy of accident prevention-nature and causes of accidents accident proneness-cost of accidents-accident prevention methods-Domino theory-safety education and training-training methods-motivation and communicating safety-personal protective equipment.

Unit 2

Occupational health and hygiene: - Functional units and activities of occupational health and hygiene-types of industrial hazards-physical, chemical, mechanical, electrical, social, biological, ergonomic and environmental hazards-factors impeding safety-housekeeping-hearing conservation programme. Industrial fire protection: - Fire chemistry-classification of fires-fire prevention activities-fire risks-fire load -contributing factors to industrial fires-fire detection-industrial fire protection systems.

Unit 3

Safety management techniques: - Safety Inspection-Safety sampling technique-Safety auditSafety survey-Incident recall technique-Job safety analysis-Damage control-Risk management. Involvement in safety: - Role of management-role of supervisors-role of workmen- role of unions-role of governments in Industrial safety

Textbooks:

1. Brown D.B, "System Analysis and Design for safety", Prentice Hall, New Jercy.
2. R.P.Blake, "Industrial Safety", Prentice Hall of India, New Delhi

Reference Books:

1. Accident prevention manual for Industrial Operations", National Safety Council, Chicago, 1989

23MEE437	ENGINEERING ECONOMIC ANALYSIS	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- Familiarize business impact of economic environment on business decisions

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Understand and evaluate the economic theories, cost concepts and pricing policies and draw inferences for the investment decisions for appraisal and profitability.	Understand
CO02	Appraise the dynamics of the market, market structures, and portray implication for profit and revenue maximization.	Analyze
CO03	Employ operations research and allied techniques in managerial economics for an enhanced analysis and decision-making.	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	2	3	2	2		2		2			3	1	1			
CO02	1	3	2	1		2		2			3	1	1			
CO03	2	3	2	2		2		2			3	1	1			

Syllabus

Unit 1

Economics: Nature and scope of managerial economics. Economic theory and managerial economics.
Cost Concepts: Types of costs - Cost functions. Cost controls: reduction – Tools & Areas. Pricing policies-methods. Capital budgeting - cost of capital. Appraising project profitability.

Unit 2

The essentials of demand and supply: The law of demand. Market demand curve. Other determinants of market demand. The law of supply. Determinants of market supply. The market mechanism. Price elasticity of demand.
Profit and revenue maximization: Optimal input combination. Total revenue maximization.

Unit 3

Market structure: Perfect competition and monopoly. Characteristics of monopolistic competition. Oligopoly Operations Research techniques in managerial economics: Inventory models. Theory of games. Decision theory, Risk and Uncertainty, Measuring risk, Consumer behavior and risk aversion, Decision making under uncertainty with complete ignorance.

Textbooks:

1. Webster, T.J., 'Managerial Economics- Theory and Practice', Elsevier 2004.

Reference Books:

1. Panneerselvam, R., 'Engineering Economics' Second edition, PHI, 20113.
2. R L Varshney& K L. Maheshwari, 'Managerial Economics', S Chand & Sons, 22e, 2014.
3. Harrison.B, Smith.C. And Davis.B. 'Introductory Economics', 2e Pr Macmillan, 2013.

23MEE438	LEAN MANUFACTURING	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- Understand Lean manufacturing principles and tools
- Inculcate the concepts of value stream mapping
- Familiarize lean implementation practices

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Identify key requirements and concepts in lean manufacturing.	Understand
CO02	Initiate a continuous improvement change program in a manufacturing organization	Evaluate
CO03	Analyze and improve a manufacturing system by applying lean manufacturing tools	Evaluate
CO04	Build value stream map for improving the productivity	Analyze
CO05	Improve productivity through lean practices	Analyze

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	2						1				1	1	2			
CO02	2	2	2	1			1		2	1	1	1	2			
CO03	2	2	2	2	1		1		2	1	1	1	2			
CO04	2	2	2	1	1	1	1			1	1	1	2			
CO05	2	2	2	1	1	1	1			1	1	1	2			

Syllabus

Unit 1

Introduction to Lean and Factory Simulation: History of Lean and comparison to other methods - The 7 Wastes, their causes and the effects - An overview of Lean Principles / concepts / tools - Stockless Production.

The Tools of Lean Manufacturing: Continuous Flow – Continuous Flow Manufacturing and Standard Work Flow – 5S and Pull Systems (Kanban and ConWIP systems) – Error Proofing and Set-up Reduction – Total Productive Maintenance (TPM) – Kaizen Event examples. Toyota production systems. Ford production systems – FPS gear model. [17 hours]

Unit 2

Value Stream Mapping – Current state: Preparation for building a Current State Value Stream Map – Building a Current State Map (principles, concepts, loops, and methodology) – Application to the factory Simulation scenario. [14 hours]

Unit 3

Value Stream Mapping – Future State: Key issues in building the Future State Map – Process tips in building the map and analysis of the customer loop, supplier loop, manufacturing loop and information loop – Example of completed Future State Maps – Application to factory simulation. Implementation of lean practices - Best Practices in Lean Manufacturing. [15 hours]

Textbooks:

1. Womack, J.P., Jones, D.T., and Roos, D., 'The Machine that Changed the World', Simon & Schuster, New York, 2007.
2. Liker, J.K., 'Becoming Lean', Industrial Engineering and Management Press, 1997

Reference Books:

1. Womack, J.P. and Jones, D.T., 'Lean thinking', Simon & Schuster, USA, 2003.
2. Rother, M. and Shook, J., 'Learning to see', The Lean Enterprise Institute, Brookline, USA, 2003.

23MEE439	MANUFACTURING PLANNING AND CONTROL	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- To provide an overview of various manufacturing systems
- To familiarize with strategic, tactical and operational planning
- To summarize quantitative methods used in plant location, and layout planning
- To familiarize the concepts of group technology, operations planning and JIT systems
- To impart knowledge on the concepts of operational control through scheduling, cost planning and simulation analysis

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Understand the manufacturing systems and analyze their impact on productivity	Understand
CO02	Understand the strategic, tactical and operational planning concepts	Understand
CO03	Select appropriate plant location and their layout methods	Apply
CO04	Develop aggregate plans, capacity plans and inventory plans	Understand
CO05	Control operations through cost planning, scheduling and simulation analysis	Understand

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2				2		1	2	1		1	3			
CO02	3	2				2		1	2	1	2	1	3			
CO03	3	2	2	2		2	2	1	2	1		1	3			
CO04	3	2		2	1		2	1	2	1		1	3			
CO05	3	2	2	2	1		2	1	2	1	2	1	3			

Syllabus

Unit 1

Overview of manufacturing systems and various issues of interest: Assembly Line, Repetitive batch manufacturing, Cellular manufacturing, FMS, JIT, CIM. [10 hours]

Unit 2

Preplanning: Forecasting, Economic analysis, Aggregate planning, Capacity planning, Inventory planning. Decision making in design of manufacturing systems: Group technology, Line balancing, Plant layout. [14 hours]

Unit 3

Operations planning MRP, MRP II, Hierarchical planning systems, JIT systems, FMS. Operation and control: Lot sizing decisions, Production scheduling, Line of balance, Quality planning and control, Cost planning and control. Simulation analysis of manufacturing systems. Case studies. [15 hours]

Textbooks:

1. Bedworth, D.D. and J.E.Bailey, Integrated Production Control, System - Management, Analysis and Design. John Wiley, 1983.
2. Elsayed E.A. and Boucher T.O., Analysis and Control of Production Systems. Prentice Hall, 1985.
3. King J.R., Production Planning and Control, Pergamon Press, Oxford, 1975

Reference Books:

1. Bestwick, P.F and Lockyer, K., Quantitative Production Management, Pitman Publications, 1982.
2. Hax, A.C and Candea, D., Production and Inventory Management.Prentice Hall, 1984.
3. Johnson, L.A and Momtgomery, D.C., O.R. in Production Planning, Scheduling and Inventory Control.John Wiley and Sons, 1974.
4. Korgaonkar, M.G., JIT Manufacturing, Macmillan Publication Co, 1992.

23MEE440	INTRODUCTION TO ERGONOMICS	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- Understand various ergonomics principles and its importance
- Understand the differences in scopes of various ergonomics streams such as physical, cognitive and organizational.
- Understand the elements of HCI

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Understand the various principles and methods of ergonomics	Understand
CO02	Evaluate the ergonomics of an existing product for improvement	Evaluate
CO03	Choose an appropriate ergonomics for the product	Evaluate
CO04	Apply ergonomics principles for better industrial safety	Create
CO05	Apply ergonomics methods for better work environment.	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	2	2	3	2	1	2	2	1					2	1		
CO02	3	2	3	2	2	2	2	1			1		2	1		
CO03	2	2	3	1	2	2	1	1				1	2	1		
CO04	3	2	3	2	3	2	2	2			3	1	2	1		
CO05	2	2	3	1	2	2	1	1					2	1		

Syllabus

Unit 1

Ergonomics / Human Factors - overview and background; Design communication and ergonomics; User-friendly man machine environment system; Capabilities and limitations of people - physical (body structure, growth, anthropometry, biomechanics, movement), physiological (allowable limits and safety factors) and psycho sociological (behavior, cognitive issues, information processing and perception).

Unit 2

Evaluation of facilities, environment, jobs and tasks, training methods and equipment, and user capabilities; Potential reduction of fatigue, errors, discomforts and unsafe acts.

Unit 3

Ergonomics design: principles and criteria, and checklist for ease and efficiency (including HCI); Occupational hazards and safety, and environment factors affecting performance

Textbooks:

1. R. S. Bridger, Introduction to Ergonomics, McGraw-Hill, Inc., 1995.
2. M. S. Sanders and E. J. McCormick, Human Factors in Engineering and Design, McGraw-Hill, Inc., 1993.
3. Chakrabarti, Debkumar. "Indian Anthropometric Dimensions for Ergonomic Design Practice", National Institute of Design. (1997).

Reference Books:

1. J. Dul and B. Weerdmeester, Ergonomics for beginners a quick reference guide, Taylor & Francis, 1993.
2. P. W. Jordan and W. S. Green (Eds.), Human Factors in Product Design- current practice and future trends, Taylor Francis, London, 1999.

THERMAL AND FLUIDS

23MEE441	GAS DYNAMICS AND JET PROPULSION	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- To discuss the effect of compressibility in gas flow
- To derive the steady one-dimensional isentropic flow equation
- To discuss the effects of friction and heat transfer on compressible flows through constant area duct
- To familiarize the occurrence of shocks and calculate property changes across a shock wave
- To derive the thrust equation and discuss its application in jet and rocket propulsion.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Apply the thermodynamics concepts in relation to compressible flows and derive relationships between various compressible flow parameters	Understand
CO02	Understanding of isentropic compressible flows in variable area ducts and apply in design of static components like nozzles and diffusers	Understand
CO03	Solve for compressible flow characteristics with friction and heat transfer	Evaluate
CO04	Develop relationship for shocks and determine their characteristics under various conditions	Analyze
CO05	Analyse the performance of aircraft and rocket propulsion engines	Analyze

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3	1	1								1	3			
CO02	3	3	1	1								1	3			
CO03	3	3	1	1								1	3			
CO04	3	3	1	1								1	3			
CO05	3	3	1	1								1	3			

Syllabus

Unit 1

Basic concepts: Energy and momentum equations of compressible fluid flows - Stagnation states - Mach waves and Mach cone - Effect of Mach number on compressibility. Isentropic flows: Isentropic flow through variable area ducts. [10 hours]

Isentropic Flow: Nozzle and Diffusers, compressors and turbines - Use of Gas tables. Flow through ducts: Flow through constant area ducts with heat transfer (Rayleigh flow) and Friction (Fanno flow) - Variation of flow properties - Use of tables and charts - Generalized gas dynamics. [10 hours]

Unit 2

Normal and oblique shocks: Governing equations - Variation of flow parameters across the normal and oblique shocks - Prandtl Meyer relations – Expansion of supersonic flow, Use of table and charts - Applications. [10 hours]

Unit 3

Jet propulsion: Theory of jet propulsion - Thrust equation - Thrust power and propulsive efficiency - Operation principle - cycle analysis and use of stagnation state performance of ramjet, turbojet, turbofan and turbo-prop engines – Aircraft combustors. [7 hours]

Space propulsion: Types of rocket engines - Propellants - Ignition and combustion - Theory of rocket propulsion – Performance study - Staging - Terminal and characteristic velocity - Applications - Space flights. [8 hours]

Textbooks:

1. Yahya S. M. “Fundamentals of Compressible Flow with aircraft and rocket propulsion”, 5/e,New Age International publishers, 2016

Reference Books:

1. Balachandran P. “Fundamentals of Compressible Fluid Dynamics”, PHI Learning India Private Ltd., 2009.
2. John D. Anderson Jr. “Modern Compressible Flow with historical perspective”, 2/e, McGraw Hill Publishing company, International Edition, 1990. S
3. Shapiro A. H. “Dynamics and Thermodynamics of Compressible Fluid Flow – Volume I”, John Wiley, New York, 1953.

23MEE442	HVAC SYSTEMS & APPLICATIONS	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- To introduce basic concepts in refrigeration and air-conditioning
- To impart knowledge on refrigerants for domestic and industrial applications
- To familiarize cooling/ heating load calculations for a given application.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Identify the suitability of refrigeration systems	Understand
CO02	Select refrigerants and components like evaporator, compressor, condenser, expansion devices etc. based on operational characteristics	Understand
CO03	Design of refrigeration and air-conditioning systems using fundamentals of heat and mass transfer principles	Analyze
CO04	Evaluate the performance of an air-conditioning system	Evaluate
CO05	Estimate cooling / heating load for given application	Evaluate

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3										1	3			
CO02	3	3	2									1	3			
CO03	3	3	2									1	3			
CO04	3	3		2								1	3			
CO05	3	3		2								1	3			

Syllabus

Unit 1

History of refrigeration, Refrigeration cycles: vapour Compression Cycle and vapour absorption systems. Thermodynamic analysis of cycles.System components: Refrigerant Compressors-Reciprocating, Hermetic, Rotary, Centrifugal Scroll Compressors -Comparison, Construction and Operation characteristics. Evaporators - DX coil flooded type Chillers, Condensing Units and Cooling Towers.

Unit 2

Refrigerants: Desirable properties, Classification, Designation, Alternate Refrigerants, Global Warming Potential & Ozone Depleting Potential Aspects Expansion devices: Automatic Expansion Valves, Capillary Tube & Thermostatic Expansion Valves. Cycling controls and system balancing Pressure and Temperature controls, Range and Differential settings. Selection and balancing of system components - Graphical method.

Unit 3

Psychrometry: Moist air behaviour - Psychrometric chart - Different Psychrometric process and their analysis. Air conditioning: Summer and Winter Air conditioning - Cooling Load Calculations - Air Distribution Patterns - Dynamic and Frictional Losses in Air Ducts - Equal Friction Method - Fan Characteristics in Duct Systems

Textbooks:

1. Ramesh Chandra Arora. "Refrigeration and Air Conditioning", Prentice Hall India, 2015

Reference Books:

1. Stocker W. F. and Jones J. W. 'Refrigeration & Air Conditioning' - McGraw Hill, 1985.
2. Dossat R. J. "Principles of Refrigeration", John Wiley, 1989.
3. Goshnay W. B. "Principles and Refrigeration", Cambridge University Press,1982

23MEE443	POWER PLANT ENGINEERING	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- To familiarize various types of power plants and their site selection
- To familiarize thermal power plant operations, mountings, accessories and its economic viability
- To design systems such as chimney, cooling tower and surface condenser for power plants
- To conceptualize the working of nuclear power plants and to create an awareness on environmental and safety aspects

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Select a suitable location for a power plant	Understand
CO02	Analyse the performance of thermal power plant	Analyze
CO03	Select fuel handling and ash handling methods in thermal power plants	Evaluate
CO04	Design chimney, cooling towers and condensers for power plants	Analyze
CO05	Performance analysis of nuclear power plants	Analyze

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	1	1			1							3			
CO02	3	2	2	1									3			
CO03	3	1	1				1				1		3			
CO04	3	2	1								1		3			
CO05	3	1	1	1							1		3			

Syllabus

Unit 1

Hydrological data - capacity and type -selection - General layout and types of hydroelectric Power Plants. Steam power plant layout and components - steam generators - functions of feed water heaters- super heaters–air Preheaters - economizers and re-heaters. Combustion equipment and firing methods- Fuel bed combustion, Mechanical Stokers, Pulverized Coal firing system, Fluidized Bed Combustion, Cyclone furnace, Coal gasifiers. Ash and Dust handling systems Types of condensers - cooling towers - Water treatment methods

Unit 2

Cogeneration. Elementary treatment of combined cycle power generation. General layout of diesel power plant and their components - Types of plant layouts - comparison of diesel plant with thermal plant. Comparison and types of gas turbine power plants and their components, combined gas and steam power plants - Advantages of gas turbine plant over diesel and thermal plants.

Unit 3

General components of Nuclear reactors - types of reactors - location safety and economics of nuclear plants - comparison with thermal power plants. Economics of power plant operation - variable load operation and economics.

Textbooks:

1. Nag .P.K. "Power Plant Technology", 4/e,McGraw Hill, 2008

Reference Books:

1. El WakilM. M. "Power Plant Technology", 5/e, McGraw Hill, 2010.
2. Weisman.J. and Eckart.R. "Modern Power Plant Engineering", Prentice Hall, 2002.

23MEE444	AUTOMOTIVE TECHNOLOGY	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- To familiarize fundamental knowledge about evolution of automobiles and its construction
- To impart knowledge on mechanical, electrical and electronic systems of an automotives
- To familiarize the various aspects of performance of automotives and to study the future technology in automotives

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Identify the functional requirements of automobile systems and components	Understand
CO02	Demonstrate the working principles of steering, suspension and braking system of automobiles	Evaluate
CO03	Make use of advanced electrical and electronics system in automotives	Evaluate
CO04	Realize the advancements in the future of automotive technology	Analyze

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2	2		1							1	3			
CO02	3	2	2		1							1	3			
CO03	3	2	2		1							1	3			
CO04	3	2	2		1							1	3			

Syllabus

Unit 1

Vehicle and Engine Construction - Chassis, Frame and Body Construction, Engine Types, Construction Details and multi-cylinder engines, Valve Arrangements, Valve Drives, Engine Cooling and Lubrication, Air Supply System, Carburetors, Electronic Fuel Injection Systems, Exhaust Systems Power Drive Line: Clutch - Types and Construction, Fluid Coupling, Transmissions - Manual, Semi and Automotive Transmission, Continuously Variable Transmission, Overdrives, Torque Converter, Propeller Shaft, Differential and Axles, Front and All Wheel Drive Vehicles

Unit 2

Running Systems: Steering Geometry and Types, Steering Linkages, Power and Power Assisted Steering, Types of Front Axle, Suspension Systems, Suspension Design Consideration Active Suspension, Braking Systems - Hydraulic, Pneumatic Brakes and Power Brakes, Anti-Lock Brake system - Wheels and Tyres, Electrical and Electronic Systems: Electrical Systems – Storage, Charging, Starting and Ignition and Lighting Systems.

Unit 3

Electronic Controls for Engine and Vehicle Body, Electronic Dashboard Instruments, Electronic and Computer Controlled Transmissions, Intelligent Transportation Systems. On-board diagnosis system, Safety and Security systems. Future Automobiles: Automobile Air Pollution, Pollution Control Norms, Alternate Power Units for Automobiles - Use of Natural Gas, LPG and Hydrogen in Automobiles as Fuels, Fuel Cells, Electric and Hybrid Vehicles.

Textbooks:

1. Heisler H. - ‘Advanced Engine Technology’ - SAE – 2012
2. William H. Crouse, Donald Anglin – ‘Automotive Mechanics’ - McGraw Hill Education (India) Private Limited- 2006 - 10th Edition

Reference Books:

1. Garrett T. K., Newton K., and Steeds W. - ‘Motor Vehicles’ - Butterworth Heinemann - 2001
2. Fenton J. - ‘Handbook of Automotive Body and System Design’ - Professional Engineering Publishing, UK - 2005
3. Giri N. K. - ‘Automobile Mechanics’, Khanna Publishers, New Delhi - 2006 - 8th Edition
4. Bishop R. - ‘Intelligent Vehicle Technology and Trends’ - AR Tech House Inc. – 1999

23MEE445	SOLAR AND WIND POWER TECHNOLOGIES	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- To introduce the conversion technologies related to solar and wind power
- To familiarize the photovoltaic and thermal conversion of solar radiation
- To inculcate the feasibility of harvesting wind power

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Develop knowledge in solar radiation, its measurement and associated conversion technologies	Understand
CO02	Compare the different forms of solar thermal collectors	Evaluate
CO03	Understand the basics of wind energy conversion	Evaluate
CO04	Assess potential of wind energy as an alternate form of non-conventional energy	Analyze

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2	2				2						2			
CO02	3	2	1				2		1				2			
CO03	3	2	1			1	2		1				2			
CO04	3	2	2								1		2			

Syllabus

Unit 1

Properties of Sun Light- Solar Radiation - Atmospheric effects - Solar Geometry - Measuring Instruments – Estimation of Solar Radiation. Solar cell physics & characteristics - Stand Alone PV System, Cost analysis and pay back calculations; Environmental and safety issues.

Solar Thermal Collectors – Flat plate collector construction and analysis – Thermal resistance network model – Heat transfer correlations – Concentrating type collectors – Construction and working – Tracking mechanisms.

Unit 2

Solar thermal energy utilisation – Heliostats with central receiver – Solar air heater – Solar chimney; Solar thermal power plants– Low, medium and high temperature systems – Performance analysis.

Solar water heaters – Thermosyphon heaters – Active and passiveheating. Solar Ponds – Convective and non-convective ponds – Salt gradient solar pond – Experimental studies; Water desalination using solar still; Solar refrigeration.

Unit 3

Meteorology of wind: Global circulation, Forces influencing wind, Local Wind systems, Wind Turbines: Types, Rotor elements; Horizontal and vertical axis wind turbines, Power in the wind, Power extracted from wind, Betz limit, Lift and drag coefficients, thrust and torque, power coefficient, thrust coefficient, axial interference factor. Pitch and stall regulation, power curve, and energy calculation.

Textbooks:

1. Wenham SR, "Applied Photovoltaic", 2/e, Earthscan Publications Ltd, 2007
2. G.N. Tiwari, "Solar Energy-Fundamentals, Design, Modeling and Applications", Narosa Publishers, 2002.
3. Joshua Earnest and Tore Wizelius, "Wind Power Plants and Project Development", PHI Learning Pvt. Ltd., New Delhi, 2011.

Reference Books:

1. Garrett T. K., Newton K., and Steeds W. - ‘Motor Vehicles’ - Butterworth Heinemann - 2001
2. Fenton J. - ‘Handbook of Automotive Body and System Design’ - Professional Engineering Publishing, UK - 2005
4. Giri N. K. - ‘Automobile Mechanics’, Khanna Publishers, New Delhi - 2006 - 8th Edition
5. Bishop R. - ‘Intelligent Vehicle Technology and Trends’ - AR Tech House Inc. – 1999

23MEE446	IC ENGINES AND EMISSION	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- To familiarize mixture requirement for SI and CI for complete combustion using thermodynamic analysis.
- To familiarize normal and abnormal combustion from pressure data and interpret its effect on engine performance.
- To introduce the effect of boosting devices on engine performance, emission, heterogeneous combustion and spray behavior.
- To appraise the need for alternate fuels and methods to reduce emissions

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Analyze thermo-chemistry of combustion by applying thermodynamic laws in engine cycles	Analyze
CO02	Understand and analyse the operation of internal combustion engines	Understand
CO03	Elucidate the effect of supercharging and turbo-charging on engine performance	Analyze
CO04	Understand various fuel-metering systems like CRDI, PFI, GDI diesel fuel injection system and latest technology in fuel injection systems in SI and CI engines	Understand
CO05	Understand emission control techniques in engines, based on emission standards/norms and to recommend modification in engine for using alternate fuels	Understand

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3											3			
CO02	3	3											3			
CO03	3	3										1	3			
CO04	3	3										1	3			
CO05	3	3	2			1	1	1				1	3			

Syllabus

Unit 1

Spark Ignition engines: Mixture requirement-Fuel injection systems. Stoichiometric combustion-combustion with excess air-equivalence ratio Stages of combustion: Normal and Abnormal combustion-Knock. Combustion chambers. Simple thermodynamic analysis of SI engine combustion. [15 hours]

Unit 2

Compression ignition engines: Nature of combustion in IC engines-Direct and Indirect injection systems- Air motion-Combustion Chambers-Spray penetration and evaporation. Supercharging - Turbo charging. Thermodynamic analysis of CI engine combustion. Wankel Engine: Operation & applications. Hybrid engines. Thermo chemistry: Pollutant formation, Instrumentation to measure pollutants-Pollutant calculation-Effect of air-fuel ratio. [15 hours]

Unit 3

Emission standards: EGR on engine emissions-Emission standards-Emission control devices. Thermal & catalytic exhaust clean-up-catalysts-automotive catalytic converters-Engine modifications to reduce emissions.

Heat release analysis of IC engines. Alternate Fuels: Engine modifications for alternate fuels (liquid and gaseous fuels), homogenous charge compression ignition engines. Additives for enhancing performance and pollution control. [15 hours]

Textbooks:

1. Heywood, J. B., ‘Internal Combustion Engine Fundamentals’, McGraw-Hill, First Indian edition, 2017. BS VI emission norms (ARAI)

Reference Books:

1. Ferguson, C.R, ‘Internal Combustion Engines’, John Wiley, 1989
2. Degobert, P., ‘Automobiles and Air Pollution’, SAE, 2002
3. B.P.Pundir, ‘IC Engines Combustion and Emissions’,Narosa Publishing House, 2010

23MEE447	**CRYOGENIC ENGINEERING**	**L-T-P-C: 3-0-0-3**

Course Objectives

The course will enable the students to

- To provide knowledge on the properties of materials at low temperatures.
- To familiarize with various gas liquefaction systems and to provide design aspects of cryogenic storage and transfer lines.
- Analyse performance of cryogenics gas liquefaction system.
- To provide knowledge of cryogenic storage and transfer systems.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Perceive the knowledge of material properties at cryogenic temperatures.	Understand
CO02	Analyze cryogenic refrigeration system performance.	Analyze
CO03	Analyze the performance of gas liquefaction systems.	Analyze
CO04	Perceive the knowledge of cryogenic storage and transfer systems	Understand
CO05	Understand the application of cryogenic systems in different engineering fields	Understand

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2	1	1									2			
CO02	3	2	1	1		1							2			
CO03	3	2	1	1		1							2			
CO04	3	2	1	1	3								2			
CO05	3	2	1	1	3								2			

Syllabus

Unit 1

Introduction to cryogenic, history and development, cryogenic temperature scale, Material properties, Low temperature properties of engineering materials, mechanical properties Thermal properties, electric and magnetic properties, Debye model of thermal conductivity. Gas liquefaction and cooling systems, introduction, production of low temperature.

Unit 2

Gas-Liquefaction and Refrigeration Systems -liquefaction systems such as Linde-Hampson, precooled Linde-Hampson, linde dual pressure, Claude, Kapitsa, Heyland systems using expanders, Philips refrigerators. Comparison of liquefaction systems. Liquefaction systems for Neon, Hydrogen & Helium.

Unit 3

Cryogenic fluid storage and transfer systems, cryogenic fluid storage vessels Insulation cryogenic fluid transfer systems, Application of cryogenic systems, super conductive devices, cryogenic space technology-cryogenics in biology and medicine. Applications of refrigeration-Industrial, comfort, food preservation, medical.

Textbooks:

1. Stoecker W.F. and Jones J W, Refrigeration and Air Conditioning, 2nd Ed., McGraw-Hill International Editions, 1982.

Reference Books:

1. Thomas.M.Flynn, Cryogenic Engineering, Marcel Dekker Inc, 2005.
2. Randell.F.Barron, Cryogenic Systems, Oxford University Press, New York, 1985.
3. Randell.F.Barron, Cryogenic Systems, Oxford University Press, New York, 1985.
4. Stoecker W.F. and Jones J W, Refrigeration and Air Conditioning, 2nd Ed., McGraw-Hill International Editions, 1982.

23MEE448	DESIGN OF THERMAL SYSTEMS	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- To impart the knowledge about the concept of design of thermal systems.
- To know the design procedure of heat exchangers related to different thermal applications like condensers, evaporators, cooling towers etc.
- To know the design procedure of cooling of electronic components.

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Understand the types of heat exchanger and use LMTD and NTU approaches to solve problems.	Understand
CO02	Analyse the design procedures in double pipe and shell and tube heat exchangers.	Analyze
CO03	Describe the working procedures and calculate the heat transfer aspects in condenser and evaporators.	Evaluate
CO04	Distinguishes the performance parameters in cooling tower performance and heat pipe applications.	Analyze
CO05	Identify various techniques for cooling of electronic equipment.	Understand

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2	2	1									2			
CO02	3	2	2	1		1							2			
CO03	3	2	2	1		1							2			
CO04	3	2	2	1									2			
CO05	3	2	2	1			1						2			

Syllabus

Unit 1

Classification of Heat Exchangers: Introduction- Recuperation & Regeneration-Tubular heat exchangers-Double pipe, Shell and Tube heat exchangers, Plate heat exchanger Exchangers-Plate fin and Tubular fin heat exchangers BASIC DESIGN METHODS OF HEAT EXCHANGERS: Basic equations in Design, Overall heat transfer coefficient-LMTD method and Effectiveness method (NTU) for heat exchanger analysis-Parallel flow, counter flow, Multi pass, Cross flow heat exchangers.

Unit 2

Double Pipe Heat Exchanger: Film coefficient for fluids in annulus, fouling factors, calorific temperature, Average fluid temperature, Calculation of double pipe exchanger, double pipe exchangers in series parallel arrangements.
Shell & Tube Heat Exchangers: General design considerations, Construction details, Tube layouts, Baffles, Shell side and tube side film coefficients. Analysis of performance and design of shell & tube heat exchangers, Flow arrangements, Shell side pressure drop and Tube side pressure drop.
Condensers & Evaporators: Types of Condensers-Air cooled condenser –Water-cooled condensers-Evaporative condensers Heat Transfer in condensers- Types of Evaporators-Heat transfer in Evaporators-Pool boiling – Heat transfer coefficient for nucleate pool boiling-Flow or forced convection boiling-Forced convection boiling correlations

Unit 3

Direct Contact Heat Exchangers: Cooling towers, relation between wet bulb & dew bulb temperatures, and calculation of cooling tower performance. Heat Pipe: Gravity assisted thermo-syphons, micro heat pipes, pulsating heat pipes, loop heat pipe operation and working principles.

Cooling of Electronic Equipment: Introduction-The chip carrier-Printed circuit boards-Cooling load of Electronic equipment Conduction cooling: Conduction in chip carriers-conduction in printed circuit board heat frames. Air-cooling: Natural convection and radiation- Forced convection- Fan selection-cooling personal computers.

Textbooks:

1. Serth. R. W, Process Heat Transfer-Principles and Applications, Elsevier, 2007.

Reference Books:

1. Coulson & Richardson's series, Sinnott R. K., Chemical Engineering Design, Elsevier, 2005
2. Kern D, Q, Process Heat Transfer, McGraw-Hill, 1965
3. Shah R K and Sekulic D P, Fundamentals of Heat Exchanger Design, John Wiley and plyk\vdfkpSons, 2002.
4. Kays W M and London A L, Compact Heat Exchanger, Krieger Publishing Company,1998
5. A.P. Frass and M.N. Ozisik, Heat Exchanger Design- John Wieley& Sons, New York

23MEE449	AEROSPACE ENGINEERING	L-T-P-C: 3-0-0-3

Course Objectives

The course will enable the students to

- Understand and describe the various types of aircrafts and its systems.
- To make students aware of the types of propulsion systems used and its merits and demerits

Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Understand the earth's atmosphere and its properties	Understand
CO02	Select an appropriate propulsion method based on the requirement from the aircraft	Apply
CO03	Compare different engine systems used in aerospace applications	Analyze
CO04	Understand the various instruments used in the aircraft and its working	Understand

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2	2	2									3			
CO02	3	2	2	2									3			
CO03	3	2	1	1									3			
CO04	3	2	1	2									3			

Syllabus

Unit 1

The atmosphere: Characteristics of Troposphere, Stratosphere, Mesosphere and Ionosphere - International Standard Atmosphere – Pressure, Temperature and Density variations in the ISA. Review of basic fluid dynamics – continuity, momentum and energy for incompressible and compressible flows – static, dynamic and stagnation pressures – phenomena in supersonic flows.

Application of dimensional analysis to 2D viscous flow over bodies (Basics only) – Reynolds number – Mach number similarity – Aerofoil characteristics – Pressure distribution – Centre of Pressure and Aerodynamic Center – Horse shoe vortex.

Unit 2

Straight and Level Flight – Stalling Speed – Minimum Drag and Minimum Power conditions – Performance Curves – Gliding – Gliding angle and speed of flattest glide – Climbing – Rate of Climb – Service and Absolute Ceilings – Take off and Landing Performance – Length of Runway Required – Circling Flight – Banked Flight – High Lift Devices – Range and Endurance of Air planes.

Unit 3

Propulsion: Momentum and Blade Element Theories (Basics only) – Propeller co-efficients and charts – Aircraft engines – Reciprocating engines, Turbo jet, Turbo fan and Ram Jet engines – Bypass and After Burners.

Aircraft Instruments: Air speed indicators – Calculation of True Air Speed – Altimeters – Rate of Climb meter – Gyro Compass, Artificial horizon etc. Rocket Motors – Solid and Liquid Propellant Rockets – Calculation of Earth Orbiting and Escape Velocities Ignoring Air Resistance and assuming Circular Orbit.

Textbooks:

1. Mechanics of Flight - Kermode A. C.
2. Aerodynamics for Engineering Students - Houghton and Brock
3. Anderson J.D. Jr., (2007), Fundamentals of Aerodynamics, Tata McGraw-Hill, New Delhi.

Reference Books:

1. Bertin J.J., (2002), Aerodynamics for Engineers, 4th Ed. Prentice-Hall Inc.
2. Kuethe A. M. and Chow C.-Y., (1986), Foundations of Aerodynamics, John Wiley & Sons Inc.

23MEE460	TURBO MACHINERY	L-T-P-C: 3-0-0-3

Course Objectives
The course will enable the students to

- To classify the turbo-machines based on energy interactions
- To study the performance characteristics of turbo-machines under different operating conditions
- To gain knowledge in the design parameters of turbo-machines

Course Outcomes:
After successful completion of the course, Students will be able to:

Sl.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Compare the features and working of various turbo machines	Understand
CO02	Apply the concepts of energy transformation in turbo machines	Apply
CO03	Analyse the performance of Hydraulic pumps and turbines	Apply
CO04	Thermal design and evaluation of critical parameters of Steam turbines	Apply
CO05	Evaluate the performance of axial and centrifugal compressors	Apply

CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3	3										3			
CO02	3	2	3										3			
CO03	3	3	3										3			
CO04	3	3	2										3			
CO05	3	3	2										3			

Syllabus

Unit 1
Definition and Classification of turbo machines, Specific Work, T-S and h-s Diagram, Incompressible and compressible flow, Losses, Total-to-Total efficiency, Total-to-Static efficiency, Effect of reheat and preheat factor, Degree of reaction, Energy transfer - Euler's equation, velocity triangles. Dimensional analysis, Dimensionless parameters and their physical significance, specific speed.
Elementary cascade theory, cascade nomenclature, compressor cascade, turbine cascade, cascade efficiency. Dimensional analysis of compressible flow machines, stalling and surging.

Unit 2
Hydraulic Pumps: Centrifugal Pumps – Some definitions, pump output and efficiencies, effect of vane angle, Cavitation, pump characteristics, multistage pumps.
Hydraulic Turbines: Classification of hydraulic turbines - Velocity triangle, Efficiencies of draft tubes, Hydraulic turbine characteristics, Francis and Kaplan turbines: Velocity triangle, Efficiencies of Draft tubes, Turbine characteristics.
Steam and Gas Turbines: Axial turbine stages, stage velocity triangles, work, single stage impulse turbine, speed ratio, maximum utilization factor , compounding of turbines and its types, degree of reaction - reaction Stages. Inward Flow Radial turbine stages (IFR) - Working principle and performance characteristics.

Unit 3
Centrifugal Compressors: Constructional details, stage pressure rise, stage pressure coefficient, stage efficiency, degree of reaction, various slip factors, Introduction to Fans and Blowers, working principle, fan laws, performance characteristics.
Axial flow Compressors: general expression for degree of reaction; velocity triangles for different values of degree of reaction, blade loading and flow coefficient, static pressure rise, work done factor.

Textbooks:

1. Yahya S. M. - 'Turbines, Fans and Compressors' - Tata McGraw Hill Publishing Company Limited – 2002

Reference Books:

1. Cengel Y. A. & Cimbala J., "Fluid Mechanics -Fundamentals and Applications", 3/e, McGraw Hill Edition, 2013.
2. Dixon S. L. - 'Fluid Mechanics & Thermodynamics of Turbo machinery' - Elsevier - 2012 - 6th Edition
3. Kadambi V. and Manohar Prasad - 'Energy Conversion - Vol.III: Turbo Machinery' - New Age International Publishers – 1999.

Courses offered under the framework of
Amrita Values Programmes I and II

22AVP201 Message from Amma's Life for the Modern World

Amma's messages can be put to action in our life through pragmatism and attuning of our thought process in a positive and creative manner. Every single word Amma speaks and the guidance received in on matters which we consider as trivial are rich in content and touches the very inner being of our personality. Life gets enriched by Amma's guidance and She teaches us the art of exemplary life skills where we become witness to all the happenings around us still keeping the balance of the mind.

22ADM211 Leadership from the Ramayana

Introduction to Ramayana, the first Epic in the world – Influence of Ramayana on Indian values and culture – Storyline of Ramayana – Study of leading characters in Ramayana – Influence of Ramayana outside India – Relevance of Ramayana for modern times.

22ADM201 Strategic Lessons from the Mahabharata

Introduction to Mahabharata, the largest Epic in the world – Influence of Mahabharata on Indian values and culture – Storyline of Mahabharata – Study of leading characters in Mahabharata – Kurukshetra War and its significance - Relevance of Mahabharata for modern times.

22AVP204 Lessons from the Upanishads

Introduction to the Upanishads: Sruti versus Smrti - Overview of the four Vedas and the ten Principal Upanishads - The central problems of the Upanishads – The Upanishads and Indian Culture – Relevance of Upanishads for modern times – A few Upanishad Personalities: Nachiketas, SatyakamaJabala, Aruni, Shvetaketu.

22AVP205 Message of the Bhagavad Gita

Introduction to Bhagavad Gita – Brief storyline of Mahabharata - Context of Kurukshetra War – The anguish of Arjuna – Counsel by Sri. Krishna – Key teachings of the Bhagavad Gita – Karma Yoga, Jnana Yoga and Bhakti Yoga - Theory of Karma and Reincarnation – Concept of Dharma – Concept of Avatar - Relevance of Mahabharata for modern times.

22AVP206 Life and Message of Swami Vivekananda

Brief Sketch of Swami Vivekananda's Life – Meeting with Guru – Disciplining of Narendra - Travel across India - Inspiring Life incidents – Address at the Parliament of Religions – Travel in United States and Europe – Return and reception India – Message from Swamiji's life.

22AVP207 Life and Teachings of Spiritual Masters India

Sri Rama, Sri Krishna, Sri Buddha, AdiShankaracharya, Sri Ramakrishna Paramahamsa, Swami Vivekananda, Sri RamanaMaharshi, Mata Amritanandamayi Devi.

22AVP208 Insights into Indian Arts and Literature

The aim of this course is to present the rich literature and culture of Ancient India and help students appreciate their deep influence on Indian Life - Vedic culture, primary source of Indian Culture – Brief introduction and appreciation of a few of the art forms of India - Arts, Music, Dance, Theatre.

22AVP209 Yoga and Meditation

The objective of the course is to provide practical training in YOGA ASANAS with a sound theoretical base and theory classes on selected verses of Patanjali's Yoga Sutra and Ashtanga Yoga. The coverage also includes the effect of yoga on integrated personality development.

22AVP210 Kerala Mural Art and Painting

Mural painting is an offshoot of the devotional tradition of Kerala. A mural is any piece of artwork painted or applied directly on a wall, ceiling or other large permanent surface. In the contemporary scenario Mural painting is not restricted to the permanent structures and are being done even on canvas. Kerala mural paintings are the frescos depicting mythology and legends, which are drawn on the walls of temples and churches in South India, principally in Kerala. Ancient temples, churches and places in Kerala, South India, display an abounding tradition of mural paintings mostly dating back between the 9th to 12th centuries when this form of art enjoyed Royal patronage. Learning Mural painting through the theory and practice workshop is the objective of this course.

22AVP213 Traditional Fine Arts of India

India is home to one of the most diverse Art forms world over. The underlying philosophy of Indian life is ‘Únity in Diversity” and it has led to the most diverse expressions of culture in India. Most art forms of India are an expression of devotion by the devotee towards the Lord and its influence in Indian life is very pervasive. This course will introduce students to the deeper philosophical basis of Indian Art forms and attempt to provide a practical demonstration of the continuing relevance of the Art.

22AVP214 Principles of Worship in India

Indian mode of worship is unique among the world civilizations. Nowhere in the world has the philosophical idea of reverence and worshipfulness for everything in this universe found universal acceptance as it in India. Indian religious life even today is a practical demonstration of the potential for realization of this profound truth. To see the all-pervading consciousness in everything, including animate and inanimate, and constituting society to realise this truth can be seen as the epitome of civilizational excellence. This course will discuss the principles and rationale behind different modes of worship prevalent in India.

22AVP215 Temple Mural Arts in Kerala

The traditional percussion ensembles in the Temples of Kerala have enthralled millions over the years. The splendor of our temples makes art enthusiast spellbound, warmth and grandeur of color combination sumptuousness of the outline, crowding of space by divine or heroic figures often with in vigorous movement are the characteristics of murals.

The mural painting specially area visual counterpart of myth, legend, gods, dirties, and demons of the theatrical world, Identical myths are popular the birth of Rama, the story of Bhīma and Hanuman, Shiva, as Kirata, and the Jealousy of Uma and ganga the mural painting in Kerala appear to be closely related to, and influenced by this theatrical activity the art historians on temple planes, wood carving and painting the architectural plane of the Kerala temples are built largely on the pan-Indians almost universal model of the Vasthupurusha.

22AVP218 Insights into Indian Classical Music

The course introduces the students into the various terminologies used in Indian musicology and their explanations, like Nadam, Sruti, Svaram – svara nomenclature, Stayi, Graha, Nyasa, Amsa, Thala,- Saptatalas and their angas, Shadangas, Vadi, Samavadi, Anuvadi. The course takes the students through Carnatic as well as Hindustani classical styles.

22AVP219 Insights into Traditional Indian Painting

The course introduces traditional Indian paintings in the light of ancient Indian wisdom in the fields of aesthetics, the Shadanga (Sixs limbs of Indian paintings) and the contextual stories from ancient texts from where the paintings originated. The course introduces the painting styles such as Madhubani, Kerala Mural, Pahari, Cheriyal, Rajput, Tanjore etc.

22AVP220 Insights into Indian Classical Dance

The course takes the students through the ancient Indian text on aesthetics the Natyasastra and its commentary the AbhinavaBharati. The course introduces various styles of Indian classical dance such as Bharatanatyan, Mohiniyatton, Kuchipudi, Odissy, Katak etc. The course takes the students through both contextual theory as well as practice time.

22AVP221 Indian Martial Arts and Self Defense

The course introduces the students to the ancient Indian system of self-defense and the combat through various martial art forms and focuses more on traditional Kerala’s traditional KalariPayattu. The course introduces the various exercise technique to make the body supple and flexible before going into the steps and techniques of the martial art. The advanced level of this course introduces the technique of weaponry.

PROFESSIONAL ELECTIVES UNDER SCIENCE STREAM

CHEMISTRY

23CHY240 COMPUTATIONAL CHEMISTRY AND MOLECULAR MODELLING	L-T-P-C: 3-0-0-3

Course Outcomes:
CO1: Get to understand the structure of molecules using symmetry.
CO2: Understanding Quantum mechanical approach to calculate the energy of a system.
CO3: Applying mathematical knowledge and quantum mechanical approach in finding out the characteristics-reactivity, stability, etc., of the molecule.
CO4: To get a brief idea about molecular mechanics based chemical calculations.
CO5: To get an idea about general methodology of molecular modeling.

Syllabus
Unit 1
Introduction: Stability, symmetry, homogeneity and quantization as the requirements of natural changes - Born – Haber cycle – Energetic – kinetics - Principles of spectra.

Computational techniques: Introduction to molecular descriptors, computational chemistry problems involvingiterative methods, matrix algebra, Curve fitting.

Molecular mechanics: Basic theory - Harmonic oscillator – Parameterization - Energy equations - Principle ofcoupling - Matrix formalism for two masses - Hessian matrix - enthalpy of formation - enthalpy of reactions.

Introduction to Quantum mechanics - Schrodinger equation - Position and momentumMO formation - Operators and the Hamiltonian operator - The quantum oscillator Oscillator Eigen value problems - Quantum numbers - labeling of atomic electrons.

Unit 2
Molecular Symmetry: Elements of symmetry - Point groups - Determination of point groups of molecules. Huckel's MO theory: Approximate and exact solution of Schrodinger equation - Expectation value of energy - Huckel's theory and the LCAO approximation - Homogeneous simultaneous equations - Secular matrix - Jacobi method - Eigen vectors: Matrix as operator - Huckel's coefficient matrix - Wheeland's method - Hoffmann's EHTmethod - Chemical applications such as bond length, bond energy, charge density, dipole moment, Resonance energy.

Unit 3
Self consistent fields: Elements of secular matrix - Variational calculations - Semi empirical methods - PPP self consistent field calculation - Slater determinants - Hartree equation - Fock equation – Roothaan - Hall equation - Semi empirical models and approximations.

Ab-initio calculations: Gaussian implementations – Gamess - Thermodynamic functions - Koopman's theorem - Isodesmic reactions, DFT for larger molecules - Computer aided assignments/mini projects with softwares - Introduction to HPC in Chemical calculations.

Molecular modelling software engineering - Modeling of molecules and processes

Signals and signal processing in Chemistry - QSAR studies and generation of molecular descriptors - Applications of chemical data mining - Familiarization with open source softwares useful for molecular modeling - Introduction tomolecular simulation - M.D. simulation.

TEXTBOOKS:

1. *K. I. Ramachandran, G Deepa and K Namboori, "Computational Chemistry and Molecular Modeling -Principles and Applications", Springer-Verlag, Berlin, Heidelberg, 2008, ISBN-13 978-3-540-77302-3.*
2. *Donald W Rogers, "Computational Chemistry Using PC", Wiley, (2003).*
3. *Alan Hinchliffe, "Chemical Modeling from atoms to liquids", Wiley, (2005).*

REFERENCES:

1. *James B Forseman and Aeleen Frisch-Gaussian, "Exploring Chemistry with Electronic Structure Method", Inc., Pittsburgh, PA, 2nd edition, (2006).*
2. *A C Philips, "Introduction to Quantum mechanics", Wiley, (2003).*
3. *Wolfram Koch, Max C. Holthausen, "A Chemist's guide to Density Functional Theory", Wiley, VCH, 2nd edition, (2001).*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23CHY241	ELECTROCHEMICAL ENERGY SYSTEMS AND PROCESSES	L-T-P-C: 3-0-0-3

Course Outcomes:
CO1: Understand the fundamental concepts of electrochemistry through electrode potential and reaction kinetics
CO2: Learn the application of the electrochemical principles for the functioning and fabrication of industrial batteries and fuel cells
CO3: Acquire knowledge in solving numerical problems on applied electrochemistry
CO4: Analysis and practical problem solving in fabrication of batteries and fuel cells
CO5: Application of concepts and principle in industrial electrochemical processes
CO6: Evaluation of comprehensive knowledge through problem solving

Syllabus

Unit 1
Background Theory: Origin of potential - electrical double layer - reversible electrode potential - standard hydrogen electrode - emf series - measurement of potential - reference electrodes (calomel and silver/silver chloride) indicator and ion selective electrodes - Nernst equation - irreversible processes - kinetic treatment - Butler- Volmer equation - Overpotential, activation, concentration and IR overpotential - its practical significance - Tafel equation and Tafel plots - exchange current density and transfer coefficients.

Unit 2
Batteries: Primary batteries: The chemistry, fabrication and performance aspects, packing classification and rating of the following batteries: (The materials taken their function and significance, reactions with equations, their performance in terms of discharge, capacity, and energy density to be dealt with). Zinc-carbon (Leclanche type), zinc alkaline (Duracell), zinc/air, zinc-silver oxide batteries; lithium primary cells - liquid cathode, solid cathode and polymer electrolyte types and lithium-ferrous sulphide cells (comparative account).

Secondary batteries: ARM (alkaline rechargeable manganese) cells, Lead acid and VRLA (valve regulated (sealed) lead acid), nickel-cadmium, nickel-zinc, nickel- metal hydride batteries, lithium ion batteries, ultra thin lithium polymer cells (comparative account). Advanced Batteries for electric vehicles, requirements of the battery - sodium-beta and redox batteries.

Unit 3
Reserve batteries and Fuel cells: Reserve batteries - water activated, electrolyte activated and thermally activated batteries - remote activation - pyrotechnic materials. Fuel Cells: Principle, chemistry and functioning - carbon, hydrogen- oxygen, proton exchange membrane (PEM), direct methanol(DMFC), molten carbonate electrolyte (MCFC) fuel cells and outline of biochemical fuel cells.

Electrochemical Processes: Principle, process description, operating conditions, process sequence and applications of Electroforming – production of waveguide and plated through hole (PTH) printed circuit boards by electrodeposition; Electroless plating of nickel, copper and gold; Electropolishing of metals; Anodizing of aluminium; Electrochemical machining of metals and alloys.

TEXTBOOKS:
1. *Derek Pletcher and Frank C. Walsh, "Industrial Electrochemistry", Blackie Academic and Professional, (1993).*
2. *Dell, Ronald M Rand, David A J, "Understanding Batteries", Royal Society of Chemistry, (2001).*

REFERENCES:
1. *Christopher M A, Brett, "Electrochemistry – Principles, Methods and Applications", Oxford University, (2004).*
2. *Watanabe T, "Nano-plating: microstructure control theory of plated film and data base of plated filmmicrostructure", Elsevier, Oxford, UK (2004).*
3. *Kanani N, "Electroplating and electroless plating of copper and its alloy", ASM International, Metals Park,*

OH and Metal Finishing Publications, Stevenage, UK (2003).
4. *Lindon David, "Handbook of Batteries", McGraw Hill, (2002).*
5. *Curtis, "Electroforming", London, (2004).*
6. *Rumyantsev E and Davydov A, "Electrochemical machining of metals", Mir, Moscow, (1989).*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23CHY242	FUELS AND COMBUSTION	L-T-P-C: 3-0-0-3

Course Objectives:

- To provide the basic knowledge about fuels, rocket propellants and explosives.

Course Outcomes:

CO1: Understand the types of fuels and variation in their properties
CO2: Able to analyze the fuel content
CO3: Obtain knowledge in identifying a proper fuel as per the requirement
CO4: Ability to know the preparation and working of propellants and explosives

Syllabus

Unit 1

Fuels - Solid fuels - Classification, preparation, cleaning, analysis, ranking and properties - action of heat, oxidation, hydrogenation, carbonization, liquefaction and gasification.
Liquid fuels – Petroleum - origin, production, composition, classification, petroleum processing, properties, testing -flow test, smoke points, storage and handling.
Secondary liquid fuels - Gasoline, diesel, kerosene and lubricating oils. Liquid fuels - refining, cracking, fractionaldistillation, polymerization. Modified and synthetic liquid fuels. ASTM methods of testing the fuels.

Unit 2

Gaseous fuels - Types, natural gas, methane from coal mine, water gas, carrier gas, producer gas, flue gas, blast furnace gas, biomass gas, refinery gas, LPG - manufacture, cleaning, purification and analysis. Fuels for spark ignition engines, knocking and octane number, anti knock additives, fuels for compression, engines, octane number, fuels forjet engines and rockets.
Flue gas analysis by chromatography and sensor techniques.

Unit 3

Combustion: Stochiometry, thermodynamics. Nature and types of combustion processes - Mechanism - ignition temperature, explosion range, flash and fire points, calorific value, calorific intensity, theoretical flame temperature.Combustion calculations, theatrical air requirements, flue gas analysis, combustion kinetics – hydrogen - oxygen reaction and hydrocarbon - oxygen reactions.
Rocket propellants and Explosives - classification, brief methods of preparation, characteristics; storage and handling.

TEXTBOOK:

1. *Fuels and Combustion, Samir Sarkar, Orient Longman Pvt. Ltd, 3rd edition, 2009.*

REFERENCES:

1. *Fuels - Solids, liquids and gases - Their analysis and valuation, H. Joshua Philips, Biobliolife Publisher,2008.*
2. *An introduction to combustion: Concept and applications - Stephen R Turns, Tata Mc. Graw Hill, 3rd edition,2012.*
3. *Fundamentals of Combustion, D P Mishra, 1st edition, University Press, 2010*
4. *Engineering Chemistry - R. Mukhopadhyay and Sriparna Datta, Newage International Pvt. Ltd, 2007.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23CHY243	GREEN CHEMISTRY AND TECHNOLOGY	L-T-P-C: 3-0-0-3

Course Objectives:
- Understand the principles of green chemistry and its contribution to the development of sustainable products
- Possess knowledge of the migration from a hydrocarbon-based economy to carbohydrate-based economy
- Evaluate the deficiencies of traditional process and acknowledge the invent of new processes
- Distinctly map the culmination of academic research to industrial chemistry

Course Outcomes:
CO1: Understand the evolving concept of Green Chemistry and its application to the manufacture of sustainableproducts
CO2: Appreciate the need for Renewable energy and Feed stock along with carbon sequestration through thefundamentals of Green Chemistry Techniques
CO3: Develop a coherence to evaluate systematic deficiencies in traditional Chemical science process and products
CO4: Undertake a purposeful Journey through the microscopic domain of academic research to the macroscopic domain of Industrial chemistry.

Syllabus
Unit 1
Our environment and its protection, chemical pollution and environmental regulations, environmental chemistry, pollution prevention strategies, challenges to the sustainability of chemical industry, Pollution Prevention Act 1990,USA, Green Chemistry and its 12 principles, toxicity of chemicals, material safety data sheet (MSDS), concept ofzero pollution technologies, atom economy, functional toxicity vs non-functional toxicity, alternative solvents, energy minimization, microwave and sonochemical reactions, renewable feed stock, carbon dioxide as a feed stock.

Unit 2
Greener strategies of the synthesis of ibuprofen synthesis, teriphthalic acid etc. phase behaviour and solvent attributes of supercritical CO2, use of supercritical carbon dioxide as a medium chemical industry, use of ionic liquids as a synthetic medium, gas expanded solvents, superheated water, etc. Synthesis of various chemicals from bio mass, polycarbonate synthesis and CO2 fixation, green plastics, green oxidations, etc.

Unit 3
Processes involving solid catalysts – zeolites, ion exchange resins, Nafion/silica nano composites and enhanced activity. Polymer supported reagents, green oxidations using TAML catalyst, membrane reactors. Green chemistry in material science, synthesis of porous polymers, green nanotechnology.

REFERENCES:

1. *Hand Book of Green Chemistry and Technology; by James Clarke and Duncan Macquarrie; Blakwell Publishing.*
2. *Anastas, P. T., Warner, J. C. Green Chemistry: Theory and Practice, Oxford University Press Inc., New York, 1998.*
3. *Matlack, A. S. Introduction to Green Chemistry Marcel Dekker: New York, NY, 2001.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23CHY244	INSTRUMENTAL METHODS OF ANALYSIS	L-T-P-C: 3-0-0-3

Course Outcomes:
CO1: To develop an understanding of principle and working of the range of instrumental methods in analytical chemistry
CO2: To provide an understanding and skills in contemporary methods of separation and appropriate selection of instruments for the successful analysis of chemical compounds
CO3: To impart skills in the scientific method of planning, conducting, reviewing, reporting experiments and problem solving in chemical analysis.

Syllabus
Unit 1
Error Analysis and Sampling: Accuracy - Precision - Classification of Errors -Minimization of errors – Standard deviation - Coefficient of variance - F-test - t-test - Significant figures. Sampling - Basis of sampling, Sampling and physical state - Safety measures of sampling.
Separation Techniques: Brief out line of column, paper and thin layer chromatography - Ion exchange methods - principle and application – HPLC.

Unit 2
Gas chromatography - principle and applications – gel chromatography.
Electroanalytical techniques: Potentiometry - Potentiometric titration - determination of equivalence point - acid base, complexometric, redox and precipitation titrations - merits and demerits. Voltammetry - Cyclic voltammetry -basic principle and application - Polarography - introduction - theoretical principles - migration current - residual current - half wave potential - instrumentation - analytical applications.

Unit 3
Spectro-chemical techniques: UV-VIS spetrophotometry - principle - Beer's Law application - photometric titration - single and double beam spectrophotometer - instrumentation of IR - sample handling - IR applications - H - NMR - Instrumentation and applications – principle - instrumentation - applications of atomic absorption spectroscopy.
Thermal and Diffraction techniques: Principles and applications of DTG - DTA DSC - X-ray - Electron Diffraction Studies - SEM, TEM.

TEXTBOOKS:
1. *Willard H W, Merritt J R, "Instrumental Methods of Analysis", 6th edition, Prentice Hall, (1986).*
2. *Skoog Douglas A, West Donald, "Fundamentals of Analytical Chemistry", 7th edition, New York Addison, Wesley, (2001).*

REFERENCES:
1. *"Vogel's Textbook of Quantitative Chemical Analysis", 5th edition, ELBS, (1989).*
2. *Kaur. H, "Instrumental Methods of Chemical Analysis", Goel Publisher, (2001).*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23CHY245	BATTERIES AND FUEL CELLS	L-T-P-C: 3-0-0-3

Course Objective:

- To provide sound knowledge on the application of electrochemistry in energy storage systems.

Course Outcome

CO1: Understand the fundamental concepts of electrochemistry through electrode potential and reaction kinetics
CO2: Learn the application of the electrochemical principles for the functioning and fabrication industrial batteries and fuel cells
CO3: Analysis of practical problem solving in fabricating batteries and fuel cells
CO4: Evaluation of comprehensive knowledge through problem solving.

Syllabus

Unit 1

Background Theory: Origin of potential - electrical double layer - reversible electrode potential - standard hydrogen electrode - emf series - measurement of potential - reference electrodes (calomel and silver/silver chloride) indicator and ion selective electrodes - Nernst equation - irreversible processes - kinetic treatment - Butler- Volmer equation - Overpotential, activation, concentration and IR overpotential - its practical significance - Tafel equation and Tafel plots - exchange current density and transfer coefficients.

Unit 2

Batteries: Primary batteries: The chemistry, fabrication and performance aspects, packing classification and rating of the following batteries: (The materials taken their function and significance, reactions with equations, their performance in terms of discharge, capacity, and energy density to be dealt with). Zinc-carbon (Leclanche type), zinc alkaline (Duracell), zinc/air batteries; Lithium primary cells - liquid cathode, solid cathode and lithium-ferrous sulphide cells (comparative account).
Secondary batteries: Lead acid and VRLA (valve regulated (sealed) lead acid), nickel-cadmium, nickel-zinc, nickel-metal hydride batteries, lithium ion batteries, ultrathin lithium polymer cells (comparative account). Advanced Batteries for electric vehicles, requirements of the battery - sodium-beta and redox batteries.

Unit 3

Fuel Cells: Description, working principle, anodic, cathodic and cell reactions, fabrication of electrodes and other components, applications, advantages, disadvantages and environmental aspects of the following types of fuel cells: Proton Exchange Membrane Fuel Cells, alkaline fuel cells, phosphoric acid, solid oxide, molten carbonate, direct methanol fuel cells. Membranes for fuel cells: Nafion – Polymer blends and composite membranes; assessment of performance – recent developments. Fuels for Fuel Cells: Hydrogen, methane, methanol - Sources and preparation, reformation processes for hydrogen –clean up and storage of the fuels – use in cells, advantages and disadvantages of using hydrogen as fuel.

TEXTBOOKS:

1. *Dell, Ronald M Rand, David A J, 'Understanding Batteries', Royal Society of Chemistry, (2001).*
2. *M. Aulice Scibioh and B. Viswanathan 'Fuel Cells – principles and applications', University Press, India (2006).*

REFERENCES:

1. *Kanani N, 'Electroplating and electroless plating of copper and its alloy', ASM International, Metals Park, OH and Metal Finishing Publications, Stevenage, UK (2003).*
2. *Curtis, 'Electroforming', London, (2004).*
3. *F. Barbir, 'PEM fuel cells: theory and practice', Elsevier, Burlington, MA, (2005).*
4. *G. Hoogers, 'Fuel cell handbook', CRC, Boca Raton, FL, (2003).*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23CHY246	**CORROSION SCIENCE**	**L-T-P-C: 3-0-0-3**

Course Outcome:
CO1: Development of skill in identifying the nature and type of corrosion
CO2: Understanding the mechanism of various types of corrosion
CO3: Analysing the problem and find out a solution to combat corrosion in any sort of environment.

CO-PO Mapping

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	1	2											3	1		
CO02		3	1	2								1	1	2		
CO03		3	3	3	2	3	3					1	3	2	3	

Syllabus
Unit 1
Basic principles: Free energy concept of corrosion - different forms of corrosion - Thermodynamic & Kinetic aspects of corrosion: The free energy criterion of corrosion possibility - Mechanism of Electrochemical corrosion - Galvanicand Electrochemical series and their significance.
Corrosion Control: Materials selection - metals and alloys - metal purification - non metallic - changing medium.

Unit 2
Anodic and cathodic protection methods - Coatings - metallic and other inorganic coatings - organic coatings - straycurrent corrosion - cost of corrosion control methods.
Corrosion protection by surface treatment: CVD and PVD processes - Arc spray - Plasma spray - Flame spray.
Corrosion Inhibitors: Passivators - Vapour phase inhibitor.

Unit 3
Stress and fatigue corrosion at the design and in service condition - control of bacterial corrosion.Corrosion protection: Automobile bodies – engines – building construction.

TEXTBOOKS:

1. *Fontana and Mars G, "Corrosion Engineering", 3rd edition, McGraw Hill, (1987).*
2. *Uhlig H H and Reviees R W, "Corrosion and its Control", Wiley, (1985).*

REFERENCES:

1. *ASM Metals Handbook, "Surface Engineering", Vol. 5, ASM Metals Park, Ohio, USA, (1994).*
2. *ASM Metals Handbook, "Corrosion", Vol. 13, ASM Metals Park, Ohio, USA, (1994).*
3. *Brain Ralph, "Material Science and Technology", CRC Series, Boston, New York.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23PHY240	ADVANCED CLASSICAL DYNAMICS	L-T-P-C: 3-0-0-3

Course Outcomes:
CO1: Able to use the Lagrangian formalism to solve simple dynamical system
CO2: Able to understand Hamiltonian formalism and apply this in solving dynamical systems
CO3: Able to apply Lagrangian formalism in bound and scattered states with specific reference to Kepler's laws and Scattering states
CO4: Able to solve problems in the Centre of Mass frame and connect it to Laboratory Frame of Reference
CO5: Understand and solve problems in rigid body rotations applying of Euler's equations.

CO-PO Mapping

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3	1	1								1				
CO02	3	3	1	1								1				
CO03	3	3	3	1								1				
CO04	3	3	3	1								2				
CO05	3	3	3	2								2				

Syllabus
Unit 1
Introduction to Lagrangian dynamics.
Survey of principles, mechanics of particles, mechanics of system of particles, constraints, D'Alembert's principle and Lagrange's equation, simple applications of the Lagrangian formulation, variational principles and Lagrange's equations, Hamilton's principles, derivation of Lagrange's equations from Hamilton's principle, conservation theorems and symmetry properties.

Unit 2
Central field problem.
Two body central force problem, reduction to the equivalent one body problem, Kepler problem, inverse square law of force, motion in time in Kepler's problem, scattering in central force field, transformation of the scattering to laboratory system, Rutherford scattering, the three body problem. Rotational kinematics and dynamics; Kinematics of rigid body motion, orthogonal transformation, Euler's theorem on the motion of a rigid body.

Unit 3
Angular momentum and kinetic energy of motion about a point, Euler equations of motion, force free motion of rigid body. Practical rigid body problems; Heavy symmetrical spinning top, satellite dynamics, torque-free motion, stability of torque-free motion - dual-spin spacecraft, satellite maneouvering and attitude control - coning maneuver - Yo-yo despin mechanism - gyroscopic attitude control, gravity- gradient stabilization.

TEXTBOOKS:
1. *H. Goldstein, Classical Mechanics, Narosa Publishing House, New Delhi, 1980, (Second Edition)*
2. *H. Goldstein, Charles Poole, John Safko, Classical Mechanics, Pearson education, 2002 (Third Edition)*
3. *Howard D. Curtis, Orbital Mechanics for Engineering Students, Elsevier, pp.475 - 543*
4. *Anderson John D, Modern Compressible flow, McGraw Hill.*

REFERENCE BOOKS:

1. *D. A. Walls, Lagrangian Mechanics, Schaum Series, McGraw Hill, 1967.*
2. *J. B. Marion and S. T. Thornton, Classical dynamics of particles and systems, Ft. Worth, TX: Saunders, 1995.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23PHY241	ELECTRICAL ENGINEERING MATERIALS	L-T-P-C: 3-0-0-3

Course Outcomes

CO1: To understand the nature of interaction between atoms in crystalline solid materials that determines their dielectric, magnetic and electrical properties.
CO2: Analyze the relation between the macroscopic dielectric constant and the atomic structure of an insulator.
CO3: Fundamental concepts of magnetic fields required to illustrate the magnetic dipoles. This forms the basis tounderstand the magnetic properties of dia, para, ferro, antiferro and ferri magnetic materials.
CO4: Fundamentals concerned with conduction mechanism in metals and superconductors.
CO5: Understand the basics for classification of materials based on its conductivity, nature of chemical bonds in Si and Ge, carrier density, energy band structure and conduction mechanism in intrinsic and extrinsic semiconductors.

CO-PO Mapping

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	1	1											1			
CO02	2	2	2										1			
CO03	2	2	2										2			
CO04	2	2	2										2			
CO05	2	2	2					2					1			

Syllabus

Unit 1
Conducting materials: The nature of chemical bond, crystal structure Ohm's law and the relaxation time, collisiontime, electron scattering and resistivity of metals, heat developed in a current carrying conductor, thermal conductivity of metals, superconductivity.

Semiconducting materials: Classifying materials as semiconductors, chemical bonds in Si and Ge and it's consequences, density of carriers in intrinsic semiconductors, conductivity of intrinsic semiconductors, carrier densities in n type semiconductors, n type semiconductors, Hall effect and carrier density.

Unit 2
Magnetic materials: Classification of magnetic materials, diamagnetism, origin of permanent, magnetic dipoles inmatter, paramagnetic spin systems, spontaneous magnetization and Curie Weiss law, ferromagnetic domains and coercive force, anti ferromagnetic materials, ferrites and it's applications.

Unit 3
Dielectric materials: Static dielectric constant, polarization and dielectric constant, internal field in solids and liquids, spontaneous polarization, piezoelectricity.

PN junction: Drift currents and diffusion currents, continuity equation for minority carriers, quantitative treatment of the p-n junction rectifier, the n-p-n transistor**.**

TEXTBOOK:

1. *A J Decker, "Electrical Engineering materials", PHI, New Delhi, 1957.*

REFERENCES:

1. *A J Decker, "Solid State Physics", Prentice Hall, Englewood Cliffs, N J 1957.*
2. *C Kittel, "Introduction to solid state Physics", Wieley, New York, 1956 (2nd edition).*
3. *Allison, Electronic Engineering materials and Devices, Tata Mc Graw Hill*
4. *F K Richtmyer E H Kennard, John N Copper, "Modern Physics", Tata Mc Graw Hill, 1995 (5th edition).*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23PHY242	PHYSICS OF LASERS AND APPLICATIONS	L-T-P-C: 3-0-0-3

Syllabus

Unit 1

Review of some basic concepts and principle of laser.
Introduction to light and its properties: Reflection, refraction, interference, diffraction and polarization.
Photometry – calculation of solid angle. Brewster's law. Snell's law and, its analysis.
Introduction to LASERS: Interaction of radiation with matter - induced absorption, spontaneous emission, stimulated emission. Einstein's co-efficient (derivation). Active material. Population inversion – concept and discussion about different techniques. Resonant cavity.

Unit 2

Properties of LASERS
Gain mechanism, threshold condition for PI (derivation), emission broadening - line width, derivation of FWHM natural emission line width as deduced by quantum mechanics - additional broadening process: collision broadening, broadening due to dephasing collision, amorphous crystal broadening, Doppler broadening in laser and broadeningin gases due to isotope shifts. Saturation intensity of laser, condition to attain saturation intensity.
Properties – coherency, intensity, directionality, monochromaticity and focussibility. LASER transition – role of electrons in LASER transition, levels of LASER action: 2 level, 3 level and 4 level laser system.

Unit 3

Types of LASERS
Solid state LASER: (i) Ruby LASER – principle, construction, working and application. (ii) Neodymium (Nd) LASERS. gas LASER: (i) He-Ne LASER - principle, construction, working and application. (i) CO2 LASER - principle, construction, working and application.
Liquid chemical and dye LASERS. Semiconductor LASER: Principle, characteristics, semiconductor diode LASERS, homo-junction and hetero-junction LASERS, high power semi conductor diode LASERS.
Applications in Communication field:
LASER communications: Principle, construction, types, modes of propagation, degradation of signal, analogue communication system, digital transmission, fiber optic communication.
Applications of LASERS in other fields:
Holography: Principle, types, intensity distribution, applications. laser induced fusion. Harmonic generation. LASER spectroscopy. LASERS in industry: Drilling, cutting and welding. Lasers in medicine: Dermatology, cardiology, dentistry and ophthalmology.

REFERENCES:

1. *William T Silfvast, "Laser Fundamentals", Cambridge University Press, UK (2003).*
2. *B B Laud, "Lasers and Non linear Optics", New Age International (P) Ltd., New Delhi.*
3. *Andrews, "An Introduction to Laser Spectroscopy (2e)", Ane Books India (Distributors).*
4. *K R Nambiar, "Lasers: Principles, Types and Applications", New Age International (P) Ltd., New Delhi.*
5. *T Suhara, "Semiconductor Laser Fundamentals", Marcel Dekker (2004).*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23PHY243	CONCEPTS OF NANOPHYSICS AND NANOTECHNOLOGY	L-T-P-C: 3-0-0-3

Course Outcomes
CO1: Understand, Comprehend and acquaint with concepts of NanoPhysics
CO2: To familiarize the material's property changes with respect to the dimensional confinements.
CO3: Acquire knowledge on the modern preparation process and analysis involved in the nanomaterial's research
CO4: To learn about the technological advancements of the nano-structural materials and devices in the engineering applications

CO-PO Mapping

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2														
CO02	2	3														
CO03				3												
CO04						3	2					1				

Syllabus
Unit 1
Introduction; Introduction to nanotechnology, comparison of bulk and nanomaterials – change in band gap and large surface to volume ratio, classification of nanostructured materials. Synthesis of nanomaterials - classification of fabrication methods – top down and bottom up methods. Concept of quantum confinement and phonon confinement. Basic concepts – excitons, effective mass, free electron theory and its features, band structure of solids. Bulk to nanotransition – density of states, potential well - quantum confinement effect – weak and strong confinement regime. Electron confinement in infinitely deep square well, confinement in two and three dimension. Blue shift of band gap - effective mass approximation. Vibrational properties of solids - phonon confinement effect and presence of surfacemodes.

Unit 2
Tools for characterization: Structural – X-ray diffraction, transmission electron microscope, scanning tunneling microscope, atomic force microscope. Optical - UV – visible absorption and photoluminescence techniques, Raman spectroscopy. Nanoscale materials – properties and applications: Carbon nanostructures – structure, electrical, vibration and mechanical properties. Applications of carbon nanotubes

Unit 3
Field emission and shielding – computers – fuel cells – chemical sensors – catalysis – mechanical reinforcement. Quantum dots and Magnetic nanomaterials – applications. Nanoelectronics and nanodevices: Impact of nanotechnology on conventional electronics. Nanoelectromechanical systems (NEMSs) – fabrication (lithography) and applications. Nanodevices - resonant tunneling diode, quantum cascade lasers, single electron transistors – operating principles and applications.

TEXTBOOKS:
1. *Robert W. Kelsall, Ian W. Hamley and Mark Geoghegan, Nanoscale Science and Technology, John Wileyand Sons Ltd 2004.*
2. *W. R. Fahrner (Ed.), Nanotechnology and Nanoelectronics, Springer 2006.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23PHY244	PHYSICS OF SEMICONDUCTOR DEVICES	L-T-P-C: 3-0-0-3

Course Outcomes:
CO1: Understand, comprehend and acquaint with the basics working principles and governing equations ofelectronic devices like diodes, Bipolar junction transistors, Mosfet and heterojunction transistors
CO2: Analyze and Solve physics problems pertaining to various process like charge conduction across semiconductor device.
CO3: Apply the knowledge for the development and design of new methods to determine semiconductorparameters and devices

Syllabus
Unit 1
Introduction: Unit cell, Bravais lattices, crystal systems, crystal planes and Miller indices, symmetry elements. Defects and imperfections – point defects, line defects, surface defects and volume defects
Electrical conductivity: Classical free electron theory – assumptions, drift velocity, mobility and conductivity, drawbacks. quantum free electron theory – Fermi energy, Fermi factor, carrier concentration. Band theory of solids –origin of energy bands, effective mass, distinction between metals, insulators and semiconductors.

Unit 2
Theory of semiconductors: Intrinsic and extrinsic semiconductors, band structure of semiconductors, carrier concentration in intrinsic and extrinsic semiconductors, electrical conductivity and conduction mechanism in semiconductors, Fermi level in intrinsic and extrinsic semiconductors and its dependence on temperature and carrierconcentration. Carrier generation - recombination, mobility, drift-diffusion current. Hall effect.
Theory of p-n junctions – diode and transistor:p-n junction under thermal equilibrium, forward bias, reverse bias, carrier density, current, electric field, barrier potential. V-I characteristics, junction capacitance and voltage breakdown.

Unit 3
Bipolar junction transistor, p-n-p and n-p-n transistors: principle and modes of operation, current relations. V-I characteristics. Fundamentals of MOSFET, JFET. Heterojunctions – quantum wells.
Semiconducting devices: Optical devices: optical absorption in a semiconductor, e--hole generation. Solar cells – p-n junction, conversion efficiency, heterojunction solar cells. Photo detectors – photo conductors, photodiode, p-i-n diode. Light emitting diode (LED) – generation of light, internal and external quantum efficiency.
Modern semiconducting devices: CCD - introduction to nano devices, fundamentals of tunneling devices, design considerations, physics of tunneling devices.

TEXTBOOKS:

1. *C Kittel, "Introduction to Solid State Physics", Wiley, 7th Edn. 1995.*
2. *D A Neamen, "Semiconductor Physics and Devices", TMH, 3rd Edn. 2007.*

REFERENCES:

1. *S M Sze, "Physics of Semiconductor Devices", Wiley, 1996.*
2. *P Bhattacharya, "Semiconductor Opto- Electronic Devices", Prentice Hall, 1996.*
3. *M K Achuthan & K N Bhat, "Fundamentals of Semiconductor Devices", TMH, 2007.*
4. *J Allison, "Electronic Engineering Materials and Devices", TMH, 1990.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23PHY245	ASTROPHYSICS	L-T-P-C: 3-0-0-3

Course Outcomes:
CO1: Get a broad knowledge of scientific and technical methods in astronomy and astrophysics.
CO2: Apply mathematical methods to solve problems in astrophysics.
CO3: Develop critical/logical thinking, scientific reasoning and skills in the area of modern astrophysics.

CO-PO Mapping:

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3											1				
CO02	2	2														
CO03	1	2														

Syllabus
Unit 1
Historical introduction: Old Indian and western – astronomy - Aryabhatta, Tycho Brahe, Copernicus, Galileo - Olbers paradox - solar system – satellites, planets, comets, meteorites, asteroids.
Practical astronomy - telescopes and observations & techniques – constellations, celestial coordinates, ephemeris. Celestial mechanics - Kepler's laws - and derivations from Newton's laws.
Sun: Structure and various layers, sunspots, flares, faculae, granules, limb darkening, solar wind and climate.

Unit 2
Stellar astronomy: H-R diagram, color-magnitude diagram - main sequence - stellar evolution – red giants, white dwarfs, neutron stars, black holes - accretion disc - Schwartzchild radius - stellar masses Saha–Boltzman equation -derivation and interpretation. Variable stars: Cepheid, RR Lyrae and Mira type variables - Novae and Super novae. Binary and multiple star system - measurement of relative masses and velocities. Interstellar clouds - Nebulae.

Unit 3
Galactic astronomy: Distance measurement - red shifts and Hubble's law – age of the universe, galaxies – morphology - Hubble's classification - gravitational lens, active galactic nuclei (AGNs), pulsars, quasars.
Relativity: Special theory of relativity - super-luminal velocity - Minkowski space - introduction to general theory ofrelativity – space - time metric, geodesics, space-time curvature. Advance of perihelion of Mercury, gravitational lens. Cosmology: Comic principles, big bang and big crunch – cosmic background radiation - Nucleo-synthesis - planklength and time, different cosmic models - inflationary, steady state. Variation of G. anthropic principle.

REFERENCES:

1. *"Textbook of Astronomy and Astrophysics with elements of Cosmology", V. B. Bhatia, Narosa publishing2001.*
2. *William Marshall Smart, Robin Michael Green "On Spherical Astronomy", (Editor) Carroll, Bradley WCambridge University Press ,1977*
3. *Bradley W. Carroll and Dale A. Ostlie. "Introduction to modern Astrophysics" Addison-Wesley, 1996.*
4. *Bradley W. Carroll and Dale A. Ostlie, "An Introduction to Modern Astrophysics" Addison-Wesley Publishing Company,1996*
5. *'Stellar Astronomy' by K. D Abhayankar.*
6. *'Solar Physics' by K. D Abhayankar.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

MATHEMATICS

23MAT240	STATISTICAL INFERENCE	L-T-P-C: 3-0-0-3

Syllabus

Unit 1
Introduction to Statistics: Data Collection and Descriptive Statistics, Populations and Samples, describing data sets, summarizing data sets, Normal Data Sets, Paired Data Sets and the Sample Correlation Coefficient. Review of Random Variables and Distributions, Distributions of Sampling Statistics, The Sample Mean, The Central Limit Theorem, The Sample Variance, Sampling Distributions from a Normal Population, Distribution of the Sample Mean, Joint Distribution of $\bar{X}$ and S^2, Sampling from a Finite Population.

Unit 2
Parameter Estimation: Introduction, Maximum Likelihood Estimators, Interval Estimates, Estimating the Difference in Means of Two normal populations, Approximate Confidence Interval for the Mean of a Bernoulli random variable, Confidence Interval of the Mean of the Exponential Distribution, Evaluating a Point Estimator, The Bayes Estimator. Hypothesis Testing: Introduction, Significance Levels, Tests Concerning the Mean of a Normal Population, Testing the Equality of Means of Two Normal Populations, Hypothesis Tests Concerning the Variance of a Normal Population, Tests Concerning the Mean of a Poisson distribution.

Unit 3
Regression: Introduction, Least Squares Estimators of the Regression Parameters, Distribution of the Estimators, Statistical Inferences about the Regression Parameters, the Coefficient of Determination and the Sample Correlation Coefficient, Analysis of Residuals, transforming to Linearity, Weighted Least Squares, Polynomial Regression, Multiple Linear Regression, Predicting Future Responses, Logistic Regression Models for Binary Output Data.

TEXTBOOK:
1. *Ross S.M., Introduction to Probability and Statistics for Engineers and Scientists, 3rd edition, Elsevier Academic Press.*

REFERENCES:
1. *Douglas C. Montgomery and George C. Runger, Applied Statistics and Probability for Engineers, John Wiley and Sons Inc., 2005*
2. *Ravichandran, J. Probability and Statistics for engineers, First Reprint Edition, Wiley India, 2012.*
3. *Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers and Keying Ye, Probability and Statistics for Engineers and Scientists, 8th Edition, Pearson Education Asia, 2007.*
4. *Hogg, R.V., Tanis, E.A. and Rao J.M., Probability and Statistical Inference, Seventh Ed, Pearson Education, New Delhi.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23MAT241	INTRODUCTION TO GAME THEORY	L-T-P-C: 3-0-0-3

Syllabus

Unit 1
Elements of Game theory, examples, Strategic Games, 2 Player Strategy Games, payoffs, Minimax, Weak and Strong Domination, Saddle Points, Nash Equilibrium, Prisoner's Dilemma, Stag Hunt, Matching pennies, BOS, Multi NE, Cooperative and Competitive Games, Strict and Non Strict NE, Best response functions for NE.

Unit 2
Combinatorial games, Winning and losing positions, Subtraction Game, 3-Pile and K-Pile Games, Proof of Correctness, Variations of K-Pile Games, Graph Games, Construction, Proof of finiteness, SG theorem for sum ofgames.

Unit 3
Cournot's Oligopoly, Bertrand's Oligopoly, Electoral Competition, Median Voter Theorem, Auctions, role of knowledge, Decision making and Utility Theory, Mixed Strategy Equilibrium, Extensive Games with Perfect Information, Stackelberg's model of Duopoly, Buying Votes, Committee Decision making, Repeated Gmes, Prisoner's Dilemma, Supermodular Game and Potential games

TEXTBOOK:
1. *Martin Osborne, An Introduction to Game Theory, Oxford University Press.*

REFERENCES:
1. *Thomas Ferguson, Game Theory, World Scientific, 2018.*
2. *Stef Tijs. Introduction to Game Theory, Hindustan Book Agency.*
3. *Allan MacKenzie, Game Theory for Wireless Engineers, Synthesis Lectures On Communications.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23MAT242	NUMERICAL METHODS AND OPTIMIZATION	L-T-P-C: 3-0-0-3

Syllabus

09 (a) Roots finding methods:
Roots of Transcendental and Polynomial Equations: Bisection method, Iteration methods based on first degree equation, Rate of convergence, system of nonlinear equations.

09 (b) Interpolations:
Interpolation and Approximation: Lagrange, Newton's Divided Difference, Newton's Forward and Backward interpolations.

07 (b) Multivariable optimization (2 Credits)
Optimality criteria – unidirectional search – direct search methods – gradient based methods. Lagrangian and Kuhn- Tucker conditions.

TEXTBOOK:
1. *Edwin K.P. Chong, Stanislaw H. Zak, "An introduction to Optimization", 2nd edition, Wiley, 2013.*
2. *M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical methods for scientific and Engineering computation, New Age International Publishers, 2007, 5th edition.*

REFERENCES:
1. *Kalyanmoy Deb, "Optimization for Engineering Design: Algorithms and Examples,Prentice Hall, 2002.*
2. *S.S. Rao, "Optimization Theory and Applications", Second Edition, New AgeInternational (P) Limited Publishers, 1995.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

FREE ELECTIVES OFFERED UNDER MANAGEMENT STREAM
COMMON TO ALL PROGRAMS

23MNG331	FINANCIAL MANAGEMENT	L-T-P-C: 3-0-0-3

Course Objectives

- Understand the overview of financial management
- Inculcate methods and concepts on valuation
- Familiarize with working capital management, financial analysis and planning

Course Outcomes

CO1: Understand and apply time value concept of money and use this for investment criteria decisions.
CO2: Evaluate the risk and return for various alternatives of investment.
CO3: Apply the capital budgeting techniques and evaluate the investment decisions.
CO4: Understand working capital management, cash and liquidity management and financial statements**.**

CO/PO Mapping

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3					1	1		3	3	1				
CO02	3	3					2	1		3	3	1				
CO03	3	2					1	1		3	3	1				
CO04	3	2			1		2	1	2	3	3	1				

Syllabus

Unit 1

Introduction: Financial Management an overview – Financial Decisions in a firm – Goal of FM – Function of thefinancial system.

Unit 2

Fundamental Valuation Concepts:Time value of money – Risk and Return. Capital Budgeting: Techniques of capitalbudgeting investment criteria– NPV – Benefit Cost Ratio – IRR – Payback Period – ARR – Investment appraisal inPractice – Estimation of Project cost flows.

Unit 3

Working Capital Management: Current Assets – Financing Ruling – Profit Criterion. Cash and Liquidity Management. Working Capital Financing.

Financial Analysis and Planning**:** financial instruments, sources of long-term, intermediate term and short term finance. Analyzing Financial Performance – Break – even analysis and Leverages – Financial Planning and Budgeting.
Mergers and Takeovers-International trade.

TEXT BOOKS

1. *Chandra, P., 'Financial Management: Theory and Practice', 9e, TMH, 2017.*
2. *Denzil Watson & Antony Head, 'Corporate Finance- Principles and Practice', 2e, Pearson Education Asia,2016.*
3. *R L Varshney& K L. Maheshwari, 'Managerial Economics', S Chand & Sons, 22e, 2014.*

REFERENCE BOOKS

1. *Stephen Blyth, 'An Introduction to Corporate Finance ',McGraw Hill Book Company, 2014.*
2. *Eugene F. Brigham & Louis C.Gapenski, 'Financial Management – Theory and Practice',14e, 2015.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

23MNG332	SUPPLY CHAIN MANAGEMENT	L-T-P-C: 3-0-0-3

Course Objectives

- Understand the complexity and key issues in supply chain management.
- Describe logistics networks, distribution planning, routing design and scheduling models.
- Familiarize dynamics of supply chain and the role of information in supply chain.
- Understand the issues related to strategic alliances, global supply chain management, procurement and outsourcing strategies.

Course Outcomes

CO1: Analyze the complexity and key issues in supply chain management
CO2: Evaluate single and multiple facility location problems, logistics network configuration, vehicle routing and scheduling models
CO3: Analyze inventory management models and dynamics of the supply chain
CO4: Develop the appropriate supply chain through distribution requirement planning and strategic alliances
CO5: Identify the issues in global supply chain management, procurement and outsourcing strategies

CO/PO Mapping

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	1	1									1	3			
CO02	2	2	3	1						1	1	2	2			
CO03	3	3	3	3	2				3	1	1	3	2			
CO04	2	2	1	1						1	1	2	2			
CO05	3	3	3	1					3	1	1	3	2			

Syllabus

Unit 1

Introduction: Introduction to SCM-the complexity and key issues in SCM – Location strategy – facility location decisions – single facility and multiple location models.
Logistics: Logistics Network Configuration – data collection-model and data validation- solution techniques- network configuration DSS – Transport strategy – Service choices: single service and inter modal services – vehicle routing and scheduling models – traveling salesman problems – exact and heuristic methods.

Unit 2

Inventory: Inventory Management and risk pooling-managing inventory in the SC. Value of Information- bullwhip effect-lead time reduction.
Supply Chain Integration: Supply chain integration-distributed strategies-push versus pull systems. Distribution Requirements Planning – DRP and demand forecasting, DRP and master production scheduling. DRP techniques – time-phased order point – managing variations in DRP – safety stock determination- Strategic alliances-third party logistics-distribution integration.

Unit 3

Issues in SCM**:** Procurement and outsourcing strategies – framework of e-procurement. International issues in SCM-regional differences in logistics. Coordinated product and supply chain design-customer value and SCM.

TEXT BOOK

1. *Simchi-Levi,D.,Kaminsky,P.,Simchi-Levi,E., Shankar,R., 'Designing and Managing the Supply Chain: Concepts,Strategies, and Cases', Tata McGraw Hill, 2008.*

REFERENCE BOOKS

1. *Christopher, M., 'Logistics and Supply Chain Management: Strtegies for reducing Cost and ImprovingService', PH, 1999.*
2. *Ballou, M., 'Business logistics / Supply chain management', Pearson Education, 2003.*
3. *Vollmann, T.E., 'Manufacturing Planning and Control for Supply Chain Management', 5e, McGraw Hill,2005.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

23MNG333	MARKETING MANAGEMENT	L-T-P-C: 3-0-0-3

Course Objective

To educate the students to apply concepts and techniques in marketing so that they become acquainted with the duties of a marketing manager with an emphasis to make the students exposed to the development, evaluation, and implementation of marketing management in a variety of business environments.

Course Outcomes

On successful completion of the Course students will be able to:

CO1: Illustrate key marketing concepts, theories and techniques for analysing a variety of marketing situations
CO2: Identify and demonstrate the dynamic nature of the environment in which marketing decisions are taken and appreciate the implication for marketing strategy determination and implementation
CO3: Develop the ability to carry out a research project that explores marketing planning and strategies for aspecific marketing situation
CO4: Understand the need and importance of sales promotions and make use of advertising
CO5: Manage a new product development process from concept to commercialization.
CO6: Illustrate the importance of modern trends in retailing and marketing logistics

CO/PO Mapping

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01			3	1								1				
CO02		1	3	3		2	1			2	2	2				
CO03	1	1	1	3	2	2	2		2	2	2	3				
CO04			2	2		2	1	1		3	3	3				
CO05	1	1	3	2		1	1			1	2	3				
CO06	1	1	3	2		1	1			1	2	3				

Syllabus

Unit 1

Marketing Process: Definition, Marketing process, dynamics, needs, wants and demands, value and satisfaction, marketing concepts, environment, mix. Philosophies, selling versus marketing, organizations, industrial versus consumer marketing, consumer goods, industrial goods, product hierarchy.

Buying Behaviour and Market Segmentation: Major factors influencing buying behaviour, buying decision process,businessbuyingbehaviour. Segmenting consumer and business markets, market targeting.

UNIT 2

Product Pricing and Marketing Research: Objectives, pricing, decisions and pricing methods, pricing management.Introduction, uses, process of marketing research.

UNIT 3

Developing New Products - Challenges in new-product Development - Effective organizational arrangements - Managing the development Process: ideas - Concept to strategy - Development to commercialization – The consumer- adoption process.
Advertising Sales Promotion and Distribution: Characteristics, impact, goals, types, and sales promotions- point purchase- unique selling proposition. Characteristics, wholesaling, retailing, channel design, logistics, and moderntrends in retailing.

TEXT BOOKS

1. *Kolter, P.,‘Marketing Management’, Pearson Education 2001.*
2. *Ramasamy and Namakumari, ‘Marketing Environment: Planning, implementation and control the Indiancontext’, 1990.*

REFERENCE BOOKS

1. *Paul, G.E. and Tull, D., 'Research for marketing decisions', Prentice Hall of India, 1975.*
2. *Tull, D.S. and Hawkins, 'Marketing Research', Prentice Hall of Inida-1997.*
3. *Kotler, P. and Armstrong, G., 'Principles of Marketing' Prentice Hall of India, 2000.*
4. *Skinner, S.J., 'Marketing', All India Publishers and Distributes Ltd. 1998.*
5. *Govindarajan, M., 'Industrial marketing management', Vikas Publishing Pvt. Ltd, 2003.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

23MNG334	PROJECT MANAGEMENT	L-T-P-C: 3-0-0-3

Course Objectives

- To discuss the project life cycle and build a successful project from pre-implementation to completion.
- To introduce different project management tools and techniques

Course Outcomes

CO1: Appraise the selection and initiation of individual projects and its portfolios in an enterprise.
CO2: Analyze the project planning activities that will predict project costs, time schedule, and quality.
CO3: Develop processes for successful resource allocation, communication, and risk management.
CO4: Evaluate effective project execution and control techniques that results in successful project completion

CO/PO Mapping

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	2	3	2	2	1				2		3	1	2	3	2	
CO02	2	3	3	2	2				3		3	2	2	3	3	
CO03	1	2	3	2	2				2		3	2	1	2	3	
CO04	1	1	2		1				2		3	1	1	1	2	

Syllabus

Unit 1

Overview of Project Management: Verities of project, Project Features, Project Life Cycle – S-Curve, J-C
Project Selection: Project Identification and Screening – New ideas, Vision, Long-term objectives, SWOT Analysis (Strength, Weakness, Opportunities, Threats).
Project Appraisal – Market Appraisal, Technical Appraisal, Economic Appraisal, Ecological Appraisal, and Financial Appraisal – Payback, Net Present Value (NPV), Internal Rate of Returns (IRR).
Project Selection – Decision Matrix, Technique for Order Preference using Similarity to Ideal Solution (TOPSIS), Simple Additive Weighting (SAW).

Unit 2

Project Presentation: WBS, Project Network – Activity on Arrow (A-O-A), Activity on Node (A-O-N).
Project Scheduling: Gant Chart, Critical Path Method (CPM), Project Evaluation & Review Technique (PERT). (6hrs)
Linear time cost trade-offs in project - Direct cost, indirect cost, Project crashing Resource Consideration - Profiling, Allocation, Levelling.
Introduction to project management software: Primavera/ Microsoft project

Unit 3

Project Execution: Monitoring control cycle, Earned Value Analysis (EVA), Project Control – Physical control, Human control, financial control.
Organizational and Behavioral Issues: Organizational Structure, Selection-Project Manager, Leadership Motivation, Communication, Risk Management.
Project Termination: Extinction, Addition, Integration, Starvation.

TEXT BOOKS

1. *Jack R. Meredith and Samuel J. Mantel, Jr. - 'Project Management- A Managerial Approach' Eighth Edition - John Wiley & Sons Inc - 2012.*
2. *Arun Kanda – 'Project Management-A Life Cycle Approach' PHI Learning Private Limited - 2011*

REFERENCE BOOKS

1. *'A Guide to Project Management Body of Knowledge' PMBOK GUIDE, Sixth edition, Project management Institute – 2017*
2. *Ted Klastrorin - 'Project Management, Tools, and Trade-Offs' - John Wiley – 2011*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

23MNG335	ENTERPRISE MANAGEMENT	L-T-P-C: 3-0-0-3

Course Objectives

- To impart knowledge on the fundamentals of costing, pricing methods and strategies.
- To give an overview of production operations planning.
- To summarize various quantitative methods of plant location, layout and lean manufacturing.
- To familiarize the concepts of e-commerce, e-purchasing, MRP and ERP in business

Course Outcomes

At the end of the course, the student will be able to:

CO1: Understand the concepts of cost and pricing of goods and appraise project proposals
CO2: Design and analyze manufacturing and service processes and to measure the work performed.
CO3: Understand and analyze the key issues of supply chain Management
CO4: Understand the application of lean manufacturing tools and six sigma concepts
CO5: Select appropriate plant location and their layout methods
CO6: Create capacity plan, aggregate plan, schedule, ERP & MRP systems

CO/PO Mapping

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	2	2	1	1							2	2				
CO02	2	1								1		2	1		1	
CO03	2	1										2	1		1	
CO04	2	1	1	1						1		2	1		1	
CO05	2	1		1								2				
CO06	2	2	1	1							1	2	1		1	

Syllabus

Unit 1

Engineering Economics: cost concepts - types of costs - cost functions. Cost controls: reduction – tools & applications.Pricing policies – methods – problems.Process design and improvement – process capacity – process layout – process reengineering – job design. Work standards – work measurement – work sampling – problems.

Unit 2

Supply Chain Management – Basic Concepts, SC dynamics, push-pull boundary, integrated supply chain, logistics,customer relationship, supplier relationship – selection, rating and development, procurement, SC metrics and performance measurement - problems. Lean Manufacturing – concepts, wastes – tools viz., pull system, standardized work, takt time, kanban system, JIT, kaizen, SMED, 5S, value stream mapping, benefits of lean and implementationissues. Introduction to Six Sigma. Plant Location – globalization, factors affecting location decisions, facility location- Break-even method, rectilinear, factor-rating and centre of gravity – problems. Plant Layout – types, process layout,product layout, Systematic layout planning (SLP), Line Balancing problems. Capacity Planning – Aggregate Planning - importance, planning process, methods – problems.

Unit 3

Role of IT in business performance improvement – e-commerce – e-purchasing –Master Production Schedule, inventory lot sizing strategies, MRP basics – MRP explosion, Available to Promise(ATP) inventory – MRP calculations – MRP II – Scheduling – Gantt chart – Introduction to ERP – ERP software – ERP modules – ERP implementation.

TEXT BOOKS

1. *L J Krajewski, L.P.RitzmanMalhotra.M and Samir K. Srivastava, 'Operations Management: Processes andValue chains, 11e, Pearson, 2015.*
2. *R L Varshney& K L. Maheshwari, 'Managerial Economics', S Chand & Sons, 22e, 2014.*

REFERENCE BOOKS

1. *Richard B. Chase, Ravi Shankar, F. Robert Jacobs, 'Operations and Supply Chain Management' McGrawHill Education (India) Private Limited.14e, 2017.*
2. *E S Buffa and R K Sariss, 'Modern Production/Operations Management', Wiley India Private Limited, 8e,2007.*
3. *Harrison.B, Smith.C. and Davis.B.,, 'Introductory Economics', 2e Pr Macmillan, 2013.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports.

23MNG336	OPERATIONS RESEARCH	L-T-P-C: 3-0-0-3

Course Objectives

- Familiarizing the students with quantitative tools and techniques, which are frequently applied in operational decisions

Course Outcomes

CO1: Formulate operations research models to optimize resources.
CO2: Solve transportation and assignment problems using suitable techniques.
CO3: Apply appropriate technique to analyze a project with an objective to optimize resources.
CO4: Solve operational problems using decision theory approaches.
CO5: Select suitable inventory model for effective utilisation of resources.
CO6: Solve Operations Research problems using software package

CO/PO Mapping

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	2	2		2						2	2	2			
CO02	3	2	2		2						2	2	2			
CO03	3	2	2		2						2	2	2			
CO04	3	2	2		2						2	2	2			
CO05	3	2	2		2						2	2	2			
CO06	3	2	2		2						2	2	2			

Syllabus

Unit1

Linear Programming: Formulations - graphical solutions - Simplex Method - Duality, Dual simplex method. Transportation model: Assignment model – Travelling Salesman Problem.

Unit 2

Decision Theory: Decision Trees. Game theory - 2 person zero sum; mixed strategies; 2 x n and m x 2 games. Network Models- Project Networks- CPM / PERT- Project Scheduling – crashing networks and cost considerations- Resource leveling and smoothing - shortest route problem, minimal spanning tree problem, maximal flow problem.

Unit 3

Sequencing model – 2 machines ‘n’ jobs, ‘m’ machines ‘n’ jobs – n jobs 2 machines.
Inventory models: deterministic & probabilistic models. Quantity discounts. Selective Inventory Management
Queuing models: Poisson arrival and exponential service times. Single server, multi-server. Queues -infinite and finite capacity queues.
Simulation –Monte Carlo simulation: simple problems

Lab session: Practicing case problems with excel solver/MatLab/LINGO package

TEXT BOOK

1. *Hillier, F .S. and Lieberman, G .J, ‘Operations Research’, 9e, McGraw Hill, 2010*

REFERENCE BOOKS

1. *Taha,H.A., 'Operations Research: an Introduction', 8e, Prentice HalI, New Delhi, 2008.*
2. *Ravindran, A., Phillips, D.J., and Solberg, J.J., 'Operations Research- Principles and Practice', John Wiley& Sons, 2005.*
3. *Wagner, H.M., 'Principles of Operations Research', Prentice Hall, New Delhi, 1998.*
4. *Hardley, G.,'Linear Programming', Narosa Book Distributors Private Ltd 2002.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment (Theory) (CAT)	15	
*Continuous Assessment(Lab) (CAL)	30	
End Semester		35

*CA – Can be Quizzes, Assignments, Projects, and Reports

23MEE321	INDUSTRIAL ENGINEERING	L-T-P-C: 3-0-0-3

Course Objectives

- To inculcate the concepts of work study and its application to industrial practice
- Impart skills to design, develop, implement, and improve manufacturing/service systems

Course Outcomes

At the end of the course, the student will be able to
CO1: Create value to organizations through the analysis, evaluation, and improvement of work systems using work study and method study
CO2: Develop work systems through motion economy principles
CO3: Apply work measurement techniques to improve productivity, fix wages and incentives
CO4: Apply systematic layout planning techniques and work station design principles based on ergonomics andmaterial handling.

CO/PO Mapping

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	2	1	1	1						1		3	2			
CO02	2	1	2	1	1					1		3	2			
CO03	1	2		1	1						1	3	2			
CO04	2	2		1	2						2	3	2			

Syllabus

Unit 1

Work System: Elements of work, maintenance of machines, interaction, effect of working conditions and environment, physical and mental fatigue.
Productivity: Productivity, factors affecting production, Measurement of productivity.
Work Study: Definition and scope of work study; Areas of application of work study in industry; Human aspects ofwork study.
Method Study: Information collection, recording techniques, and processing aids; critical examination; development, installation and maintenance of improved methods.

Unit 2

Motion Economy and Analysis: Principles of motion economy; Motion analysis; Micromotion and Memomotion study; Therbligs and SIMO charts; Normal work area and design of work places; Basic parameters and principles ofwork design.
Work Measurement: Work measurement techniques; Calculation of standard time, work sampling and predetermined Motion time systems.
Wages and Incentive Schemes: Introduction, wage payment of direct and indirect labour, wage payment plans andincentives, various incentive plans, incentives for indirect labour

Unit 3

Plant Layout: Concept of plant layout, types of layout; factors affecting plant layout.
Ergonomics: Ergonomic Design of equipment and work place. work station design, factors considered in designing awork station, ergonomic design standards - Study of development of stress in human body and their consequences.Case Studies.Production planning and scheduling.
Material Handling: Introduction and functions of material handling equipment, selection of material handling equipment for different requirements, safety requirements.
Recent advances in Industrial Engineering.

TEXT BOOKS

1. *Barnes, R, "Motion and Time Study" - Design and Measurement of Work . NY: John Wiley and Sons, 8th Edition, 1985.*
2. *"Introduction to Work Study", 4ed, International Labor Office, Geneva, 2006.*

REFERENCE BOOKS

1. *Martand T. Telsang, 'Industrial Engineering and Production Management' S Chand; 2nd Rev Edn 2006.*
2. *Mahajan M., "Industrial Engineering and Production Management" Dhanpat rai and Sons Publishers, 2005.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continues Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

23MEE322	MANAGERIAL STATISTICS	L-T-P-C: 3-0-0-3

Course Objective

- To impart the knowledge of basic statistical tools for analysis and interpretation of qualitative and quantitative data for decision making

Course Outcomes

CO1: Apply basic probability and statistics concepts for various business problems
CO2: Perform test of hypothesis
CO3: Compute and interpret the result of regression and correlation analysis for forecasting
CO4: Solve real time problems by applying different decision making methods.

CO/PO Mapping

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	3		2	2						2	2	3			
CO02	3	3		2	2						2	2	3			
CO03	3	3		2	2						2	2	3			
CO04	3	3		2	2						2	2	3			

Syllabus

Unit 1

Quantitative methods: Basic terminology in probability, probability rules, conditions of statistical dependence andindependence, Bayes Theorem, Discrete Random Variables review of probability distributions, measure of centraltendency.
Sampling and sampling distributions: Introduction to sampling, random sampling, design of experiments, introduction to sampling distributions
Estimation: point estimates, interval estimates and confidence intervals, calculating interval estimates of mean from large samples, using t test, sample size estimation**.**

Unit 2

Testing hypothesis: Introduction, basic concepts, testing hypothesis, testing when population standard deviation isknown and not known, two sample tests.
Chi-square and analysis of variance: introduction, goodness of fit, analysis of variance, inferences about a population variation

Unit 3

Regression and correlation: Estimation using regression line, correlation analysis, finding multiple regression equation, modelling techniques,
Non parametric methods and time series and forecasting: Sign test for paired data, rank sum test, rank correlation, Kolmogrov – smirnov test, variations in time series, trend analysis, cyclic variation, seasonal variation and irregularvariation. Decision theory**:** Decision tree analysis

TEXT BOOKS

1. *Levin R. I. and Rubin D. S. - 'Statistics for management' - Pearson Education – 2007 - 5th Edition*
2. *Montgomery D. C. and Runger G. C. - 'Applied Statistics and Probability for Engineers' - John Wiley & Sons - 2002 - 3rd Edition*

REFERENCE BOOKS

1. *Bain.L. J. and Engelhardt M. - 'Introduction to Probability and Mathematical Statistics' - Duxbury Press - March 2000 - 2nd Edition*
2. *Hinkelmann K. and Kempthorne O. - 'Design and Analysis of Experiments : Volume I' - John Wiley & Sons, Inc. - December 2007 - 2nd Edition*
3. *Johnson R. A. and Wichern D. W. - 'Applied Multivariate Statistical Analysis' - Prentice-Hall, Inc. - December 2001 - 5th Edition*
4. *Myers R. H. - 'Classical and Modern Regression with Applications' - PWS-Kent Publishing Company - March 2000 - 2nd Edition*
5. *Devore J. L. - 'Probability and Statistics for Engineering and the Sciences' - Brooks/Cole Publishing Company - December 1999 - 5th Edition*
6. *Freund J. E. and Walpole R. E. - 'Mathematical Statistics' - Prentice-Hall Inc. - October 1986 - 4th Edition*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

23MEE323	TOTAL QUALITY MANAGEMENT	L-T-P-C: 3-0-0-3

Course Objective

- To impart knowledge on quality management principles, tools, techniques and quality standards for real life applications

Course Outcomes

CO1: Evaluate the principles of quality management and to explain how these principles can be applied within quality management systems.
CO2: Evaluate the performance measures using various quality and management tools
CO3: Apply the Quality Function Deployment, Taguchi principles, Total Productive Maintenance and Failure Mode and Effect Analysis concepts to solve industrial problems.
CO4: Practice the various quality system in industry.

CO/PO Mapping

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	1	2										2	2			
CO02	1	2										2	2			
CO03	2	2	2									2	2			
CO04	2	2	2	2								2	2			

Syllabus

Unit 1

Definition of quality - dimensions of quality. Quality planning - quality costs. Total Quality Management: historical review and principles –leadership - quality council - quality statements - strategic planning - Deming philosophy. Barriers to TQM implementation

Unit 2

Customer satisfaction – Customer retention - Employee involvement - Performance appraisal - Continuous process improvement - Supplier partnership - Performance measures. Seven tools of quality.Statistical fundamentals - Control Charts for variables and attributes - Process capability - Concept of six sigma - New seven management tools - Benchmarking**.**

Unit 3

Quality function deployment (QFD) - Taguchi quality loss function - Total Productive Maintenance (TPM) - FMEA.Need for quality systems - ISO 9000:2000 – Elements of quality systems (such as ISO 9000:2000). Implementation of quality system – documentation - quality auditing - QS 9000-ISO 14000

TEXT BOOK

1. *Besterfiled D. H. - 'Total Quality Management' - Pearson Education Asia – 2015-4th Edition*

REFERENCE BOOKS

1. *Evans J. R, and Lidsay W. M. - 'The Management and Control of Quality' - Southwestern (Thomson Learning) - 2002 - 5th Edition*
2. *Feigenbaum A. V. - 'Total Quality Management - Vol I &II ' – McGraw Hill – 1991.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

23MEE324	LEAN MANUFACTURING	L-T-P-C: 3-0-0-3

Course Objectives

- Understand Lean manufacturing principles and tools
- Inculcate the concepts of value stream mapping
- Familiarize lean implementation practices

Course Outcomes

CO1: Identify key requirements and concepts in lean manufacturing.
CO2: Initiate a continuous improvement change program in a manufacturing organization
CO3: Analyze and improve a manufacturing system by applying lean manufacturing tools
CO4: Build value stream map for improving the productivity
CO5: Improve productivity through lean practices

CO/PO Mapping

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	2											2	2			
CO02	2	2	2	1					2	1		1	2		1	
CO03	2	2	2	2	1				2	1		1	2	1	2	
CO04	2	2	2	1	1	1	1			1		2	2	1	1	
CO05	2	2	2	1	1	1	1			1		2	2	1	1	

Syllabus

Unit 1

Introduction to Lean and Factory Simulation: History of Lean and comparison to other methods - The 7 Wastes, their causes and the effects - An overview of Lean Principles / concepts / tools - Stockless Production.
The Tools of Lean Manufacturing: Continuous Flow – Continuous Flow Manufacturing and Standard Work Flow –5S and Pull Systems (Kanban and ConWIP systems) – Error Proofing and Set-up Reduction – Total Productive Maintenance (TPM) – Kaizen Event examples. Toyota production systems.
Ford production systems – FPS gear model

Unit 2

Value Stream Mapping – Current state: Preparation for building a Current State Value Stream Map – Building a Current State Map (principles, concepts, loops, and methodology) – Application to the factory Simulation scenario.

Unit 3

Value Stream Mapping – Future State: Key issues in building the Future State Map – Process tips in building the map and analysis of the customer loop, supplier loop, manufacturing loop and information loop – Example of completedFuture State Maps – Application to factory simulation
Implementation of lean practices - Best Practices in Lean Manufacturing.

TEXT BOOKS

1. *Womack, J.P., Jones, D.T., and Roos, D., 'The Machine that Changed the World', Simon & Schuster, New York, 2007.*
2. *Liker, J.K., 'Becoming Lean', Industrial Engineering and Management Press, 1997.*

REFERENCES BOOKS

1. *Womack, J.P. and Jones, D.T., 'Lean thinking', Simon & Schuster, USA, 2003.*
2. *Rother, M. and Shook, J., 'Learning to see', The Lean Enterprise Institute, Brookline, USA, 2003.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

23CSE321	SOFTWARE PROJECT MANAGEMENT	L-T-P-C: 3-0-0-3

Course Objectives

- This course describes the key aspects of a software project.
- It introduces the basic principles of Engineering Software Projects. Most, if not all, students' complete projects as part of assignments in various courses undertaken. These projects range in size, subject and complexity but there are basic project essentials that need to be understood and practiced for successful team project outcomes.
- The course provides an understanding of the purpose, methods and benefits of process management by exposing the student to the concepts, practices, processes, tools and techniques used in process management for software development.

Course Outcomes

CO1: To understand the basic concepts, terminologies and issues of software project management.
CO2: To apply appropriate methods and models for the development of solutions.
CO3: To analyze the cost-benefits of calculations so as to optimize the selection strategy
CO4: To evaluate methods, models and technologies towards achieving project success
CO5: To design and evaluate network planning models with criticality

CO-PO Mapping

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3	1	1								1		3	2		
CO02	3	2	3						3	3		2	3	2		
CO03	3	2	2	3	2	2	2	2	3	3	2	2	3	2		
CO04	2	2	2	1	3	2	2	2	3	3		2	3	2		
CO05	3	2	3	3	3	2	2	2	3	3		2	3	2		

Syllabus

Unit 1

Introduction to Software Project Management- Software Projects - ways of categorizing software projects – problems with software projects - Project Life Cycle– Management -Setting objectives –Stakeholders - Project Team- Step-wise : An overview of project planning -project Evaluation –Selection Of Appropriate Project Objectives- Software Effort Estimation Techniques, Function Point Analysis-Object Point-COCOMO.

Unit 2

Activity planning-- project schedules - sequencing and scheduling projects - Network planning model – AON andAOA-identifying critical activities-Crashing And Fast Tracking-,Risk management—Categories , Risk planning, Management and Control - Evaluating risks to the schedule. PERT- Resource Allocation, Monitoring and Tracking -Monitoring and control - allocation - identifying resource requirements - scheduling resources - creating critical paths - publishing schedule - cost schedules- sequence schedule.

Unit 3

Monitoring and control – Visualizing Progress, Earned value analysis, managing people and organizing teams-organizational structures- Planning for small projects. Case Study: PMBOK, Agile Development

TEXT BOOK(S)

1. *Mike Cotterell, Bob Hughes. Software Project Management, Fifth Edition, Tata McGraw-Hill; 2012.*

REFERENCE(S)

1. *Roger S. Pressman. Software Engineering – A Practioner's Approach, Eighth Edition, Tata McGraw-Hill publishers; 2014.*
2. *Jalote P. Software Project Management in practice, Second edition, Person Education; 2003.*

Evaluation Pattern

Assessment	Internal	External
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23CSE322	FINANCIAL ENGINEERING	L-T-P-C: 3-0-0-3

Pre-Requisite(s): 19MAT112 Linear Algebra, 19MAT205 Probability and Random Processes

Course Objectives

- This course serves as an introduction to financial engineering including cash flows, financial decision making etc
- It gives a thorough yet highly accessible mathematical coverage of standard and recent topics of introductory investments: fixed-income securities, modern portfolio theory, optimal portfolio growth and valuation of multi-period risky investments.

Course Outcomes

CO1: Apply basic concepts to understand and evaluate cash flows
CO2: Evaluate and arrive at a financial investment decision employing the underlying knowledge of stocks andderivatives
CO3: Analyse and design Portfolio selection methods
CO4: Understand capital market theory for stock performance evaluation

CO-PO Mapping

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	2	1			2								3	2		
CO02	2	3	1										3	2		
CO03	1	3			2								3	2		
CO04	2	1											3	2		

Syllabus

Unit 1

Cash Flows and Fixed income securities: Investments and markets - Principal and interest - Present and future valuesof streams - IRR. Fixed income securities - Market value for future cash - Bond value - Bond details – Yields – Convexity – Duration - Immunization. Bond portfolio management - Level of market interest rates, Term structureof interest-rate theories.

Unit 2

Stocks and Derivatives: Common stock valuation - Present value of cash dividends - Earnings approach - Value versus price - Efficient markets theory - Technical analysis. Analysis of financial statements. Derivatives - futures and options - Black Scholes formula - Utility functions - Applications in financial decision making.

Unit 3

Portfolio analysis and capital market theory: Covariance of returns – Correlation - Portfolio return - Portfolio standard deviation - Two asset case - Efficient frontier - Optimum portfolio. Capital market theory - Capital market line - Sample diversifications to reduce risk - Characteristic line - Capital asset pricing model. Arbitrage price theory - Stock performance evaluation.

TEXT BOOK(S)

1. *David Luenberger, Investment Science. Second Edition, Oxford University Press; 2013*
2. *Jack Clark Francis, Richard W. Taylor. Investments, Schaum's Outlines, Tata McGraw Hill; 2006.*

REFERENCE(S)

1. *Lyuu YD. Financial Engineering and Computation. Cambridge University Press; 2004.*
2. *Perry H. Beaumont. Financial Engineering Principles. John Wiley and Sons Inc, New Jersey; 2004.*

Evaluation Pattern

Assessment	Internal	External
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23CSE323	ENGINEERING ECONOMIC ANALYSIS	L-T-P-C: 3-0-0-3

Course Objectives

- Prepare engineering students to analyze and understand the business, impact of economic environment onbusiness decisions

Course Outcomes

CO1: Understand and evaluate the economic theories, cost concepts and pricing policies and draw inferences forthe investment decisions for appraisal and profitability
CO2: Appraise the dynamics of the market and market structures and portray implication for profit and revenuemaximization
CO3: Employ operations research and allied techniques in managerial economics for an enhanced analysis anddecision making

CO-PO Mapping

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	2	3	2	2		2		2			3	2	3	2		
CO02	1	3	2	1		2		2			3	2	3	2		
CO03	2	3	2	2		2		2			3	2	3	2		

Syllabus

Unit 1

Economics: Nature and scope of managerial economics. Economic theory and managerial economics, Cost Concepts: Types of costs - Cost functions. Cost controls: reduction – Tools & Areas. Pricing policies- methods. Capital budgeting - cost of capital. Appraising project profitability

Unit 2

The essentials of demand and supply: The law of demand. Market demand curve. Other determinants of market demand. The law of supply. Determinants of market supply. The market mechanism. Price elasticity of demand, Profit and revenue maximization: Optimal input combination. Total revenue maximization.

Unit 3

Market structure: Perfect competition and monopoly. Characteristics of monopolistic competition. Oligopoly Operations Research techniques in managerial economics: Inventory models. Theory of games. Decision theory, Risk and Uncertainty, Measuring risk, Consumer behavior and risk aversion, Decision making under uncertainty with complete ignorance

TEXT BOOK(S)

1. *Webster, T.J. Managerial Economics- Theory and Practice, Elsevier; 2004.*

REFERENCE(S)

1. *Panneerselvam, R. Engineering Economics, Second Edition, PHI; 2013.*
2. *R L Varshney,K L. Maheshwari. Managerial Economics, S Chand & Sons;2014.*
3. *Harrison.B, Smith.C., and Davis.B. Introductory Economics, Second Edition, Pr Macmillan; 2013.*

Evaluation Pattern

Assessment	Internal	External
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23CSE324	INFORMATION SYSTEMS	L-T-P-C: 3-0-0-3

Course Objectives

- This course is to expose the students to the managerial issues relating to information systems and alsounderstand the role of Business Process Reengineering technique in an organization.
- The course also focus on the management of information technology to provide efficiency and effectiveness or strategy decision making.

Course Outcomes

CO1: Understand the fundamental concepts of Information Systems in business.
CO2: Understand and analyse the strategic role played by Information Systems in e-commerce.
CO3: Analyse management challenges in Global Businesses predominantly dependent on IS functions.

CO-PO Mapping

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01	3												3	2		
CO02	2	2			2								3	2		
CO03	1	3			2	2					2	1	3	2		

Syllabus

Unit 1

Introduction to IS -Fundamental concepts-IS in Business- Role of IS –Information system and technologies – Components of IS –resources and acivities –Types of IS- E business Applications –Role of BI and Analytics in IS-Functional Business Systems - Marketing Systems, Manufacturing systems, Human Resource Systems, Accounting Systems and Financial Management Systems.-Cross-Functional Enterprise Systems Cross-Functional Enterprise Applications, Enterprise Application Integration, Transaction Processing Systems and Enterprise Collaboration Systems. Enterprice Business Systems CRM, ERP, SCM, Case Studies.

Unit 2

Electronic Commerce Systems: Scope of e-Commerce, Essential e-Commerce Processes and Electronic Payment Processes - E-commerce Applications & Issues -Decision Support Systems- Business and Decision Support, Decision Support Trends, Management Information Systems, Online Analytical Processing, Decision Support Systems, Executive Information Systems, Enterprise Portals and Decision Support - Knowledge Management Systems. Artificial Intelligence Technologies and its application in Business- Strategic role of IT- Competing with IT, valuechain ,reengineering, virtual organization ,knowledge creation-Organizational Planning, The Scenario Approach, Planning for Competitive Advantage, SWOT Business Models and Planning, Business IT Planning, -Business/ ITStrategies and Business Application Planning- Developing and Implementing Business Systems - ImplementationChallenges- barriers - change management-: Case Studies.

Unit 3

Management challenges-Security, Ethical and Societal Challenges- Ethical Responsibility of Business Professionals, Computer Crime, Privacy Issues, Health Issues, and Societal Solutions- Security Management of IT- Tools of security Management, Internetworked Security Defenses, other security measures –system controls and audits- Enterprise and Global Management of IT- Managing the IS Function and Failures in IT Management - Global IT Management, Cultural, Political and Geo-economic Challenges, Global Business/IT Strategies, Global Business/IT Applications, Global IT Platforms, Global Data Access Issues and Global Systems Development –Case studies.

TEXT BOOK(S)

1. *O'Brien JA, Marakas GM. Management information systems. McGraw-Hill Irwin; 2006.*
2. *Brien,Marakas G M and Behi R , MIS,9th edition, Tata McGraw Hill Special Indian Edition;2010.*

REFERENCE(S)

1. *Laudon K, Laudon JP. Management Information Systems; 2010*

Evaluation Pattern

Assessment	Internal	External
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

FREE ELECTIVES OFFERED UNDER HUMANITIES / SOCIAL SCIENCE STREAMS COMMON TO ALL PROGRAMS

23CUL230	**ACHIEVING EXCELLENCE IN LIFE -AN INDIAN PERSPECTIVE**	**L-T-P-C: 2-0-0-2**

Course Objectives:
The course offers to explore the seminal thoughts that influenced the Indian Mind on the study of human possibilitiesfor manifesting excellence in life. This course presents to the students, an opportunity to study the Indian perspectiveof Personality Enrichment through pragmatic approach of self analysis and application.

Syllabus
Unit 1
Goals of Life – Purusharthas
What are Purusharthas (Dharma, Artha, Kama, Moksha); Their relevance to Personal life; Family life; Social life & Professional life; Followed by a Goal setting workshop;
Yogic way of Achieving Life Goals – (Stress Free & Focused Life)
Introduction to Yoga and main schools of Yoga; Yogic style of Life & Time Management (Work Shop);
Experiencing life through its Various Stages
Ashrama Dharma; Attitude towards life through its various stages (Teachings of Amma);

Unit 2
Personality Development
What is Personality – Five Dimensions – Pancha Kosas (Physical / Energy / Mental / Intellectual / Bliss); Stress Management & Personality; Self Control & personality; Fundamental Indian Values & Personality;
Learning Skills (Teachings of Amma)
Art of Relaxed Learning; Art of Listening; Developing 'Shraddha' – a basic qualification for obtaining Knowledge; Communication Skills - An Indian Perspective;

Unit 3
Developing Positive Attitude & Friendliness - (Vedic Perspective);
Achieving Work Excellence (Karma Yoga by Swami Vivekananda & teachings based on Amma);Leadership Qualities – (A few Indian Role models & Indian Philosophy of Leadership);

REFERENCE BOOKS:

1. *Awaken Children (Dialogues with Sri Mata Amritanandamayi) Volumes 1 to 9*
2. *Complete works of Swami Vivekananda (Volumes 1 to 9)*
3. *Mahabharata by M. N Dutt published by Parimal publications – New Delhi (Volumes 1 to 9)*
4. *Universal message of Bhagavad-Gita (An exposition of Gita in the light of modern thought and Modern needs) by Swami Ranganathananda. (Vols.1 to 3)*
5. *Message of Upanishads, by Swami Ranaganathananda published by Bharatiya Vidya Bhavan, Bombay.*
6. *Personality Development – Swami Vivekananda published by Advaitha Ashram, Kolkatta.*
7. *Art of Man Making - Swami Chinmayananda published by Chinmaya Mission, Bombay*
8. *Will Power and its Development- Swami Budhananda published by Advaitha Ashram, Kolkatta*
9. *Ultimate Success - Swami Ramakrishnananada Puri published by Mata Amritanandamayi Math, Kollam*
10. *Yoga In Daily Life - Swami Sivananda – published by Divine Life Society*
11. *Hindu Dharma - H. H. Sri Chandrasekharandra Saraswati published by Bharatiya Vidya Bhavan, Bombay*
12. *All about Hinduism – Swami Sivananda - Published by Divine Life Society*
13. *The Mind and its Control by Swami Budhananda published by Advaitha Ashram, Kolkatta*
14. *Krida Yoga - Vivekananda Kendra, Publication.*
15. *Valmiki Ramayana – Four volumes- published by Parimal Publications, Delhi*
16. *New perspectives in Stress Management - Dr H R Nagendra & Dr R Nagaratna published by Swami Vivekananda Yoga Prakashana, Bangalore.*
17. *Mind Sound Resonance Technique (MSRT) Published by Swami Vivekananda Yoga Prakashana, Bangalore.*

18. *Yoga & Memory - Dr H R Nagendra & Dr. Shirley Telles, published by Swami Vivekananda Yoga Prakashana, Bangalore.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23CUL231	EXCELLENCE IN DAILY LIFE	L-T-P-C: 2-0-0-2

Syllabus

Unit 1

1. The anatomy of 'Excellence'. What is 'excellence'? Is it judged by external factors like wealth?
2. The Great Flaw. The subject-object relationship between individual and world. Promote subject enhance excellence.
3. To work towards excellence, one must know where he is. Our present state... An introspective analysis. Our faculties within.

Unit 2

4. The play of the mind. Emotions – convert weakness into strength.
5. The indispensible role of the intellect. How to achieve and apply clear thinking?
6. The quagmire of thought.The doctrine of Karma – Law of Deservance.
7. Increase Productivity, reduce stress.. work patterning.

Unit 3

8. The art of right contact with the world. assessment, expectations.
9. Myths and Realities on key issues like richness, wisdom, spirituality.
10. Collect yourself, there is no time to waste. The blue-print of perfect action.

REFERENCES:

The Bhaja Govindam and the Bhagavad Gita.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23CUL232	EXPLORING SCIENCE AND TECHNOLOGY IN ANCIENT INDIA	L-T-P-C: 2-0-0-2

OBJECTIVES:

This course offers a journey of exploration through the early developments in India of astronomy, mathematics, technologies and perspectives of the physical world. With the help of many case studies, the students will be equipped to understand concepts as well as well as actual techniques.

Syllabus

Unit 1

1. General introduction: principles followed and sources;
2. Astronomy & mathematics from the Neolithic to the Indus civilization;
3. Astronomy & mathematics in Vedic literature;
4. Vedanga Jyotisha and the first Indian calendars;
5. Shulba Sutras and the foundations of Indian geometry;

Unit 2

1. Astronomy & mathematics in Jain and Buddhist literature;
2. The transition to the Siddhantic period; Aryabhata and his time;
3. The Aryabhatiya: concepts, content, commentaries;
4. Brahmagupta and his advances;
5. Other great Siddhantic savants;
6. Bhaskara II and his advances;

Unit 3

1. The Kerala school of mathematics;
2. The Kerala school of astronomy;
3. Did Indian science die out?;
4. Overview of recent Indian scientists, from S. Ramanujan onward;
5. Conclusion: assessment and discussion;

TEXTBOOK:

Indian Mathematics and Astronomy: Some Landmarks, by S. Balachandra Rao

REFERENCE:

IFIH's interactive multimedia DVD on Science & Technology in Ancient India.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23CUL233	**YOGA PSYCHOLOGY**	**L-T-P-C: 2-0-0-2**

OBJECTIVES:
This course offers the foundation necessary to understand Eastern approaches to psychology and spirituality. Thecourse includes experiential components centering on meditation and spiritual practice.

Syllabus
Unit 1
Introduction
Introduction to Modern Psychology
A short history of Modern Psychology - Major Schools of Modern Psychology - The three major forces in WesternPsychology - Freudian Psychoanalysis; Behaviourism; Humanistic Psychology.

Introduction to Indian Psychology
What is Yoga? - Rise of Yoga Psychology tradition - Various schools of Yoga Psychology - Universal Goal of allYoga-schools.

Patanjali Yoga Sutra – 1
Introduction to Rishi Patanjali - Bird view of Yoga-Sutra - Definition of Yoga – Vrittis.

Patanjali Yoga Sutra – 2
Five Kinds of Vrittis - Pramanam - sources of right knowledge - Viparyayah – unfolded belief - Vikalpah – Unfoldedbelief - Smriti – Memory.

Unit 2
Patanjali Yoga Sutra – 3
Two formulae - Necessity of Abhyasah and Vairagyah - Foundation of Abhyasah - Foundation of Vairagyah.

Patanjali Yoga Sutra – 4
Introduction to Samadhi - Samprajnata-Samadhi - Reasoning in Samprajnata-Samadhi - Reflection in Samprajnata- Samadhi - Bliss in Samprajnata-Samadhi - Sense of Individuality in Samprajnata-Samadhi.

Patanjali Yoga Sutra – 5
Main obstacles in the path of Yoga - other obstructions - removal of obstacles by one – pointedness; by controlling Prana - by observing sense experience - by inner illumination - by detachment from matter - by knowledge of dream and sleep - by meditation as desired.

Patanjali Yoga Sutra – 6
How to make mind peaceful? - Cultivating opposite virtues: happiness – friendliness - misery – compassion – virtue – gladness - vice – indifference.

Patanjali Yoga Sutra – 7
Five causes of Pain - avidya – ignorance (Root Cause) - asmita – ‘I-Feeling’ – raga – attraction - dwesha – repulsion - abhinivesha – clinging to life.

Unit 3
Patanjali Yoga Sutra – 8
Necessity of Yoga practice - eight parts of Yoga practice - five Yamas: ahimsa – satya – asteya – brahmacharyam – aparigraha.

Patanjali Yoga Sutra – 9
Five Niyamas: Soucha – Santhosha – Tapas – Swadyah – Ishwara - Pranidhanam.

Patanjali Yoga Sutra – 10
Asanam – Pranayamah - various kinds of Pranayamah - Pratyaharah - Mastery over the senses. Report review
Conclusion

REFERENCES:

1. *The course book will be "The four chapters of Freedom" written by Swami Satyananda Saraswati of Bihar School of Yoga, Munger, India.*
2. *"The message of Upanishads" written by Swami Ranganathananda. Published by Bharathiya Vidya Bhavan.*
3. *Eight Upanishads with the commentary of Sankaracharya, Translated by Swami Gambhirananda, Published by Advaita Ashram, Uttaranjal.*
4. *'Hatha Yoga Pradipika' Swami Muktibodhananda, Yoga Publications Trust, Munger, Bihar, India*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23ENG230	BUSINESS COMMUNICATION	L-T-P-C: 1-0-3-2

OBJECTIVES:
To introduce business vocabulary; to introduce business style in writing and speaking; to expose students to the cross-cultural aspects in a globalised world; to introduce the students to the art of persuasion and negotiation inbusiness contexts.

Course Outcomes
CO1: Familiarize and use appropriate business vocabulary and etiquettes in verbal communication in the professional context
CO2: Understand organizational structures, pay structures and performance assessments
CO3: Apply language skills in drafting various business documents and other necessary communications in thebusiness context
CO4: Understand and address cross cultural differences in the corporate environment
CO5: Participate in planned and extempore enactments of various business situations

CO-PO Mapping

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01										3		2				
CO02									1		1					
CO03										3						
CO04						2										
CO05																

Syllabus
Unit 1
Business Vocabulary - Writing: Drafting Notices, Agenda, and Minutes - Reading: Business news, Business articles.

Unit 2
Writing: Style and vocabulary - Business Memorandum, letters, Press Releases, reports – proposals – Speaking:Conversational practice, telephonic conversations, addressing a gathering, conducting meetings.

Unit 3
Active Listening: Pronunciation – information gathering and reporting - Speaking: Cross-Cultural Issues, GroupDynamics, negotiation & persuasion techniques.

Activities
Case studies & role-plays.

BOOKS RECOMMENDED:
1. *Jones, Leo & Richard Alexander. New International Business English. CUP. 2003.*
2. *Horner, David & Peter Strutt. Words at Work. CUP. 1996.*
3. *Levi, Daniel. Group Dynamics for Teams. 3 ed. Sage Publications India Pvt. Ltd. New Delhi, 2011.*
4. *Owen, Roger. BBC Business English. BBC. 1996.*
5. *Henderson, Greta Lafollette & Price R Voiles. Business English Essentials. 7th Edition. Glencoe / McGraw Hill.*
6. *Sweeney, Simon. Communicating in Business. CUP. 2000.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23ENG231	INDIAN THOUGHT THROUGH ENGLISH	L-T-P-C: 2-0-0-2

OBJECTIVES:
To expose the students to the greatness of Indian Thought in English; to develop a sense of appreciation for the lofty Indian Thought; to develop an understanding of the eclectic Indian psyche; to develop an understanding about thesocietal changes in the recent past.

Syllabus
Unit 1
Poems
Rabindranath Tagore's Gitanjali (1-10); Nizzim Ezekiel's Enterprise; A.K. Ramanujam's Small-Scale Reflections on a Great House.

Unit 2
Prose
Khushwant Singh's The Portrait of a Lady; Jhumpa Lahiri's Short Story - Interpreter of Maladies.

Unit 3
Drama and Speech
Vijay Tendulkar's Silence, the Court is in Session; Motivational speeches by Jawaharlal Nehru/ S. Radhakrishnan / A. P. J. Abdul Kalam's My Vision for India etc. (any speech).

REFERENCES:

1. *Lahiri, Jhumpa. Interpreter of Maladies, Harper Collins Publications, 2000.*
2. *Ramanujan A. K. ed. K. M. George, Modern Indian Literature: An Anthology, Vol. I, Sahitya Akademi, 1992.*
3. *Singh, Khushwant. The Portrait of a Lady: Collected Stories, Penguin, 2009.*
4. *Tagore, Rabindranath. Gitanjali, Penguin Books India Pvt. Ltd, 2011.*
5. *Tendulkar, Vijay. Five Plays, Oxford University Press, 1996.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23ENG232	INSIGHTS INTO LIFE THROUGH ENGLISH LITERATURE	L-T-P-C: 2-0-0-2

OBJECTIVES:
To expose the students to different genres of Literature; to hone reading skills; to provide deeper critical and literaryinsights; to enhance creative thinking; to promote aesthetic sense.

Syllabus
Unit 1
Poems
1. W. H. Auden: Refugee Blues; 2. A. K. Ramanujan: Obituary; 3. William Blake: The LittleBlack Boy; 4. Gieve Patel: Grandparents at a Family Get–together.

Unit 2
Short Stories
1. Chinua Achebe: Marriage is a Private Affair; 2. Ruskin Bond: The Thief; 3. Isai Tobolsky: Not Just Oranges; 4.K A Abbas: The Refugee

Unit 3
Prose
1. A G Gardiner: On The Philosophy of Hats; 2. Robert Lynd: Mispronunciation

Practicals:

Role plays: The Proposal, Chekov / Remember Ceaser, Gordon Daviot / Final Solutions, Mahesh Dattani, Bookreviews, Movie reviews.

SUGGESTED READING:
The Old Man and the Sea, Hemingway / Any one of the novels of R.K. Narayan, etc.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23ENG233	TECHNICAL COMMUNICATION	L-T-P-C: 2-0-0-2

OBJECTIVES:
To introduce the students to the elements of technical style; to introduce the basic elements of formal correspondence; to introduce technical paper writing skills and methods of documentation; to improve oral presentation skills in formal contexts.

Course Outcomes:
After the completion of the course the student will be able to:
CO1: Understand and use the basic elements of formal correspondence and methods of documentation
CO2: Learn to edit technical content for grammatical accuracy and appropriate tone and style
CO3: Use the library and internet recourses for research purposes
CO4: Demonstrate the ability to communicate effectively through group mock-technical presentations and other activities

CO-PO Mapping

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01										3						
CO02										3						
CO03				1												
CO04									3	3						

Syllabus:

Unit 1
Mechanics of writing: Grammar rules – punctuation - spelling rules - tone and style - graphical Representation.

Unit 2
Different kinds of written documents: Definitions – descriptions – instructions – recommendations - manuals -reports – proposals; Formal Correspondence: Letter Writing including job applications with Resume.

Unit 3
Technical paper writing: Library research skills - documentation style - document editing – proof reading –formatting.
Practice in oral communication and Technical presentations

REFERENCES:

1. *Hirsh, Herbert. L "Essential Communication Strategies for Scientists, Engineers and Technology Professionals". II Edition. New York: IEEE press, 2002*
2. *Anderson, Paul. V. "Technical Communication: A Reader-Centred Approach". V Edition. Harcourt Brace College Publication, 2003*
3. *Strunk, William Jr. and White. E B. "The Elements of Style" New York. Alliyan & Bacon, 1999.*
4. *Riordan, G. Daniel and Pauley E. Steven. "Technical Report Writing Today" VIII Edition (Indian Adaptation). New Delhi: Biztantra, 2004.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23ENG234	INDIAN SHORT STORIES IN ENGLISH	L-T-P-C: 2-0-0-2

OBJECTIVES:
To help the students learn the fine art of story writing; to help them learn the techniques of story telling; to help them study fiction relating it to the socio- cultural aspects of the age; to familiarize them with different strategies of reading short stories; to make them familiar with the morals and values held in high esteem by the ideals of Indianness.

Syllabus
Unit 1
Introduction: Differences between novel and short stories – origin and development of short stories – Rabindranath Tagore: Kabuliwallah; Mulk Raj Anand: The Gold Watch.

Unit 2
R. K. Narayan: Sweets for Angels; K. A. Abbas: The Refugee; Khushwant Singh: The Mark of Vishnu.

Unit 3
Masti Venkatesha Iyengar: The Curds-Seller; Manohar Malgonkar: Upper Division Love; Romila Thapar: The Spell; Premchand: The Voice of God.

TEXT:
M. G. Narasimha Murthy (ed), Famous Indian Stories. Hyderabad: Orient Black Swan, 2014

REFERENCE:
Mohan Ramanan (Ed), English and the Indian Short Story: Essays in Criticism, Hyderabad, Orient Black Swan,2000.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23FRE230	PROFICIENCY IN FRENCH LANGUAGE (LOWER)	L-T-P-C: 2-0-0-2

Syllabus

Unit 1

Population - Identity

How to introduce yourself (name, age, address, profession, nationality); Numbers; How to ask questions; Grammar – Pronouns - subjects; Regular verbs of 1st group (er) in the present; Être (to be) and avoir (to have) inthe present; Interrogative sentence; Gender of adjectives.

Unit 2

The suburbs - At the train station

Introduce someone; Buy a train ticket or a cinema ticket; Ask for information; Official time; Ask for a price; Thecity (church, town hall, post office…)

Grammar – Pronouns - subjects (continuation); Gender of adjectives (continuation); Plural of nouns and adjectives; Definite and indefinite articles; Interrogative adjectives; I would like (Je voudrais).

Unit 3

Paris and the districts - Looking for a room

Locate a room and indicate the way; Make an appointment; Give a price; Ordinal numbers; Usual time; Ask for thetime.

Grammar - Imperative mode; Contracted articles (au, du, des); negation.

TEXTBOOK:

Metro St Michel - Publisher: CLE international

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23FRE231	PROFICIENCY IN FRENCH LANGUAGE (HIGHER)	L-T-P-C: 2-0-0-2

Syllabus
Unit 1
The first room of a student
A party to celebrate the 1st room; Description of a room; furniture; Locate objects: prepositions (devant, derrière, dans…), Read advertisement; Appreciation (I like, I prefer,).

Grammar - Perfect past tense with avoir; Possessive adjectives (mon, ton, son…); Demonstrative adjectives (ce, cet, cette); Yes (oui, si).

Unit 2 Small jobs
Conversation on the phone; Give Time indications; Answer a job offer; Describe a job; Suggest a meeting time. Grammar - Perfect past tense with être and avoir (continuation); Possessive adjectives (notre, votre, leur); Prepositions (à, pour, avec …); Pronoun as direct object (le, la, l', les).

Unit 3
University Restaurant
Inquiry; Express an opinion; Ask questions (continuation); Food, meals, taste, preferences; Nutrition, diet, choose a menu or diet, Expression of quantities (beaucoup, peu).

Grammar - Partitif (expressing quantity) (du, de la, pas de….); Comparison (plus...que, moins….que, autant …que); Interrogation (continuation), inversion, Est-ce que, qu'est-ce que?.

TEXTBOOK:
Metro St Michel - Publisher: CLE International

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23GER230	GERMAN FOR BEGINNERS I	L-T-P-C: 2-0-0-2

Syllabus

Unit 1

Greetings; Introducing one-self (formal and informal context), saying their name, origin, living place, occupation. Numbers 1-100; Saying the telephone number. Countries and Languages.
Grammar: Structure – W - Questions and Yes/No questions and statements, personal pronouns, verb conjugations. Articles.
Vocabulary: Professions.

Unit 2

Giving the personal details. Name, age, marital status, year of birth, place of birth, etc. Numbers till 1000. Saying a year. Alphabets – spelling a word.
Filling up an application form; In the restaurant – making an order.
Grammar: Definite, indefinite and negative article in nominative. Accusative: indefinite and negative Article Vocabulary: Food items

Unit 3

Numbers above 1000. Orientation in Shopping plazas: asking the price, where do I find what, saying the opinion. Grammar: Accusative – definite article. Adjectives and plural forms. Vocabulary: Furniture and currencies.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23GER231	GERMAN FOR BEGINNERS II	L-T-P-C: 2-0-0-2

Syllabus

Unit 1
Shopping and orientation in supermarket; Conversation between the customer and salesman; Where one finds what in supermarket; Asking for requests and suggestions.

Grammar: Dative of personal pronouns. Imperative form. Vocabulary: Consumables and measurements;

Unit 2
Appointments; Work and leisure time activities; Time, weekdays, months and seasons; saying the date; fixing upan appointment.

Grammar: Model verbs; Prepositions with time and place; Ordinal numbers. Vocabulary: Leisure activities, weekdays, months and seasons.

Unit 3
Family and household; Family and relations; household and daily routine. Grammar: Possessive articles; Divisibleand indivisible verbs.
Vocabulary: Family circle; Household articles.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23GER232	PROFICIENCY IN GERMANLANGUAGE (LOWER)	L-T-P-C: 2-0-0-2

Syllabus

To have an elementary exposure to German language; specifically

1. to have some ability to understand simple spoken German, and to be able to speak it so as to be able to carry on life in Germany without much difficulty (to be able to do shopping, etc.);
2. to be able to understand simple texts, and simple forms of written communication;
3. to have a basic knowledge of German grammar;
4. to acquire a basic vocabulary of 500 words;
5. to be able to translate simple letters with the use of a dictionary; and
6. to have some familiarity with the German life and culture.

(This will not be covered as part of the regular classroom teaching; this is to be acquired by self-study.) Some useful websites will be given.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23GER233	PROFICIENCY IN GERMAN LANGUAGE (HIGHER)	L-T-P-C: 2-0-0-2

Syllabus

The basic vocabulary and grammar learned in the earlier course is mostly still passive knowledge. The endeavourof this course is to activate this knowledge and develop the skill of communication.

Topics are: Airport, railway station, travelling; shopping; invitations, meals, meeting people; around the house; the human body; colours; professions.

Past and future tenses will be introduced. Applying genitive, dative and accusative. Some German culture. Films.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23HIN230	HINDI I	L-T-P-C: 2-0-0-2

OBJECTIVES:
To teach Hindi for effective communication in different spheres of life - Social context, Education, governance,Media, Business, Profession and Mass communication.

Course Outcomes:
After the completion of the course the student will be able to:
CO1: Gain knowledge about the nature and culture of Hindi language
CO2: Understand the structural aspects of Hindi language
CO3: Apply the knowledge of the grammatical structures to communicate in Hindi
CO4: Analyse the social significance of modern literature.
CO5: Develop the ability to translate a given text to Hindi

CO-PO Mapping:

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01									2	3						
CO02									2	3						
CO03									2	3						
CO04										3						
CO05									2							

Syllabus
Unit 1
Introduction to Hindi Language, National Language, Official Language, link Language etc. Introduction to Hindilanguage, Devanagari script and Hindi alphabet.

Shabda Bhed, Roopanthar ki Drishti se- Bhasha – Paribhasha aur Bhed – Sangya - Paribhasha Aur Bhed - Sangyake Roopanthar - kriya.

Unit 2
Common errors and error corrections in Parts of Speech with emphasis on use of pronouns, Adjective and verb indifferent tenses – Special usage of adverbs, changing voice and conjunctions in sentences, gender& number - General vocabulary for conversations in given context –understanding proper pronunciation - Conversations, Interviews, Short speeches.

Unit 3
Poems – Kabir 1st 8 Dohas, Surdas 1st 1 Pada; Tulsidas 1st 1 Pada; Meera 1st 1 Pada

Unit 4
Letter writing – personal and Formal – Translation from English to Hindi.

Unit 5
Kahani – Premchand: Kafan, Abhilasha, Vidroh, Poos ki rath, Juloos.

BOOKS:
1. *Prem Chand Ki Srvashrestha Kahaniyam: Prem Chand; Diamond Pub Ltd. New Delhi*
2. *Vyavaharik Hindi Vyakaran ,Anuvad thaha Rachana : Dr. H. Parameswaran, Radhakrishna publishing House, New Delhi*
3. *Kamtha Prasad Guru : Hindi Vyakaran, Best Book pub House, New Delhi*
4. *Poetry : Kavya Ras - Ed: T.V. Basker - Pachouri Press; Mathura*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23HIN231	HINDI II	L-T-P-C: 2-0-0-2

OBJECTIVES:
Appreciation and assimilation of Hindi Literature both drisya & shravya using the best specimens provided asanthology.

Course Outcomes:
After the completion of the course the student will be able to:
CO1: Understand the grammatical structures of Hindi
CO2: Understand the post modern trends of literature
CO3: Enhance critical thinking and writing skills
CO4: Identify and analyse different literary and audio-visual material
CO5: Apply fundamental knowledge of Hindi in formal and informal writing

CO-PO Mapping:

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01									1	2						
CO02									1	2						
CO03									1	2						
CO04										3						
CO05									1	2						

Syllabus:

Unit 1
Kavya Tarang; Dhumil ke Anthim Kavitha [Poet-Dhumil]; Dhabba [Poet-Kedarnath Singh]; Proxy [Poet-Venugopal]; Vakth [Poet-Arun Kamal]; Maachis [Poet-Suneeta Jain].

Unit 2
Communicative Hindi - Moukhik Abhivyakthi

Unit 3
Audio-Visual Media in Hindi – Movies like Tare Zameen par, Paa, Black etc., appreciation and evaluation. Newsreading and presentations in Radio and TV channels in Hindi.

Unit 4
Gadya Manjusha – Budhapa, Kheesa, Sadachar ka Thavis

Unit 5
Translation: Theory and Practice - Letter writing: Formal and Personal – Introduction to Hindi Software.

BOOKS:
1. *Kavay Tarang: Dr. Niranjan, Jawahar Pusthakalay, Mathura.*
2. *Gadya Manjusha: Editor: Govind, Jawahar Pusthakalay, Mathura*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23HUM230	EMOTIONAL INTELLIGENCE	L-T-P-C: 2-0-0-2

Syllabus

Unit 1
Emotional Intelligence: Concept of Emotional Intelligence, Understanding the history and origin of Emotional Intelligence, Contributors to Emotional Intelligence, Science of Emotional Intelligence, EQ and IQ, Scope of Emotional Intelligence.

Unit 2
Components of Emotional Intelligence: Self-awareness, Self-regulation, Motivation, Empathy, Social skills. Emotional Intelligence Competencies, Elements of Emotional Intelligence, Models of Emotional Intelligence: The Ability-based Model, The Trait Model of Emotional Intelligence, Mixed Models of Emotional Intelligence.

Unit 3
Emotional Intelligence at Work place: Importance of Emotional Intelligence at Work place? Cost–savings of Emotional Intelligence, Emotionally Intelligent Leaders, Case Studies Measuring Emotional Intelligence: Emotionally Intelligence Tests, Research on Emotional Intelligence, Developing Emotional Intelligence.

REFERENCES:

1. *Daniel Goleman (1996). Emotional Intelligence- Why it can Matter More than IQ. Bantam Doubleday Dell Publishing Group*
2. *Daniel Goleman (2000). Working with Emotional Intelligence. Bantam Doubleday Dell Publishing Group*
3. *Liz Wilson, Stephen Neale & Lisa Spencer-Arnell (2012). Emotional Intelligence Coaching. Kogan Page India Private Limited*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23HUM231	GLIMPSES INTO THE INDIAN MIND - THE GROWTH OF MODERN INDIA	L-T-P-C: 2-0-0-2

Syllabus
Unit 1 Introduction
General Introduction; 'His + Story' or 'History' ?; The concepts of 'nation', 'national identity' and 'nationalism'; Texts and Textualities: Comparative Perspectives.

Unit 2
Selected writings / selections from the complete works of the following authors will be taken up for study in achronological order:
Raja Ram Mohan Roy; Dayananda Saraswati; Bal Gangadhar Tilak; Rabindranath Tagore;

Unit 3
Selected writings / selections from the complete works of the following authors will be taken up for study in achronological order:
Swami Vivekananda; Sri Aurobindo; Ananda K. Coomaraswamy; Sister Nivedita; Mahatma Gandhi; Jawaharlal Nehru; B.R. Ambedkar; Sri Chandrasekharendra Saraswati, the Paramacharya of Kanchi; Dharampal; Raja Rao;
V.S. Naipaul.

Conclusion.

REFERENCES:

1. *Tilak, Bal Gangadhar. The Orion / Arctic Home in the Vedas.*
2. *Tagore, Rabindranath. The History of Bharatavarsha / On Nationalism / Greater India.*
3. *Vivekananda, Swami. "Address at the Parliament of Religions"/"The Future of India"/"In Defence of Hinduism" from Selections from the Complete Works of Swami Vivekananda.*
4. *Aurobindo, Sri. The Renaissance in India / On Nationalism.*
5. *Coomaraswamy, Ananda K. Essays in Indian Idealism (any one essay) / Dance of Shiva.*
6. *Nivedita, Sister. "Noblesse Oblige: A Study of Indian Caste" / "The Eastern Mother" from The Web of Indian Life.*
7. *Gandhi, Mahatma. Hind Swaraj.*
8. *Nehru, Jawaharlal. "The Quest" from Discovery of India.*
9. *Ambedkar, B. R. "Buddha and His Dhamma" from Collected Works.*
10. *Saraswati, Chandrasekharendra. "The Sastras and Modern Life" from The Hindu Dharma.*
11. *Dharampal. Bharatiya Chitta, Manas and Kala / Understanding Gandhi.*
12. *Naipaul, V. S. India: A Wounded Civilization / India: A Million Mutinies Now.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23HUM232	GLIMPSES OF ETERNAL INDIA	L-T-P-C: 2-0-0-2

Syllabus

Unit 1

Introduction

A peep into India's glorious past

Ancient India – the vedas, the vedic society and the Sanatana Dharma – rajamandala and the Cakravartins – Ramarajya – Yudhisthira's ramarajya; Sarasvati - Sindhu Civilization and the myth of the Aryan Invasion; Classical India – Dharma as the bedrock of Indian society – Vaidika Brahmanya Dharma and the rise of Jainism and Buddhism – the sixteen Mahajanapadas and the beginning of Magadhan paramountcy - Kautilya and his Arthasastra – Chandragupta Maurya and the rise of the Mauryan empire – Gupta dynasty Indian art and architecture – classicalsanskrit literature – Harsavardhana; Trade and commerce in classical and medieval India and the story of Indiansupremacy in the Indian ocean region; The coming of Islam – dismantling of the traditional Indian polity – the Mughal empire – Vijayanagara samrajya and days of Maratha supremacy.

Unit 2

India's contribution to the world: spirituality, philosophy and sciences

Indian Philosophy – the orthodox (Vaidika) and the heterodox (atheistic) schools; Ramayana and Mahabharata; Bhagavad Gita; Saints and sages of India; Ancient Indian medicine: towards an unbiased perspective; Ancient Indian mathematics; Ancient Indian astronomy; Ancient Indian science and technology.

The arrival of Europeans, British paramountcy and colonization

What attracted the rest of the world to India?; India on the eve of the arrival of European merchants; The story of colonization and the havoc it wrecked on Indian culture and civilization; Macaulay and the start of the distortion ofIndian education and history; Indian economy – before and after colonization: a brief survey; The emergence ofmodern India.

Unit 3

Women in Indian society

The role and position of women in Hindu civilization; Gleanings from the Vedas, Brihadarnyaka Upanishad, Saptasati Devi Mahatmyam, Ramayana, Mahabharata, Manusmriti, Kautilya's Arthasastra and Mrichchhakatikamof Sudraka; The role and position of Indian women vis-a-vis Islam and European cultures; The great women of India.

Modern India

The national movement for freedom and social emancipation; Swami Vivekananda, Sri Aurobindo, RabindranathTagore; Understanding Mahatma Gandhi; A new nation is born as a republic – the pangs of birth and growth; India since Independence – the saga of socio-political movements; Problems facing the nation today; Globalization and Indian Economy; Bharatavarsha today and the way ahead: Regeneration of Indian National Resources.

Conclusion

The Wonder that was India; The 'politics' and 'purpose' of studying India.

REFERENCES:

1. *Parameswaran, S. The Golden Age of Indian Mathematics. Kochi: Swadeshi Science Movement.*
2. *Somayaji, D. A. A Critical Study of Ancient Hindu Astronomy. Dharwar: 1972.*
3. *Sen, S. N. & K. V. Sarma eds. A History of Indian Astronomy. New Delhi, 1985.*
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13. *Tagore, Rabindranath. The History of Bharatavarsha / On Nationalism / Greater India.*
14. *Majumdar, R. C. et. al. An Advanced History of India. Macmillan.*
15. *Mahajan, V. D. India Since 1526. New Delhi: S. Chand & Company.*
16. *Durant, Will. The Case for India. Bangalore: Strand Book Stall, 2008.*
17. *Aurobindo, Sri. The Indian Renaissance / India's Rebirth / On Nationalism.*
18. *Nivedita, Sister. The Web of Indian Life. Kolkata: Advaita Ashrama.*
19. *Durant, Will. The Story of Civilization. Volume 1 – Our Oriental Heritage. New York: Simon & Schuster.*
20. *Ranganathananda, Swami. Eternal Values for A Changing Society. Bombay: Bharatiya Vidya Bhavan.*
21. *Ranganathananda, Swami. Universal Message of the Bhagavad Gita. Kolkata: Advaita Ashrama.*
22. *Seturaman, V. S. Indian Aesthetics. Macmillan.*
23. *Coomaraswamy, Ananda K. The Dance of Shiva. New Delhi: Sagar Publications.*
24. *Coomaraswamy, Ananda K. Essays on Indian Idealism. New Delhi: Munshiram Manoharlal.*
25. *Danino, Michel. The Invasion That Never Was.*
26. *Kautilya. Arthasastra.*
27. *Altekar, A. S. State and Government in Ancient India. New Delhi: Motilal Banarsidass.*
28. *Altekar, A. S. The Position of Women in Hindu Civilization. New Delhi: Motilal Banarsidass.*
29. *Sircar, D. C. Studies in the Religious Life of Ancient and Medieval India. New Delhi: Motilal Banarsidass.*
30. *Sircar, D. C. Studies in the Political and Administrative Systems in Ancient and Medieval Times.New Delhi: Motilal Banarsidass.*
31. *Madhavananda, Swami & R. C. Majumdar eds. The Great Women of India. Kolkata: Advaita Ashrama.*
32. *Dutt, R. C. The Economic History of India. London, 1902.*
33. *Dharampal. Collected Works.*
34. *Dharampal. Archival Compilations (unpublished)*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23HUM233	GLIMPSES OF INDIAN ECONOMY AND POLITY	L-T-P-C: 2-0-0-2

Syllabus
Unit 1
Introduction
General Introduction; Primitive man and his modes of exchange – barter system; Prehistoric and proto-historic polity and social organization.
Ancient India – up to 600 B.C.
Early India – the vedic society – the varnashramadharma – socio-political structure of the various institutions based on the four purusarthas; The structure of ancient Indian polity – Rajamandala and Cakravartins – Prajamandala; Socio-economic elements from the two great Epics – Ramayana and Mahabharata – the concept of the ideal King (Sri Rama) and the ideal state (Ramarajya) – Yudhisthira's ramarajya; Sarasvati - Sindhu civilization and India's trade links with other ancient civilizations; Towards chiefdoms and kingdoms – transformation of the polity: kingship – from gopati to bhupati; The mahajanapadas and the emergence of the srenis – states and cities of the Indo-Gangetic plain.

Unit 2
Classical India: 600B.C. – 1200 A.D.
The rise of Magadha, emergence of new religions – Buddhism and Jainism – and the resultant socio-economic impact; The emergence of the empire – the Mauryan Economy and Kautilya's Arthasastra; of Politics and trade –the rise of the Mercantile Community; Elements from the age of the Kushanas and the Great Guptas; India's maritime trade; Dharma at the bedrock of Indian polity – the concept of Digvijaya: dharma-vijaya, lobha-vijaya and asura-vijaya; Glimpses into the south Indian economies: political economies of the peninsula – Chalukyas, Rashtrakutas and Cholas

Medieval India: 1200 A.D. – 1720 A.D.
Advent of Islam – changes in the social institutions; Medieval India – agrarian economy, non-agricultural production and urban economy, currency system; Vijayanagara samrajya and maritime trade – the story of Indian supremacy in the Indian Ocean region; Aspects of Mughal administration and economy; The Maratha and other provincial economies.

Unit 3
Modern India: 1720 - 1947
the Indian market and economy before the arrival of the European traders; Colonisation and British supremacy (dismantling of everything that was 'traditional' or 'Indian') – British attitude towards Indian trade, commerce and economy and the resultant ruining of Indian economy and business – man-made famines – the signs of renaissance: banking and other business undertakings by the natives (the members of the early Tagore family, the merchants of Surat and Porbander, businessmen of Bombay, etc. may be referred to here) – the evolution of the modern banking system; Glimpses into British administration of India and administrative models; The National movement and nationalist undertakings in business and industry: the Tatas and the Birlas; Modern India: the growth of large- scale industry – irrigation and railways – money and credit – foreign trade; Towards partition – birth of two new nations
– division of property; The writing of the Indian Constitution – India becomes a democratic republic – a new polity is in place.

Independent India – from 1947
India since Independence – the saga of socio-political movements; Indian economy since Independence – the fiscal system – the five year plans – liberalisation – the GATT and after; Globalisation and Indian economy; Impact of science and (new/ emerging) technology on Indian economy; Histories of select Indian business houses and business entrepreneurship.
Conclusion

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1. *The Cultural Heritage of India. Kolkata: Ramakrishna Mission Institute of Culture.Kautilya. Arthasastra.*
2. *Altekar, A. S. State and Government in Ancient India. New Delhi: Motilal Banarsidass.*
3. *Sircar, D. C. Studies in the Political and Administrative Systems in Ancient and Medieval Times. New Delhi: Motilal Banarsidass.*
4. *Dutt, R. C. The Economic History of India. London, 1902.*
5. *Dharampal. Collected Works (Volumes IV & V).*
6. *Dharampal. Archival Compilations (unpublished).*
7. *Bajaj, Jitendra & M. D. Srinivas. Indian Economy and Polity. Chennai: Centre for Policy Studies.*
8. *Bajaj, Jitendra & M. D. Srinivas. Timeless India, Resurgent India. Chennai: Centre for Policy Studies.*
9. *Joshi, Murli Manohar. Science, Sustainability and Indian National Resurgence. Chennai: Centre for Policy Studies, 2008.*
10. *Tripathi, Dwijendra. The Oxford History of Indian Business. New Delhi: Oxford University Press, 2004.*
11. *McGuire, John, et al, eds. Evolution of World Economy, Precious Metals and India. New Delhi: Oxford University Press, 2001.*
12. *Tripathi, Dwijendra and Jyoti Jumani. The Concise Oxford History of Indian Business. New Delhi: Oxford University Press, 2007.*
13. *Kudaisya, Medha M. The Life and Times of G. D. Birla. New Delhi: Oxford University Press, 2003.*
14. *Raychaudhuri, Tapan and Irfan Haib, eds. The Cambridge Economic History of India. Volume*
15. *New Delhi: Orient Longman, 2004.*
16. *Kumar, Dharma, ed. The Cambridge Economic History of India. Volume 2. New Delhi: Orient Longman, 2005.*
17. *Sabavala, S. A. and R. M. Lala, eds. J. R. D. Tata: Keynote. New Delhi: Rupa & Co., 2004.*
18. *Mambro, Arvind ed. J. R. D. Tata: Letters. New Delhi: Rupa & Co., 2004.*
19. *Lala, R. M., For the Love of India: The Life and Times of Jamsetji Tata. New Delhi: Penguin, 2006.*
20. *Thapar, Romila. The Penguin History of Early India: From the Origins to AD 1300. New Delhi Penguin, 2002.*
21. *Majumdar, R. C., et. al. An Advanced History of India. Macmillan.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23HUM234	HEALTH AND LIFESTYLE	L-T-P-C: 2-0-0-2

Syllabus
Unit 1
Introduction to Health
Health is wealth; Role of lifestyle habits on health; Importance of adolescence; Stages, Characteristics and changes during adolescence; Nutritional needs during adolescence why healthy lifestyle is important for adolescence. Eating Habits - eating disorders, skipping breakfast, junk food consumption.

Practicals - Therapeutic Diets

Unit 2
Food and Nutritional Requirements during Adolescence
Fluid intake; nutrition related problems; lifestyle related problems, Role of physical activity; resting pattern andpostures, Personal habits – alcoholism, and other tobacco products, electronic addiction etc

Practicals - Ethnic Foods

Unit 3
Need for a Positive Life Style Change
Peer pressure & procrastination, Stress, depression, suicidal tendency, Mini project review and viva, Whole portions revision.

Practical - Cooking without Fire or Wire-healthy Snacks

TEXTBOOKS:
1. *B. Srilakshmi, "Dietetics", New age international (P) ltd, publishers, 2010.*
2. *"Nutrient requirement and Recommended Dietary Allowances for Indians", published by Indian Council of Medical Research, ICMR, 2010.*

REFERENCE BOOKS:
1. *K Park "Textbook of preventive and social medicine", 2010.*
2. *WHO Report on Adolescent Health: 2010*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23HUM235	INDIAN CLASSICS FOR THE TWENTY-FIRST CENTURY	L-T-P-C: 2-0-0-2

Syllabus

Unit 1
Introductory study of the Bhagavad Gita and the Upanishads.

Unit 2
The relevance of these classics in a modern age.

Unit 3
Goals of human life - existential problems and their solutions in the light of these classics etc.

REFERENCE:
The Bhagavad Gita, Commentary by Swami Chinmayananda

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23HUM236	INTRODUCTION TO INDIA STUDIES	L-T-P-C: 2-0-0-2

PREAMBLE:

This paper will introduce the students to the multiple dimensions of the contribution of India to the fields of philosophy, art, literature, physical and social sciences. The paper intends to give an insight to the students aboutthe far-reaching contributions of India to world culture and thought during the course of its long journey from thehoary antiquity to the present times. Every nation takes pride in its achievements and it is this sense of pride andreverence towards the achievements that lays the foundation for its all-round progress.

Syllabus

Unit 1

A brief outline of Indian history from prehistoric times to the present times. Contributions of India to world culture and civilization: Indian Philosophy and Religion; Art and Literature; Physical and Social Sciences.

Unit 2

Modern India: Challenges and Possibilities. Scientific and technological progress in post-independence era; Socio-cultural and political movements after independence; Challenges before the nation today - unemployment – corruption – degradation of cultural and moral values - creation of a new system of education; Creation of a modern and vibrant society rooted in traditional values.

Unit 3

Modern Indian Writing in English: Trends in Contemporary Indian Literature in English.

TEXTBOOK:

Material given by the Faculty

BACKGROUND LITERATURE:

1. *Selections from The Cultural Heritage of India, 6 volumes, Ramakrishna Mission Institute of Culture (Kolkata) publication.*
2. *Selections from the Complete Works of Swami Vivekananda, Advaita Ashrama publication.*
3. *Invitations to Indian Philosophy, T. M. P. Mahadevan, University of Madras, Chennai.*
4. *Outlines of Indian Philosophy, M. Hiriyanna, MLBD.*
5. *An Advanced History of India, R. C. Majumdar et al, Macmillan.*
6. *India Since 1526, V. D. Mahajan, S. Chand & Company*
7. *The Indian Renaissance, Sri Aurobindo.*
8. *India's Rebirth, Sri Aurobindo.*
9. *On Nationalism, Sri Aurobindo.*
10. *The Story of Civilization, Volume I: Our Oriental Heritage, Will Durant, Simonand Schuster, New York.*
11. *Eternal Values for a Changing Society, Swami Ranganathananda, Bharatiya Vidya Bhavan.*
12. *Universal Message of the Bhagavad Gita, Swami Ranganathananda, Advaita Ashrama.*
13. *Awaken Children: Conversations with Mata Amritanandamayi*
14. *Indian Aesthetics, V. S. Seturaman, Macmillan.*
15. *Indian Philosophy of Beauty, T. P. Ramachandran, University of Madras, Chennai.*
16. *Web of Indian Thought, Sister Nivedita*
17. *Essays on Indian Nationalism, Anand Kumaraswamy*
18. *Comparative Aesthetics, Volume 2, Kanti Chandra Pandey, Chowkhamba, Varanasi*
19. *The Invasion That Never Was, Michel Danino*
20. *Samskara, U. R. Ananthamurthy, OUP.*
21. *Hayavadana, Girish Karnard, OUP.*
22. *Naga-Mandala, Girish Karnard, OUP.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23HUM237 INTRODUCTION TO SANSKRIT LANGUAGE AND LITERATURE L-T-P-C: 2-0-0-2

OBJECTIVES:
To familiarize students with Sanskrit language; to introduce students to various knowledge traditions in Sanskrit; to help students appreciate and imbibe India's ancient culture and values.

Syllabus
Unit 1
Sanskrit Language – Vakya Vyavahara (प्रथमादीक्षा) - Introduction to Sanskrit language - Devanagari script and Sanskrit alphabet - Vowels and Consonants – Pronunciation - Classification of Consonants – Samyukthakshara Words – Nouns and Verbs - Cases – Introduction to Numbers and Time – Verbs: Singular, Dual and Plural – SarvaNamas: First Person, Second Person, Third Person – Tenses: Past, Present and Future -Words for Communication – Selected Slokas – MoralStories – Subhashithas – Riddles.

Unit 2
Language Studies - Role of Sanskrit in Indian & World Languages.

Unit 3
Introduction to Sanskrit Classical Literature – KavyaTradition – Drama Tradition - Stotra Tradition – Panchatantra Stories.

Unit 4
Introduction to Sanskrit Technical Literature – Astronomy – Physics – Chemistry – Botany – Engineering – Aeronautics – Ayurveda – Mathematics – Medicine – Architecture - Tradition of Indian Art – Administration – Agriculture.

Unit 5
Indology Studies – Perspectives and Innovations.

TEXTBOOKS AND REFERENCE BOOKS:
1. *Vakya Vyavahara- Prof. Vempaty Kutumba Sastri, Rashtriya Sanskrit Sansthan, New Delhi*
2. *The Wonder that is Sanskrit - Dr.Sampadananda Mishra, New Delhi*
3. *Science in Sanskrit – Samskritha Bharathi, NewDelhi*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23HUM238	NATIONAL SERVICE SCHEME	L-T-P-C: 2-0-0-2

Syllabus

Unit 1
Introduction to Basic Concepts of NSS: History, philosophy, aims and objectives of NSS, Emblem, flag, motto, song, badge etc., Organisational structure, roles and responsibilities of various NSS functionaries.
NSS Programmes and Activities: Concept of regular activities, special campaigning, Day Camps, Basis of adoption of village / slums, methodology of conducting survey, financial pattern of the scheme, other youth programme/schemes of GOI, Coordination with different agencies, Maintenance of the Diary.

Unit 2
Volunteerism and Shramdan: Indian Tradition of volunteerism, Needs and importance of volunteerism, Motivation and Constraints of volunteerism, Shramdan as part of volunteerism, Amalabharatam Campaign, Swatch Bharath.

Unit 3
Understanding youth: Definition, profile and categories of youth, Issues, challenges and opportunities for youth, Youth as an agent of social change.
Youth and Yoga: History, philosophy and concept of Yoga, Myths and misconceptions about Yoga, Different Yoga traditions and their impacts, Yoga as a preventive and curative method, Yoga as a tool for healthy life style

Unit 4
Youth Development Programmes in India: National Youth Policy, Youth development programmes at the national level, state level and voluntary sector, youth-focused and youth-led organizations.
Youth and Crime: Sociological and psychological factors influencing youth crime, Peer mentoring in preventing crimes, Awareness about Anti-Ragging, Cyber Crime and its prevention, Juvenile Justice.

Unit 5
Environmental Issues: Environment conservation, enrichment and sustainability, climate change, waste management, rain water harvesting, energy conservation, waste land development.

Project Work / Practical

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23HUM239	PSYCHOLOGY FOR EFFECTIVE LIVING	L-T-P-C: 2-0-0-2

Course Objectives

- To help students acquire the basic knowledge of behavior and effective living
- To create an awareness of the hazards of health compromising behaviours
- To develop and strengthen the tools required to handle the adversities of life

Course Outcome

CO1: Understand the basic concepts of Behavioral Psychology
CO2: Demonstrate self reflective skills through activities
CO3: Apply the knowledge of psychology to relieve stress
CO4: Analyse the adverse effects of health compromising behaviours.
CO5: Evaluate and use guided techniques to overcome and cope with stress related problems.

CO-PO Mapping

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01						1						1				
CO02						2	3		3	3						
CO03						3	3	2	1		3	2				
CO04						2	2	3				1				
CO05						1	2				1	1				

Syllabus

Unit 1

Self-Awareness & Self-Motivation

Self analysis through SWOT, Johari Window, Maslow's hierarchy of motivation, importance of self esteem andenhancement of self esteem.

Unit 2

The Nature and Coping of Stress

Conflict, Relationship issues, PTSD. Stress – stressors – eustress - distress, coping with stress, stress managementtechniques.

Unit 3

Application of Health Psychology

Health compromising behaviours, substance abuse and addiction.

TEXTBOOKS:

1. *V. D. Swaminathan & K. V. Kaliappan "Psychology for effective living - An introduction to Health*
2. *Psychology. 2nd edition Robert J. Gatchel, Andrew Baum & David S. Krantz, McGraw Hill.*

REFERENCE BOOKS:

1. *S. Sunder, 'Textbook of Rehabilitation', 2nd edition, Jaypee Brothers, New Delhi. 2002.*
2. *Weiben & Lloyd, 'Psychology applied to Modern Life', Thompson Learning, Asia Ltd.2004.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23HUM240	PSYCHOLOGY FOR ENGINEERS	L-T-P-C: 2-0-0-2

Course Objectives:

- To strengthen the fundamental knowledge of human behavior
- To strengthen the ability to understand the basic nature and behavior of humans in organizations as a whole
- To connect the concepts of psychology to personal and professional life

Course Outcome

CO1: Understand the fundamental processes underlying human behavior such as learning, motivation, individual differences, intelligence and personality.
CO2: Apply the principles of psychology in day- to- day life for a better understanding of oneself and others.
CO3: Apply the knowledge of Psychology to improve study skills and learning methods
CO4: Apply the concepts of defense mechanisms to safeguard against abusive relationships and to nurture healthy relationships.

CO-PO Mapping

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01						3	3		3	2		1				
CO02						3	3	2	3	3	1	2				
CO03										2	1					
CO04							3		2	2		2				

Syllabus

Unit 1

Psychology of Adolescents: Adolescence and its characteristics.

Unit 2

Learning, Memory & Study Skills: Definitions, types, principles of reinforcement, techniques for improving study skills, Mnemonics.

Unit 3

Attention & Perception: Definition, types of attention, perception.

TEXTBOOKS:

1. *S. K. Mangal, "General Psychology", Sterling Publishers Pvt. Ltd.2007*
2. *Baron A. Robert,"Psychology", Prentice Hall of India. New Delhi 2001*

REFERENCE BOOKS:

1. *Elizabeth B. Hurlock, Developmental Psychology - A life span approach, 6th edition.*
2. *Feldman, Understanding Psychology, McGraw Hill, 2000.*
3. *Clifford Morgan, Richard King, John Scholper,"Introduction to Psychology", Tata Mcgraw Hill, PvtLtd 2004.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23HUM241	SCIENCE AND SOCIETY - AN INDIAN PERSPECTIVE	L-T-P-C: 2-0-0-2

Syllabus

Unit 1
Introduction
Western and Indian views of science and technology
Introduction; Francis Bacon: the first philosopher of modern science; The Indian tradition in science and technology: an overview.

Unit 2
Indian sciences
Introduction; Ancient Indian medicine: towards an unbiased perspective; Indian approach to logic; The methodology of Indian mathematics; Revision of the traditional Indian planetary model by Nilakantha Somasutvan in circa 1500 AD

Science and technology under the British rule
Introduction; Indian agriculture before modernization; The story of modern forestry in India; The building of New Delhi

Unit 3
Science and technology in Independent India
Introduction; An assessment of traditional and modern energy resources; Green revolution: a historical perspective; Impact of modernisation on milk and oilseeds economy; Planning without the spirit and the determination.

Building upon the Indian tradition
Introduction; Regeneration of Indian national resources; Annamahatmyam and Annam Bahu Kurvita: recollecting the classical Indian discipline of growing and sharing food in plenty and regeneration of Indian agriculture to ensure food for all in plenty.

Conclusion

REFERENCES:

1. *Joseph, George Gheverghese. The Crest of the Peacock: Non-European Roots of Mathematics. London: Penguin (UK), 2003.*
2. *Iyengar, C. N. Srinivasa. History of Hindu Mathematics. Lahore: 1935, 1938 (2 Parts).*
3. *Amma, T. A. Saraswati. Geometry in Ancient and Medieval India. Varanasi: Motilal Banarsidass, 1979.*
4. *Bag, A. K. Mathematics in Ancient and Medieval India. Varanasi: Motilal Banarsidass, 1979.*
5. *Sarma K. V. & B. V. Subbarayappa. Indian Astronomy: A Source-Book. Bombay: Nehru Centre, 1985.*
6. *Sriram, M. S. et. al. eds. 500 Years of Tantrasangraha: A Landmark in the History of Astronomy. Shimla: Indian Institute of Advanced Study, 2002.*
7. *Bajaj, Jitendra & M. D. Srinivas. Restoring the Abundance: Regeneration of Indian Agriculture toEnsure Food for All in Plenty.Shimla: Indian Institute of Advanced Study, 2001.*
8. *Bajaj, Jitendra ed. Report of the Seminar on Food for All: The Classical Indian Discipline of Growingand Sharing Food in Plenty. Chennai: Centre for Policy Studies, 2001.*
9. *Bajaj, Jitendra & M. D. Srinivas. Annam Bahu Kurvita: Recollecting the Indian Discipline of Growing and Sharing Food in Plenty. Madras: Centre for Policy Studies, 1996.*
10. *Parameswaran, S. The Golden Age of Indian Mathematics. Kochi: Swadeshi Science Movement.*
11. *Somayaji, D. A. A Critical Study of Ancient Hindu Astronomy. Dharwar: 1972.*
12. *Sen, S. N. & K. V. Sarma eds. A History of Indian Astronomy. New Delhi, 1985.*
13. *Rao, S. Balachandra. Indian Astronomy: An Introduction. Hyderabad: Universities Press, 2000.*
14. *Bose, D. M. et. al. A Concise History of Science in India. New Delhi: 1971.*
15. *Bajaj, Jitendra & M. D. Srinivas. Indian Economy and Polity. Chennai: Centre for Policy Studies.*
16. *Bajaj, Jitendra & M. D. Srinivas. Timeless India, Resurgent India. Chennai: Centre for Policy Studies.*

17. *Joshi, Murli Manohar. Science, Sustainability and Indian National Resurgence. Chennai: Centre for Policy Studies, 2008.*
18. *The Cultural Heritage of India. Kolkata: Ramakrishna Mission Institute of Culture.*

** The syllabus and the study material in use herein has been developed out of a 'summer programme' offered by the Centre for Policy Studies (CPS), Chennai at the Indian Institute of Advanced Study (IIAS), Rashtrapati Nivas,Shimla, sometime ago. The same has been very kindly made available to us by Professors Dr M.D. Srinivas (Chairman) and Dr J.K. Bajaj (Director) of the CPS.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23HUM242	THE MESSAGE OF BHAGWAD GITA	L-T-P-C: 2-0-0-2

Syllabus

Unit 1
Introduction: Relevance of Bhagavad Gita today – Background of Mahabharatha. ArjunaVishada Yoga: Arjuna's Anguish and Confusion – Symbolism of Arjuna's Chariot.
Sankhya Yoga: Importance of Self-knowledge – Deathlessness: Indestructibility of Consciousness – Being Established in Wisdom – Qualities of a Sthita-prajna.

Unit 2
Karma Yoga: Yoga of Action – Living in the Present – Dedicated Action without Anxiety over Results - Conceptof Swadharma.

Dhyana Yoga: Tuning the Mind – Quantity, Quality and Direction of Thoughts – Reaching Inner Silence.

Unit 3
Bhakti Yoga: Yoga of Devotion – Form and Formless Aspects of the Divine – Inner Qualities of a True Devotee.

GunatrayaVibhaga Yoga: Dynamics of the Three Gunas: Tamas, Rajas, Sattva – Going Beyond the Three Gunas –Description of a Gunatheetha.

TEXTBOOKS / REFERENCES:
1. *Swami Chinmayananda, "The Holy Geeta", Central Chinmaya Mission Trust, 2002.*
2. *Swami Chinmayananda, "A Manual of Self Unfoldment", Central Chinmaya Mission Trust, 2001.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23HUM243	THE MESSAGE OF THE UPANISHADS	L-T-P-C: 2-0-0-2

OBJECTIVES:
To give students an introduction to the basic ideas contained in the Upanishads; and explores how their messagecan be applied in daily life for achieving excellence.

Syllabus
Unit 1
An Introduction to the Principal Upanishads and the Bhagavad Gita - Inquiry into the mystery of nature - Sruti versus Smrti - Sanatana Dharma: its uniqueness - The Upanishads and Indian Culture - Upanishads and ModernScience.

Unit 2
The challenge of human experience & problems discussed in the Upanishads – the True nature of Man – the Moving power of the Spirit – The Message of Fearlessness – Universal Man - The central problems of the Upanishads – Ultimate reality – the nature of Atman - the different manifestations of consciousness.

Unit 3
Upanishad Personalities - episodes from their lives and essential teachings: Yajnavalkya, Aruni, Uddalaka, Pippalada, Satyakama Jabala, Svetaketu, Nachiketas, Upakosala, Chakrayana Ushasti, Raikva, Kapila and Janaka. Important verses from Upanishads - Discussion of Sage Pippalada’s answers to the six questions in Prasnopanishad.

REFERENCES:
1. *The Message of the Upanishads by Swami Ranganathananda, Bharatiya Vidya Bhavan*
2. *Eight Upanishads with the commentary of Sankaracharya, Advaita Ashrama*
3. *Indian Philosophy by Dr. S. Radhakrishnan, Oxford University Press*
4. *Essentials of Upanishads by R L Kashyap, SAKSI, Bangalore*
5. *Upanishads in Daily Life, Sri Ramakrishna Math, Mylapore.*
6. *Eternal stories of the Upanishads by Thomas Egenes and Kumuda Reddy*
7. *Upanishad Ganga series – Chinmaya Creations*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23HUM244 UNDERSTANDING SCIENCE OF FOOD AND NUTRITION L-T-P-C: 2-0-0-2

Course Objectives:
- To introduce the significance of food, nutrients, locally available food resources, synergic food combinations, good cooking methods and importance of diversity in foods
- To understand nutritional imbalances and chronic diseases associated with the quality of food.
- To gain awareness about the quality of food - Organic food, genetically modified food, adulterated food, allergic food, food poisoning and food safety.
- To understand food preservation processing, packaging and the use of additives.

Course Outcomes:
CO1: Acquire knowledge about the various food and food groups
CO2: Understand nutritional imbalances and chronic diseases prevailing among different age groups.
CO3: Understand the significance of safe food and apply the food safety standards
CO4: Demonstrate skills of food processing, preservation and packaging methods with or without additives
CO5: Evaluate the quality of food based on the theoretical knowledge of Food and Nutrition

CO-PO Mapping:

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01		1	1			1	2	1	1	1	1	3				
CO02		1	1			1	1	1	1	1	1	3				
CO03		1	1			1	1	1	1	1	1	3				
CO04		1	1			1	1	1	1	1	1	3				
CO05		1	1			1	2	1	2	1	1	3				

Syllabus
Unit 1
Food and Food Groups
Introduction to foods, food groups, locally available foods, Nutrients, Cooking methods, Synergy between foods, Science behind foods, Food allergies, food poisoning, food safety standards.

Cookery Practicals - *Balanced Diet*

Unit 2
Nutrients and Nutrition
Nutrition through life cycle, RDA, Nutrition in disease, Adulteration of foods & Food additives, Packaging and labeling of foods.

Practicals - *Traditional Foods*

Unit 3
Introduction to Food Biotechnology
Future foods - Organic foods and genetically modified foods, Fortification of foodsvalue addition of foods, functional foods, Nutraceuticals, supplementary foods, Processing and preservation of foods, applications of food technology in daily life, and your prospects associated with food industry – Nanoparticles, biosensors, advancedresearch.

Practicals - *Value added foods*

TEXTBOOKS:

1. *N. Shakuntalamanay, M. Shadaksharaswamy, "Food Facts and principles", New age international (P)ltd, publishers, 2005.*
2. *B. Srilakshmi, "Dietetics", New age international (P) ltd, publishers, 2010.*

REFERENCE BOOKS:

1. *B. Srilakshmi, "Food Science", New age international (P) ltd, publishers, 2008.*
2. *"Nutrient requirement and Recommended Dietary Allowances for Indians", published by Indian Councilof Medical Research, ICMR, 2010.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23JAP230	PROFICIENCY IN JAPANESE LANGUAGE (LOWER)	L-T-P-C: 2-0-0-2

Syllabus

This paper will introduce the basics of Japanese language. Students will be taught the language through various activities like writing, reading, singing songs, showing Japanese movies etc. Moreover this paper intends to givea thorough knowledge on Japanese scripts that is Hiragana and Katakana. Classes will be conducted throughoutin Japanese class only. Students will be able to make conversations with each other in Japanese. Students can make self-introduction and will be able to write letters in Japanese. All the students will be given a text on Japanese verbs and tenses.

Students can know about the Japanese culture and the lifestyle. Calligraphy is also a part of this paper. Informalsessions will be conducted occasionally, in which students can sing Japanese songs, watch Japanese movies, doOrigami – pattern making using paper.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23JAP231	PROFICIENCY IN JAPANESE LANGUAGE (HIGHER)	L-T-P-C: 2-0-0-2

Syllabus

Students will be taught the third and the most commonly used Japanese script, Kanji. Students will be taught to write as well as speak.

Students will be given detailed lectures on Calligraphy.

This version of the course includes a new project where the students should make a short movie in Japanese language selecting their own topics.

By the end of the semester they the students will master the subject in all means. They will be able to speak Japanese as fluently as they speak English. Students will be encouraged to write stories and songs in Japaneselanguage themselves.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23KAN230	KANNADA I	L-T-P-C: 2-0-0-2

OBJECTIVES:
To enable the students to acquire basic skills in functional language; to develop independent reading skills and reading for appreciating literary works; to analyse language in context to gain an understanding of vocabulary, spelling, punctuation and speech.

Syllabus
Unit 1
Adalitha Kannada: bhashe, swaroopa, belavanigeya kiru parichaya Paaribhaashika padagalu
Vocabulary Building

Unit 2
Prabhandha – Vyaaghra Geethe - A. N. Murthy Rao
Prabhandha – Baredidi…baredidi, Baduku mugiyuvudilla allige…- Nemi Chandra Paragraph writing – Development: comparison, definition, cause & effect Essay – Descriptive & Narrative

Unit 3
Mochi – Bharateepriya
Mosarina Mangamma – Maasti Venkatesh Iyengar Kamalaapurada Hotelnalli – Panje Mangesh Rao Kaanike – B.M. Shree
Geleyanobbanige bareda Kaagada – Dr. G. S. Shivarudrappa Moodala Mane – Da. Ra. Bendre Swathantryada Hanate – K. S. Nissaar Ahmed

Unit 4
Letter W riting - Personal: Congratulation, thanks giving, invitation, condolence

Unit 5
Reading Comprehension; nudigattu, gaadegalu Speaking Skills: Prepared speech, pick and speak

REFERENCES:

1. *H. S. Krishna Swami Iyangar – Adalitha Kannada – Chetana Publication, Mysuru*
2. *N. Murthy Rao – Aleyuva Mana – Kuvempu Kannada Adyayana Samste*
3. *Nemi Chandra – Badhuku Badalisabahudu – Navakarnataka Publication*
4. *Sanna Kathegalu - Prasaranga, Mysuru University , Mysuru*
5. *B. M. Shree – Kannadada Bavuta – Kannada Sahitya Parishattu*
6. *K. S. Nissar Ahmed – 75 Bhaavageetegalu – Sapna Book House (P) Ltd.*
7. *Dr. G. S. Shivarudrappa – Samagra Kavya – Kamadhenu Pustaka Bhavana*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23KAN231	KANNADA II	L-T-P-C: 2-0-0-2

OBJECTIVES:
To enable the students to acquire basic skills in functional language; to develop independent reading skills and reading for appreciating literary works; to develop functional and creative skills in language; to enable the students to plan, draft, edit & present a piece of writing.

Syllabus
Unit 1
Official Correspondence: Adhikrutha patra, prakatane, manavi patra, vanijya patra

Unit 2
Nanna Hanate - Dr. G. S. Shivarudrappa
Mankuthimmana Kaggada Ayda bhagagalu – D. V. Gundappa (Padya Sankhye 5, 20, 22, 23, 25, 44, 344, 345, 346, 601)
Ella Marethiruvaga - K. S. Nissaar Ahmed Saviraru Nadigalu – S Siddalingayya

Unit 3
Sayo Aata – Da. Ra. Bendre

Unit 4
Sarva Sollegala turtu Maha Samelana - Beechi Swarthakkaagi Tyaga - Beechi

Unit 5
Essay writing: Argumentative & Analytical Précis writing

REFERENCES:

1. *H. S. Krishnaswami Iyangar – Adalitha Kannada – Chetan Publication, Mysuru*
2. *Dr. G. S. Shivarudrappa – Samagra Kavya. - Kamadhenu Pustaka Bhavana*
3. *Shrikanth - Mankuthimmana Kagga – Taatparya – Sri Ranga Printers & Binders*
4. *K. S. Nissar Ahmed – 75 Bhaavageetegalu – Sapna book house*
5. *Dr. Da. Ra. Bendre – Saayo Aata – Shri Maata Publication*
6. *Beechi – Sahukara Subbamma – Sahitya Prakashana*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23MAL230	MALAYALAM I	L-T-P-C: 2-0-0-2

Course Objectives:
To appreciate the aesthetics & cultural implications; to enhance creative thinking in mother0-tongue; to learn ourculture & values; to equip students read & write correct Malayalam; to correct the mistakes in pronunciation; to create awareness that good language is the sign of complete personality

Course Outcome:
After the completion of the course the student will be able to:
CO1: Understand and inculcate philosophical thoughts and practices
CO2: Understand and appreciate the post modern trends of literature.
CO3: Analyse the literary texts and comprehend the cultural diversity of Kerala
CO4: Distinguish the different genres in Malayalam literature
CO5: Demonstrate the ability to effectively communicate in Malayalam

CO-PO Mapping:

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01									2	3						
CO02									2	3						
CO03									2	3						
CO04										3						
CO05									1	1						

Syllabus
Unit 1
Ancient poet trio: Adhyatmaramayanam,
Lakshmana Swanthanam (valsa soumitre… mungikidakayal), Ezhuthachan - Medieval period classics – Jnanappana (kalaminnu… vilasangalingane), Poonthanam

Unit 2
Modern Poet trio: Ente Gurunathan, Vallathol Narayana Menon - Critical analysis of the poem.

Unit 3
Short stories from period 1/2/3, Poovanpazham - Vaikaom Muhammed Basheer - Literary & Cultural figures ofKerala and about their literary contributions.

Unit 4
Literary Criticism: Ithihasa studies - Bharatha Paryadanam - Vyasante Chiri - Kuttikrishna Mararu - Outline of literary Criticism in Malayalam Literature - Introduction to Kutti Krishna Mararu & his outlook towards literature & life.

Unit 5
Error-free Malayalam: 1. Language; 2. Clarity of expression; 3. Punctuation – Thettillatha Malayalam Writing - a. Expansion of ideas; b .Precis Writing; c. Essay Writing; d. Letter writing; e. Radio Speech; f. Script /Feature / Script Writing; g. News Editing; h. Advertising; i. Editing; j. Editorial Writing; k. Critical appreciation of literary works (Any one or two as an assignment).

REFERENCES:

1. *P. K. Balakrishnanan, Thunjan padhanangal, D. C. Books, 2007.*
2. *G. Balakrishnan Nair, Jnanappanayum Harinama Keerthanavum, N. B. S, 2005.*
3. *M. N. Karasseri, Basheerinte Poonkavanam, D. C. Books, 2008.*
4. *4 M. N. Vijayan, Marubhoomikal Pookkumbol, D. C. Books, 2010.*
5. *M. Thomas Mathew, Lavanyanubhavathinte Yukthisasthram, National Book Stall, 2009.*

6. *M. Leelavathy, Kavitha Sahityacharitram, National Book Stall, 1998.*
7. *Thayattu Sankaran, Vallathol Kavithapadhanam, D. C. Books, 2004.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23MAL231	MALAYALAM II	L-T-P-C: 2-0-0-2

OBJECTIVES:
To appreciate the aesthetics & cultural implications; to enhance creative thinking in mother-tongue; to learn our culture & values; to equip students read & write correct Malayalam; to correct the mistakes in pronunciation; to create awareness that good language is the sign of complete personality.

Course Outcomes:
After the completion of the course the student will be able to:
CO1: Understand the different cultural influences in linguistic translation
CO2: Identify and appreciate the Romantic elements of modern literature
CO3: Analyze the genre of autobiographical writing
CO4: Critically evaluate the significance of historical, political and socio cultural aspects in literature
CO5: Demonstrate good writing skills in Malayalam

CO-PO Mapping:

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01									2	3						
CO02									2	3						
CO03									2	3						
CO04										3						
CO05									1	1						

Syllabus
Unit 1
Ancient poet trio: Kalayanasougandhikam, (kallum marangalun… namukkennarika vrikodara) Kunjan Nambiar - Critical analysis of his poetry - Ancient Drama: Kerala Sakunthalam (Act 1), Kalidasan (Translated by Attor Krishna Pisharody).

Unit 2
Modern / romantic / contemporary poetry: Manaswini, Changampuzha Krishna Pillai – Romanticism – modernism.

Unit 3
Anthology of short stories from period 3/4/5: Ninte Ormmayku, M. T. Vasudevan Nair - literary contributions of his time

Unit 4
Part of an autobiography / travelogue: Kannerum Kinavum, V. T. Bhattathirippadu - Socio-cultural literature - historical importance.

Unit 5
Error-free Malayalam - 1. Language; 2. Clarity of expression; 3. Punctuation - Thettillatha Malayalam W riting - a. Expansion of ideas; b. Précis Writing ; c. Essay Writing; d. Letter writing; e. Radio Speech; f. Script /Feature / Script Writing; g. News Editing; h. Advertising; i. Editing; j. Editorial Writing; k. Critical appreciationof literary works (Any one or two as an assignment).

REFERENCES:

1. *Narayana Pillai. P. K, Sahitya Panchanan. Vimarsanathrayam, Kerala Sahitya Academy, 2000*
2. *Sankunni Nair. M. P, Chathravum Chamaravum, D. C. Books, 2010.*
3. *Gupthan Nair. S, Asthiyude Pookkal, D. C Books. 2005*
4. *Panmana Ramachandran Nair, Thettillatha Malayalam, Sariyum thettum etc., D. C. Book, 2006.*
5. *M. Achuthan, Cherukatha-Innale, innu, National Book Stall, 1998.*

6. *N. Krishna Pillai, Kairaliyude Katha, National Book Stall, 2001.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23SAN230	SANSKRIT I	L-T-P-C: 2-0-0-2

OBJECTIVES:
To familiarize students with Sanskrit language and literature; to enable them to read and understand Sanskrit verses and sentences; to help them acquire expertise for self- study of Sanskrit texts and communication in Sanskrit; to help the students imbibe values of life and Indian culture as propounded in scriptures.

Syllabus
Unit 1
Introduction to Sanskrit language, Devanagari script - Vowels and consonants, pronunciation, classification of consonants, conjunct consonants, words – nouns and verbs, cases – introduction, numbers, Pronouns, communicating time in Sanskrit. Practical classes in spoken Sanskrit

Unit 2
Verbs- Singular, Dual and plural – First person, Second person, Third person. Tenses – Past, Present and Future –Atmanepadi and Parasmaipadi-karthariprayoga

Unit 3
Words for communication, slokas, moral stories, subhashithas, riddles (from the books prescribed)

Unit 4
Selected slokas from Valmiki Ramayana, Kalidasa's works and Bhagavad Gita. Ramayana – chapter VIII - verse5, Mahabharata - chapter 174, verse -16, Bhagavad Gita – chapter - IV verse 8, Kalidasa's Sakuntalam Act IV – verse 4

Unit 5
Translation of simple sentences from Sanskrit to English and vice versa.

ESSENTIAL READING:
1. *Praveshaha; Publisher: Samskrita bharati, Aksharam, 8th cross, 2nd phase, girinagar, Bangalore - 560 085*
2. *Sanskrit Reader I, II and III, R. S. Vadhyar and Sons, Kalpathi, Palakkad*
3. *Prakriya Bhashyam written and published by Fr. John Kunnappally*
4. *Sanskrit Primer by Edward Delavan Perry, published by Ginn and Company Boston*
5. *Sabdamanjari, R. S. Vadyar and Sons, Kalpathi, Palakkad*
6. *Namalinganusasanam by Amarasimha published by Travancore Sanskrit series*
7. *Subhashita Ratna Bhandakara by Kashinath Sharma, published by Nirnayasagar press*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23SAN231	SANSKRIT II	L-T-P-C: 2-0-0-2

OBJECTIVES:
To familiarize students with Sanskrit language and literature; to enable them to read and understand Sanskrit verses and sentences; to help them acquire expertise for self- study of Sanskrit texts and communication in Sanskrit; to help the students imbibe values of life and Indian culture as propounded in scriptures.

Syllabus
Unit 1
Seven cases, indeclinables, sentence making with indeclinables, Saptha karakas.

Unit 2
Ktavatu Pratyaya, Upasargas, Ktvanta, Tumunnanta, Lyabanta. Three Lakaras – brief introduction, Lot lakara.

Unit 3
W ords and sentences for advanced communication. Slokas, moral stories (Pancatantra) Subhashitas, riddles.

Unit 4
Introduction to classical literature, classification of Kavyas, classification of Dramas - The five Mahakavyas, selected slokas from devotional kavyas- Bhagavad Gita – chapter - II verse 47, chapter - IV verse 7, chapter - VI verse 5, chapter - VIII verse 6, chapter - XVI verse 21, Kalidasa’s Sakuntala act IV – verse 4, Isavasyopanishat 1st Mantra, Mahabharata chapter 149 verses 14 - 120, Neetisara chapter - III

Unit 5
Translation of paragraphs from Sanskrit to English and vice versa.

ESSENTIAL READING:
1. *Praveshaha; Publisher: Samskrita bharati, Aksharam, 8th cross, 2nd phase, girinagar, Bangalore -560085*
2. *Sanskrit Reader I, II and III, R.S. Vadhyar and Sons, Kalpathi, Palakkad*
3. *Prakriya Bhashyam written and published by Fr. John Kunnappally*
4. *Sanskrit Primer by Edward Delavan Perry, published by Ginn and Company Boston*
5. *Sabdamanjari, R. S. Vadyar and Sons, Kalpathi, Palakkad*
6. *Namalinganusasanam by Amarasimha published by Travancore Sanskrit series*
7. *Subhashita Ratna Bhandakara by Kashinath Sharma, published by Nirnayasagar Press.*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23SWK230	CORPORATE SOCIAL RESPONSIBILITY	L-T-P-C: 2-0-0-2

Syllabus

Unit 1
Understanding CSR - Evolution, importance, relevance and justification. CSR in the Indian context, corporate strategy. CSR and Indian corporate. Structure of CSR - In the Companies Act 2013 (Section 135); Rules under Section 13; CSR activities, CSR committees, CSR policy, CSR expenditure CSR reporting.

Unit 2
CSR Practices & Policies - CSR practices in domestic and international area; Role and contributions of voluntary organizations to CSR initiatives. Policies; Preparation of CSR policy and process of policy formulation; Government expectations, roles and responsibilities. Role of implementation agency in Section 135 of the Companies Act, 2013. Effective CSR implementation.

Unit 3
Project Management in CSR initiatives - Project and programme; Monitoring and evaluation of CSR Interventions. Reporting - CSR Documentation and report writing. Reporting framework, format and procedure.

REFERENCES:

1. *Corporate Governance, Ethics and Social Responsibility, V Bala Chandran and V Chandrasekaran, PHI learning Private Limited, New Delhi 2011.*
2. *White H. (2005) Challenges in evaluating development effectiveness: Working paper 242, Institute of Development Studies, Brighton.*
3. *UNDP (nd) Governance indicators: A users guide. Oslo: UNDP*
4. *Rao, Subbha (1996) Essentials of Human Resource Management and Industrial Relations, Mumbai, Himalaya*
5. *Rao, V. S. L. (2009) Human Resource Management, New Delhi, Excel Books,*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23SWK231	WORKPLACE MENTAL HEALTH	L-T-P-C: 2-0-0-2

Syllabus

Unit 1
Mental Health – concepts, definition, Bio-psycho-social model of mental health. Mental health and mental illness, characteristics of a mentally healthy individual, Signs and symptoms of mental health issues, presentation of a mentally ill person. Work place – definition, concept, prevalence of mental health issues in the work place, whyinvest in workplace mental health, relationship between mental health and productivity, organizational culture and mental health. Case Study, Activity.

Unit 2
Mental Health Issues in the Workplace: Emotions, Common emotions at the workplace, Mental Health issues - Anger, Anxiety, Stress & Burnout, Depression, Addictions – Substance and Behavioural, Psychotic Disorders - Schizophrenia, Bipolar Disorder, Personality disorders. Crisis Situations - Suicidal behavior, panic attacks, reactions to traumatic events. Stigma and exclusion of affected employees. Other issues –work-life balance, Presenteeism, Harassment, Bullying, Mobbing. Mental Health First Aid - Meaning. Case Study, Activity.

Unit 3
Strategies of Help and Care: Positive impact of work on health, Characteristics of mentally healthy workplace, Employee and employer obligations, Promoting mental health and well being- corporate social responsibility (CSR), an inclusive work environment, Training and awareness raising, managing performance, inclusive recruitment, Supporting individuals-talking about mental health, making reasonable adjustments, Resources and support for employees - Employee Assistance Programme / Provider (EAP), in house counsellor, medical practitioners, online resources and telephone support, 24 hour crisis support, assistance for colleagues and care givers, Legislations. Case Study, Activity.

REFERENCES:

1. *American Psychiatric Association. "Diagnostic and statistical manual of mental disorders: DSM-IV 4th ed." www.terapiacognitiva.eu/dwl/dsm5/DSM-IV.pdf*
2. *American Psychiatric Association. (2000) www.ccsa.ca/Eng/KnowledgeCentre/OurDatabases/ Glossary/Pages/index.aspx.*
3. *Canadian Mental Health Association, Ontario "Workplace mental health promotion, A how to guide"wmhp.cmhaontario.ca/*
4. *Alberta Health Services Mental Health Promotion. (2012). Minding the Workplace: Tips for employeesand managers together. Calgary: Alberta Health Services.http:// www.mentalhealthpromotion.net/resources/minding-the-workplace-tips-for-employees-and- managers-together.pdf*
5. *Government of Western Australia, Mental Health Commission. (2014) "Supporting good mental health in the work place." http://www.mentalhealth.wa.gov.au/Libraries/pdf_docs/ supporting_good_mental_health_in_the_workplace_1.sflb.ashx*
6. *Mental Health Act 1987 (India) www.tnhealth.org/mha.htm*
7. *Persons with disabilities Act 1995 (India) socialjustice.nic.in*
8. *The Factories Act 1948 (India) www.caaa.in/Image/19ulabourlawshb.pdf*

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23TAM230	TAMIL I	L-T-P-C: 2-0-0-2

Course Objectives:

- To introduce the students to different literature- Sangam literature, Epics, Bhakthi literatureandmodern literature.
- To improve their ability tocommunicate with creative concepts, and also to introduce them to the usefulness of basicgrammaticalcomponents in Tamil.

Course Outcomes

CO1: To understand the Sangam literature
CO2: To understand the creative literature
CO3: To understand the literary work on religious scriptures
CO4: To improve the communication and memory skills
CO5: To understand the basic grammar components of Tamil language and their usage and applications.
CO6: Understand creative writing aspects and apply them.

CO-PO Mapping

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01									2	2						
CO02									2	2						
CO03									2	2						
CO04									2	2						
CO05									2	2						
CO06									2	2						

Syllabus

Unit1

The history ofTamilliterature: Nāṭṭupuṟap pāṭalkaḷ, kataikkaḷ, paḻamoḻikaḷ - ciṟukataikaḷ tōṟṟamum vaḷarcciyum, ciṟṟilakkiyaṅkaḷ: Kaliṅkattup paraṇi (pōrpāṭiyatu) - mukkūṭaṟ paḷḷu 35.
Kāppiyaṅkaḷ: Cilappatikāram – maṇimēkalai naṭaiyiyal āyvu maṟṟum aimperum – aiñciṟuṅ kāppiyaṅkaḷ toṭarpāṉa ceytikaḷ.

Unit 2

tiṇai ilakkiyamum nītiyilakkiyamum - patiṉeṇkīḻkkaṇakku nūlkaḷ toṭarpāṉa piṟa ceytikaḷ - tirukkuṟaḷ (aṉpu, paṇpu, kalvi, oḻukkam, naṭpu, vāymai, kēḷvi, ceynaṉṟi, periyāraittuṇakkōṭal, viḻippuṇarvu pēṉṟa atikārattil uḷḷa ceytikaḷ.
Aṟanūlkaḷ: Ulakanīti (1-5) – ēlāti (1,3,6). - Cittarkaḷ: Kaṭuveḷi cittar pāṭalkaḷ (āṉantak kaḷippu –1, 4, 6, 7, 8, maṟṟum akappēy cittar pāṭalkaḷ (1-5).

Unit 3

tamiḻ ilakkaṇam: Vākkiya vakaikaḷ – taṉviṉai piṟaviṉai – nērkkūṟṟu ayaṟkūṟṟu

Unit 4

tamiḻaka aṟiñarkaḷiṉ tamiḻ toṇṭum camutāya toṇṭum: Pāratiyār, pāratitācaṉ, paṭṭukkōṭṭai kalyāṇacuntaram, curatā, cujātā, ciṟpi, mēttā, aptul rakumāṉ, na.Piccaimūrtti, akilaṉ, kalki, jī.Yū.Pōp, vīramāmuṉivar, aṇṇā, paritimāṟ kalaiñar, maṟaimalaiyaṭikaḷ.

Unit 5

tamiḻ moḻi āyvil kaṇiṉi payaṉpāṭu. - Karuttu parimāṟṟam - viḷampara moḻiyamaippu – pēccu - nāṭakam paṭaippu -ciṟukatai, katai, putiṉam paṭaippu.

Textbooks:

1. http:/Www.tamilvu.trg/libirary/libindex.htm.
2. http:/Www.tunathamizh.tom/2013/07/blog0post_24.html
3. Mu.Varatarācan̲ “tamil̲ ilakkiya varalāṟu” cāhitya akaṭemi papḷikēṣan̲s, 2012
4. nā.Vān̲amāmalai “pal̲aṅkataikaḷum, pal̲amol̲ikaḷum” niyū ceñcuri puttaka veḷiyīṭṭakam,1980,2008
5. nā.Vān̲amāmalai, “tamil̲ar nāṭṭuppāṭalkaḷ” niyū ceñcuri puttaka veḷiyīṭṭakam 1964,2006
6. pon̲ maṇimāṟan̲ “aṭōn̲ tamil̲ ilakkaṇam “aṭōn̲ papḷiṣiṅ kurūp, vañciyūr,
7. tiruvan̲antapuram, 2007.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.

23TAM231	TAMIL II	L-T-P-C: 2-0-0-2

Course Objectives

- To learn the history ofTamilliterature.
- To analyze different styles of Tamil Language.
- To strengthen thecreativity in communication, Tamilbasicgrammar and use of computer on Tamil Language.

Course Outcomes

CO1: Understand the history of Tamil literature.
CO2: Apply practical and comparative analyses on literature.
CO3: Understand thinai literature, literature on justice, Pathinenkeelkanaku literature.
CO4: Understand the tamil scholars' service to Tamil language and society.
CO5: Understand components of Tamil grammar and its usage
CO6: Understand creative writing aspects and apply them

CO-PO Mapping

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO01									2	2						
CO02									2	2						
CO03									2	2						
CO04									2	2						
CO05									2	2						
									2	2						

Syllabus

Unit 1

The history ofTamilliterature: Nāṭṭupuṟap pāṭalkaḷ, kataikkaḷ, paḻamoḻikaḷ - ciṟukataikaḷ tōṟṟamum vaḷarcciyum, ciṟṟilakkiyaṅkaḷ: Kaliṅkattup paraṇi (pōrpāṭiyatu) - mukkūṭaṟ paḷḷu 35.
Kāppiyaṅkaḷ: Cilappatikāram – maṇimēkalai naṭaiyiyal āyvu maṟṟum aimperum – aiñciṟuṅ kāppiyaṅkaḷ toṭarpāṉa ceytikaḷ.

Unit 2

tiṇai ilakkiyamum nītiyilakkiyamum - patiṉeṇkīḻkkaṇakku nūlkaḷ toṭarpāṉa piṟa ceytikaḷ - tirukkuṟaḷ (aṉpu, paṇpu, kalvi, oḻukkam, naṭpu, vāymai, kēḷvi, ceynaṉṟi, periyāraittuṇakkōṭal, viḻippuṇarvu pēṉṟa atikārattil uḷḷa ceytikaḷ.
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Unit 3

tamiḻ ilakkaṇam: Vākkiya vakaikaḷ – taṉviṉai piṟaviṉai – nērkkūṟṟu ayaṟkūṟṟu

Unit 4

tamiḻaka aṟiñarkaḷiṉ tamiḻ toṇṭum camutāya toṇṭum: Pāratiyār, pāratitācaṉ, paṭṭukkōṭṭai kalyāṇacuntaram, curatā, cujātā, ciṟpi, mēttā, aptul rakumāṉ, na.Piccaimūrtti, akilaṉ, kalki, jī.Yū.Pōp, vīramāmuṉivar, aṇṇā, paritimāṟ kalaiñar, maṟaimalaiyaṭikaḷ.

Unit 5

tamiḻ moḻi āyvil kaṇiṉi payaṉpāṭu. - Karuttu parimāṟṟam - viḷampara moḻiyamaippu – pēccu - nāṭakam paṭaippu -ciṟukatai, katai, putiṉam paṭaippu.

Text Books / References

1. http:/Www.tamilvu.trg/libirary/libindex.htm. http:/Www.tunathamizh.tom/2013/07/blog0post_24.html Mu.Varatarācaṉ "tamiḻ ilakkiya varalāṟu" cāhitya akaṭemi papḷikēṣaṉs, 2012
2. nā.Vāṉamāmalai "paḻaṅkataikaḷum, paḻamoḻikaḷum" niyū ceñcuri puttaka veḷiyīṭṭakam, 1980,2008 nā.Vāṉamāmalai, "tamiḻar nāṭṭuppāṭalkaḷ" niyū ceñcuri puttaka veḷiyīṭṭakam 1964,2006 poṉ maṇimāṟaṉ "aṭōṉ tamiḻ ilakkaṇam "aṭōṉ papḷiṣiṅ kurūp, vañciyū

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, Projects, and Reports.