DEPARTMENT OF MECHANICAL ENGINEERING

B. TECH PROGRAM IN AUTOMATION AND ROBOTICS

CURRICULUM AND SYLLABI
(2023 Admission onward)

B.Tech Programme

AUTOMATION AND ROBOTICS

Programme Overview

Most industries have adopted Robotics and Automation to enhance productivity with high reliability, which demands a specialized workforce. Automation and robotics were being increasingly adopted across various industries, including manufacturing, healthcare, agriculture, and logistics. This trend will expected to continue, leading to a growing demand for skilled automation and robotics engineers. The fourth industrial revolution, often referred to as Industry 4.0, involves the integration of digital technologies, automation, and smart systems into the manufacturing environment. Automation and robotics engineers play a crucial role in designing and implementing these advanced manufacturing processes.

The integration of Artificial Intelligence (AI) with robotics and automation systems was becoming more prevalent. Engineers with expertise in AI, machine learning, and computer vision were likely to be in high demand. In order to foster Engineering graduates at par with the current industry practices and requirements, this undergraduate programme on B.Tech in Automation and Robotics is conceived. The curriculum for this undergraduate programme provides with the necessary foundation in mathematics, computer programming, machine learning, etc., thereby enabling them to pursue the program.

The skill set required for automation and robotics engineers was evolving, with an increasing emphasis on software development, data analytics, and interdisciplinary collaboration. Engineers with a broad skill set that includes both hardware and software expertise were likely to be more competitive. This programme encompasses the essential courses necessary to build competence in understanding and solving challenges in design and implementation of Automation and Robotics solutions in industries. The extensive syllabus for this programme has been framed to capture the current trends in the industry, accentuating the need for a skilled and specialized workforce.

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

Program Educational Objectives (PEOs) - Program educational objectives are the broad statements describing the career and professional accomplishments the program prepares graduates to achieve. Student outcomes are statements that describe what students are expected to know or be able to do by the time they complete an academic program.

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

Program Specific Outcomes (PSOs) – Program Outcomes are statements describing what students are expected to acquire specific knowledge, skills, and attitudes through the program. PSOs are written by the department offering the program.

Course Outcomes (COs) – 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 behavior students acquire in their progress through the course.

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 the latest computational, analytical, and 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.
PEO5: Nurture entrepreneurial ventures and foster research activities that support sustainable economic development to enhance the quality of life.

PROGRAM OUTCOMES FOR ENGINEERING

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **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.
3. **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.
4. **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.
5. **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.
6. **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.
7. **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.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **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.
11. **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.
12. **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.

Programme Specific Outcomes (PSOs)

PSO1 – Apply knowledge acquired in the field of kinematics, dynamics, robotics and control systems to develop automation and robotic system aligning with the changing requirements of industry.
PSO2 – Extend and implement innovative thinking on design of smart products and processes with the aid of modern tools.
PSO3 – Design and implement autonomous systems for emerging domains like manufacturing, automotive, health care, industrial safety and for hazardous natural environment.

VISION AND MISSION OF THE DEPARTMENT

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.

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	5	4	1	3	4	2	-	-	19	11
2.	Basic Science (including Mathematics) & General Engineering courses	16	13	5	4	5	-	-	-	43	25
3.	Engineering Core Courses	-	5	13	17	14	13	10	-	72	43
4.	Professional Elective Courses, Free Electives & Open Elective Courses, Live-in-Labs	-	-	2	-	-	6	6	6	20	13
5.	Project work, Seminar, and Internship in Industry or elsewhere	-	-	-	-	-	1	2	10	13	8
6.	Audit Courses [Environmental Sciences, Research Methodology, Indian Constitution]	-	-	ES	-	-	IC	RM	-	-	-
Total		**21**	**22**	**21**	**24**	**23**	**22**	**18**	**16**	**167**	**100**

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Department of Mechanical Engineering
Curriculum B. Tech Automation and Robotics- 2023 Admission

Semester 1

Code	Course	Credits
23MAT133	Multivariable Calculus	3
23CSE107	Programming in C	4
23PHY107	Engineering Physics C	3
23MEE107	Engineering Mechanics	4
23ARE101	Computer Aided Drafting	2
23ENG101	Technical Communication	3
22ADM101	Foundations of Indian Heritage	2
	Total	**21**

Semester 2

Code	Course	Credits
23MAT128	Linear Algebra	3
23ARE111	Thermo-fluids	3
23EEE102	Basic Electrical and Electronics Engineering	3
23CHY107	Engineering Chemistry C	3
23CSE118	Programming in C++	3
23EEE182	Basic Electrical and Electronics Engineering Lab	1
23ARE112	Manufacturing Process I	2
22ADM111	Glimpses of Glorious India	2
22AVP103	Mastery Over Mind	2
	Total	**22**

Semester 3

Code	Course	Credits
23MAT209	Differential Equations and Numerical Methods	4
23ARE201	Robot kinematics	4
23ARE202	Mechanics of Materials	4
23ARE203	Manufacturing Process II	2
23ARE204	Actuators and Drives	3
	Free Elective I**	2
23CSE109	Python Programming	1
22ADM211	Leadership from Ramayana	1
23ENV300	Environmental Science	P/F
23LSE201	Life Skills for Engineers I	1 0 2 P/F
	Total	**21**

Semester 4

Code	Course	Credits
23MAT223	Probability and Statistics	4
23ARE211	Sensors and Signal Processing	4
23ARE212	Robot Dynamics	3
23ARE213	Additive Manufacturing	2
23ARE214	Design of Machine Elements	3
23ARE215	Control Systems	4
23ARE281	Dynamics lab	1
23LSE211	Life Skills for Engineers II	2
22ADM201	Strategic Lessons from Mahabharata	1
	Total	**24**

Semester 5

Code	Course	Credits
23MAT306	Graph theory algorithms and Complex analysis	4
23ARE301	Introduction to Data Science	3
23ARE302	Microcontrollers and Embedded Systems	3
23ARE303	Fluid power systems for industrial automation	3
23ARE304	Robotics and Control	4
23LIV390*	Live in Lab I	[3]
23ARE381	Microcontrollers and Embedded Systems Lab	1
23ARE382	Design Thinking A	1
	Free Elective II**	2
23LSE301	Life Skills for Engineers III	2
	Total	**23 + [3]**

Semester 6

Code	Course	Credits
23MEE306	Optimization Techniques	3
23ARE311	Introduction to Machine Learning	4
23ARE312	Real Time Operating Systems	3
23ARE313	Industrial Process Automation	3
23LIV490*	Live in Labs II*	[3]
	Professional Elective I*	3
	Professional Elective II*	3
23LSE311	Life Skills for Engineers IV	2
23ARE399	Mini Project	1
23LAW300	Indian Constitution	P/F
	Total	**22 +[3]**

Semester 7

Code	Course	Credits
23ARE401	Mobile Robotics	3
23ARE402	Introduction to Deep Reinforcement Learning	3
23ARE403	Industrial Internet of Things	3
	Professional Elective III*	3
	Professional Elective IV*	3
23ARE481	CNC and System Simulation Lab	1
23ARE300	Research Methodology	P/F
23ARE497	Summer Internship	P/F
23ARE498	Project Phase I	2
	Total	**18**

Semester 8

Code	Course	Credits
	Professional Elective V*	3
	Professional Elective VI*	3
23ARE499	Project Phase II	**10**
	Total	**16**

Total Credits: 167

DEPARTMENT OF MECHANICAL ENGINEERING

MINOR PROGRAM

Minor Program Offered.

S.No.	Name of the Minor
1	Robotics & Automation

DEPARTMENT OF MECHANICAL ENGINEERING

MINOR: ROBOTICS AND AUTOMATION

Preamble:

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

List of courses for Minor in Robotics and Automation:

Minimum of 18 credits required for Minor programme

S.No.	Course Code	Name of the Course	Semester	L-T-P	Credits
Mandatory Courses (13 credits)					
1	23MEE231M	Actuators and Drives	-	3-0-0	3
2	23MEE232M	Robot Kinematics and Dynamics	-	3-0-0	3
3	23MEE233M	Microcontrollers and Embedded Systems	-	2-0-3	3
4	23MEE234M	Robotics and Control	-	3-0-3	4
Any two of the following courses can be selected in addition to above four courses for the minor program **(6 credits)**					
5	23MEE235M	Industrial Internet of Things	-	2-0-3	3
6	23MEE236M	Industrial Process Automation	-	2-0-3	3
7	23MEE237M	Mobile Robots	-	2-0-3	3
8	23MEE238M	Real Time Operating Systems	-	2-0-3	3
9	23MEE239M	Drone Technology	-	2-0-3	3

PROFESSIONAL ELECTIVES

Cat.	Code	Title	Credits
STREAM 1: FIELD / SERVICE ROBOTS			
1	23ARE331	Bio-Inspired Robots	3
	23ARE332	Humanoid Robots	3
	23ARE333	Medical Robots	3
	23ARE334	Underwater Robots	3
	23ARE335	Cognitive Robots	3
	23ARE336	Drone Technology	3
	23ARE337	Autonomous Vehicles 1	3
	23ARE338	Autonomous Vehicles 2	3
	23ARE339	Agricultural Robots	3
STREAM 2: ADVANCED ROBOTIC TECHNOLOGIES			
2	23ARE341	Robot Navigation and Obstacle Avoidance	3
	23ARE342	Robot Operating System	3
	23ARE343	Intelligent Control Systems for Robots	3
	23ARE344	Optimization for Robot Modelling	3
	23ARE345	Computer Vision and Image Processing	3
	23ARE346	Advanced Materials for Robotics	3
	23ARE347	Advanced Robotics and Analysis	3
	23ARE348	Composite Materials for Robotic Applications	3
STREAM 3: ADVANCED SENSORS AND COMMUNICATION SYSTEMS			
3	23ARE351	Smart Sensors	3
	23ARE352	Machine-to-Machine Communications	3
	23ARE353	Human Computer Interaction	3
	23ARE354	UAV Networks	3
	23ARE355	Wireless Sensor Networks	3
	23ARE356	Neural Networks	3
STREAM 4: ADVANCED TECHNOLOGIES FOR AUTOMATION			
4	23ARE361	Advanced Manufacturing Processes	3
	23ARE362	Industry 4.0	3
	23ARE363	Smart Manufacturing	3
	23ARE364	Micro and Nano Electromechanical Systems	3
	23ARE365	Intelligent Manufacturing Systems	3
	23ARE366	Simulation Modeling of Manufacturing Systems	3
	23ARE367	Sustainable Manufacturing	3
	23ARE368	Digital Twins	3
STREAM 5: ADVANCED DATA SCIENCE TECHNOLOGIES			
5	23ARE431	Cryptography and Network Security	3
	23ARE432	Introduction to Big Data Analysis	3
	23ARE433	Mobile Application Development	3
	23ARE434	Virtual and Augmented Reality	3
	23ARE435	Web Technologies and Applications	3

STREAM 6: COMMON ELECTIVES			
6	23ARE371	Finite Element Method	3
	23ARE372	Stochastic Processes	3
	23ARE373	Stochastic Dynamics	3
	23ARE374	Nonlinear Control Systems	3
	23ARE375	Entrepreneurship	3
	23MEE334	Theory of Vibrations	3
	23ARE376	Electric Drives	3
	23ARE377	Engineering Economic Analysis	3
	23MEE433	Project Management	3
	23MNG371	Operations Research	3
	23ARE379	Lean Manufacturing	3
	23ARE378	Non-linear Dynamics and Chaos	3

***Professional Elective** - 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.

**** Free Electives** - This 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).

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

Note:

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

Course Evaluation Pattern

<table>
<tr><td>Course Type</td><td>Int : Ext</td><td colspan="6">Evaluation Scheme</td><td colspan="2">Total (100)</td></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="5">60 : 40</td><td>CA1</td><td>CA2</td><td>MT</td><td>CA3</td><td>CA4</td><td>ES</td><td colspan="2">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 colspan="2">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 colspan="2" 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 colspan="2">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 colspan="2">CA1+MT+CA2</td><td>ES</td></tr>
<tr><td colspan="10">Project / Internship</td></tr>
<tr><td rowspan="4">PRJ</td><td rowspan="4">60 : 40</td><td colspan="5">CA (60)</td><td>ES (40)</td><td colspan="2">Total (100)</td></tr>
<tr><td colspan="7">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="7">Internship</td></tr>
<tr><td></td><td colspan="5">External report (Industry / Research Organization)</td><td>Presentation & Internship Report</td><td colspan="2">CA+ES</td></tr>
</table>

Notes

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

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

SEMESTER 1

23MAT133	MULTI VARIABLE CALCULUS	L-T-P-C: 2-1-0-3

Course Objectives

- To understand parameterisation of curves and to find arc lengths.
- To familiarise with calculus of multiple variables.
- To use important theorems in vector calculus in practical problems.

Course Outcomes

At the end of the course, the student will be able to
CO1: Understand the basic concepts of vector valued functions, limits, derivatives and its geometrical interpretations.
CO2: Understand the concept of scalar and vector fields.
CO3: Understand and apply the concepts extreme values and Lagrange multipliers for simple optimization problems.
CO4: Understand and apply the concepts line and double integrals to various problems including Green's theorem for plane
CO5: Understand the concepts of surface integrals, divergence theorem and Stokes theorem.

CO-PO Mappings

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	3	1									1			
CO2	1	2	2									1			
CO3	3	2	2									1			
CO4	2	2	2									1			
CO5	2	2	1									1			

Syllabus

Unit 1
Limits and continuity of Functions of Severable Variables, Partial derivatives, Differentiability of Functions, Chain rule. Directional derivatives, Gradient and tangent planes, Extreme values and saddle points, Lagrange multipliers.

Unit 2
Line integrals, Vector fields, Circulation and Flux, Path independence, Potential Functions and Conservative Fields. Green's theorem in a Plane.

Unit 3
Parameterized Surfaces, Surface Areas and Surface Integrals, Orientation of Surfaces. Stoke's Theorem and Divergence Theorem.

Text Books
'Calculus', G.B. Thomas Pearson Education, 2009, Eleventh Edition.
'Advanced Engineering Mathematics', E Kreyszig, John Wiley and Sons, Tenth Edition, 2018.

References
'Calculus', Monty J. Strauss, Gerald J. Bradley and Karl J. Smith, Third Edition, 2002.
'Advanced Engineering Mathematics', E Kreyszig, John Wiley and Sons, Tenth Edition, 2018.
'Advanced Engineering Mathematics', Dennis G. Zill and Michael R.Cullen, second edition, CBS Publishers, 2012.
'Engineering Mathematics', Srimanta Pal and Subhodh C Bhunia, John Wiley and Sons, 2012, Ninth Edition.

23CSE107	PROGRAMMING IN C	L-T-P-C:3-0-3-4	S1

Course objectives

- To familiarize programming languages using C as a tool for implementation.
- To include the concept of arrays and structures in programming
- To write programs that solve simple practical engineering problems

Course outcomes

At the end of the course the student will be able to
CO1: Understand the typical programming constructs: data (primitive and compound), control, modularity, recursion etc. thereby to understand a given program
CO2: Understand and analyse a given program by tracing, identify coding errors and debug them
CO3: Make use of the programming constructs appropriately and effectively while developing computer programs
CO4: Develop computer programs that implement suitable algorithms for problem scenarios and applications

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1							1	1	1		1			
CO2	1	1	1					1	1	1		1			
CO3	1	2	2					2	1	1		1			
CO4	2	3	2					3	1	1		1			

Syllabus

Unit 1
Introduction and Review of C language constructs. Functions – inter function communication, standard functions, scope. Recursion – recursive definition, recursive solution, designing recursive functions, limitations of recursion. Arrays – 1D numeric, searching and sorting, 2D numeric arrays.

Unit 2
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.

Unit 3
Structures: Structure vs array comparison, complex structures, structures and functions, Union. Files and streams, file input output, command line arguments.

Text Book
Behrouz A. Forouzan and Richard F. Filberg, "Computer Science A Structured Programming Approach Using C", Third Edition, Cengage Learning, 2006.

Reference Books
Byron Gottfried. Programming With C. Fourth Edition, McGraw Hill,; 2018
Brian W.Kernighan and Dennis M.Ritchie, "The C Programming Language", Second Edition, Prentice Hall, 1988.
Eric S. Roberts, "Art and Science of C", Addison Wesley, 1995.
Jeri Hanly and Elliot Koffman, "Problem Solving and Program Design in C", Fifth Edition, Addison Wesley (Pearson), 2007.

23PHY107	ENGINEERING PHYSICS C	L-T-P-C: 3-0-0-3	S1

Course Objectives

- To impart knowledge on the fundamental concepts of Classical and Modern Physics and its few applications in the field of Engineering.

Course Outcomes

At the end of the course the student will be able to
CO1: Understand the fundamental concepts of Newtonian mechanics, conservation laws and solve numerical problems.
CO2: Exposed to Special theory of relativity and its consequences while dealing with Relativistic speed.
CO3: Understand wave motion, its characteristics, conceptualize mathematically the wave equation, and apply in real life problems in sciences and engineering.
CO4: Introduced to basics of Quantum mechanics- formulation and basic applications in the field of science.
CO5: Comprehend the elements of Statistical mechanics and its applications to materials property.

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2								2			
CO2	3	3	2	2								2			
CO3	3	3	3	3								2			
CO4	3	3	2	3								2			
CO5	3	3	2	2								2			

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. Conservation of momentum. Conservation of energy. Elastic and inelastic collisions. Circular motion: Radial and tangential forces. Centripetal acceleration and centripetal force.

Unit 2
RELATIVISTIC MECHANICS: Inertial & non-inertial frames, Michelson- Morley experiment, Einstein's postulates. Lorentz transformation equations. Length contraction & Time dilation, Addition of velocities; Variation of mass with velocity Mass energy equivalence.

Unit 3
WAVE MOTION: Definition of a plane progressive wave. Attenuation of waves. Representation of waves using complex numbers. Differential equation of a plane progressive wave. Phase velocity. Phase and phase difference. Phenomenon of interference and diffraction- Solution of the differential equation of a plane progressive wave. Differential equation of 2-dimensional wave motion.

Unit 4
QUANTUM MECHANICS: Double slit experiment, Axioms of QM, Schrodinger equations, formulation and solution, operators, elementary applications- One dimensional potential well.

Unit 5
STATISTICAL MECHANICS: Microstates and macro states, Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics, Fermi level and its significance.

Text Book/ References
Richard Wolfson, "Essential University Physics", Vols. 1 and 2. Pearson Education, Singapore, 2011.
Halliday D., Resnick R. and Walker J., "Fundamentals of Physics", Wiley Publications, 2008.
Crawford Jr Waves, F.S. – "Berkeley Physics Course", 2008.
Beiser A., "Concepts of modern physics", McGraw-Hill India, 2006.
Sears and Zemanski, "University Physics", Pearson, 2011.

23MEE107	ENGINEERING MECHANICS	L-T-P-C: 3-1-0-4

S1

Course Objectives

- Inculcate the principles of statics and dynamics
- Comprehend and solve engineering mechanics problems using the principles of Coulomb friction
- Familiarize with the concept of centroid, first moment, second moment of area
- Impart knowledge on kinematics of particles and rigid bodies in motion

Course Outcomes

At the end of the course, the student will be able to

CO1: Determine rectangular components of a force
CO2: Derive the equivalent force - couple system
CO3: Analyse the equilibrium state of a particle and rigid body
CO4: Estimate the moment of inertia of composite areas
CO5: Determine the kinematic variables for rigid bodies in general plane motion.

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	2								1	3	1	
CO2	3	3	3	2								1	3	1	
CO3	3	3	3	2								1	3	1	
CO4	3	3	2	2								1	3	1	
CO5	3	3	3	2								1	3	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.

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. Method of virtual work for static equilibrium problems.

Unit 3

Dynamics of particles: kinematics of particles – rectilinear motion – relative motion – relative motion – position, velocity and acceleration calculation in cylindrical coordinates. Dynamics of rigid bodies: General plane motion – translation and rotation of rigid bodies – Chasle's theorem – velocity and acceleration calculation in moving frames – Corioil's acceleration.

Text Book

Beer,F.P. & Johnston,E.R., "Vector Mechanics for Engineers-Statics and Dynamics", Eleventh Edition, McGraw Hill International Book Co., 2017

Reference Books

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

23ARE101	COMPUTER AIDED DRAFTING	L-T-P-C:1-0-3-2	S1

Course Objectives

- Familiarize with the Computer Aided Drafting packages
- Introduce standards and codes in engineering drawings
- Provide hands on training to make the students proficient with 2D drafting of simple machine elements and assemblies

Course Outcomes

At the end of the course the student will be able to
CO1: Apply standard drawing codes and practices to produce engineering drawings
CO2: Construct 2D geometry with proper dimensioning using Computer Aided drafting software
CO3: Create 2D representations of 3D objects using CAD software
CO4: Develop isometric drawings using orthographic views

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	2	3	1	1	1		3	2	2	2
CO2	3	3	3	3	3	2	3	1	1	1		3	2	2	2
CO3	3	3	3	3	3	2	3	1	1	1		3	2	2	2
CO4	3	3	3	3	3	2	3	1	1	1		3	2	2	2

Syllabus

Unit 1
Drawing Standards - Introduction to CAD software – CAD user interface – Data input modes - Coordinate systems - Units and precision – Setting Limits and display units – Drawing templates - Features of GUI. Sketching basic geometric entities. Sketching simple geometric entities: points, lines, circles, arcs, ellipse, rectangle, polygons, polylines, splines – Use of object snaps - Practice exercises using simple geometric entities.

Unit 2
Modifying drawings: Move, copy, rotate and offset drawings; Mirroring, Scaling, Trim, extend, erase, explode - Fillet and chamfering – Rectangular, Polar and Path array - Drawing exercise: Sketching and modifying 2D drawings.

Unit 3
Drawing properties: Line type, Line weight, Object properties – Hatch and gradient – Working with Layers - Dimensioning and annotations – Adding tolerance to dimensions – Working with text and tables – Sketching with blocks and groups - Use of attributes – Working with external references – Layout, printing and publishing drawings - Exercise involving sketching 2D orthographic views of 3D geometries with dimensions and tolerances.
Introduction to 3D - Isometric drafting - Conversion of orthographic projections of simple components into isometric views. Creating 3D components and assembly.

Project: Students have to complete a project involving creating orthographic/ 3D views of the simple machine elements / assemblies such as centrifugal pumps, hydraulic cylinders, gear boxes etc. with dimensions following standard drawing practices using CAD software.

Text / Reference Books
James D Bethune, "Engineering Graphics with AutoCAD 2017", Pearson Education, 2018.
Gopalakrishna, K.R., and Sudheer Gopalakrishna "Computer Aided Engineering Drawing", Subhas Publications, 2015.
AUTO-CAD manual (In-House)

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

S1

Course Objectives

- 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 techniques of scanning for specific information, comprehension and organization of ideas
- To enhance their technical presentation skills

Course Outcomes

At the end of the course the student will be able to
CO1: To gain knowledge about the mechanics of writing and the elements of formal correspondence
CO2: To understand and summarize technical documents
CO3: To apply the basic elements of language in formal correspondence
CO4: To interpret and analyze information and to organize ideas in a logical and coherent manner
CO5: To compose project reports/ documents, revise them for language accuracy and make technical presentations

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1									2	3					
CO2				1					2	3					
CO3									2	3					
CO4				1					2	3					
CO5									2	3					

Syllabus

Unit 1
Mechanics of Writing: Grammar rules -articles, tenses, auxiliary verbs (primary & modal) prepositions, subject-verb agreement, 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 - Organising 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.

Reference Books
Hirsh, Herbert. L "Essential Communication Strategies for Scientists, Engineers and Technology Professionals". II Edition. New York: IEEE press, 2002
Anderson, Paul. V. "Technical Communication: A Reader-Centred Approach". V Edition. Harcourt Brace College Publication, 2003
Strunk, William Jr. and White. EB. "The Elements of Style" New York. Alliyan & Bacon, 1999.
Riordan, G. Daniel and Pauley E. Steven. "Technical Report Writing Today" VIII Edition (Indian Adaptation). New Delhi: Biztantra, 2004.
Michael Swan. '' Practical English Usage'', Oxford Univ. Press, 2000

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

S1

Course Objectives

- 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.

Course Outcomes

At the end of the course the student will be able to
CO1: Increase student understanding of true essence of India's cultural and spiritual heritage. Emancipating Indian histories and practices from manipulation, misunderstandings, and other ideological baggage thus, shows its contemporary relevance.
CO2: Understand the ethical and political strategic concepts to induce critical approach to various theories about India.
CO3: Familiarize students with the multi-dimension of man's interaction with nature, fellow beings and society in general.
CO4: Appreciate the socio-political and strategic innovations based on Indian knowledge systems. Gives an understanding of bringing Indian teaching into practical life

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1				2				2							
CO2		1				1	1	3							
CO3						1	2	3							
CO4	3					3	3	3							

Syllabus

Unit 1
Educational Heritage of Ancient India
Life and Happiness
Impact of Colonialism and Decolonization
A timeline of Early Indian Subcontinent

Unit 2
Pinnacle of Selflessness and ultimate freedom
Indian approach towards life
Circle of Life
Ocean of love; Indian Mahatmas.

Unit 3
Man's association with Nature
Celebrating life 24/7.
Metaphors and Tropes
Become A Strategic Thinker (Games / Indic activity)
India: In the Views of Other Scholars and Travellers

Unit 4
Personality Development Through Yoga.
Hallmark of Indian Traditions: Advaita Vedanta, Theory of oneness
Conversations on Compassion with Amma

Text Book
Foundations of Indian Heritage- In house publication

Reference Book(s)
The beautiful tree by Dharampal
Peasants and Monks in British India by William Pinch
India that is Bharat: Coloniality, Civilisation, Constitution by J Sai Deepak
Awaken Children Dialogues with Mata Amritanandamayi
Man and Nature by Mata Amritanandamayi Devi
What Becomes of the Soul After Death, Divine Life Society

23MAT128	LINEAR ALGEBRA	L-T-P-C: 2-1-0-3

Course Objectives

- Understand the basic concepts of vector space, subspace, basis and dimension.
- Familiarize with the inner product space, finding the orthogonal vectors using inner product.
- Understand and apply linear transform for various matrix decompositions.

Course Outcomes

At the end of the course the student will be able to
CO1: Understand the basic concepts of vector space, subspace, basis and dimension.
CO2: Understand the basic concepts of inner product space, norm, angle, orthogonality and projection and Gram-Schmidt process.
CO3: Understand the concepts of linear transformations, the relation between matrices and linear transformations.
CO4: Understand the concepts of Eigenvalues and Eigenvectors.
CO5: Understand various matrix decompositions like, QR, Jordan and SVD.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1									1	1		
CO2	3	3	2									1	1		
CO3	3	3	2									1	1		
CO4	3	2	1									1	1		
CO5	3	1	2									1	1		

Syllabus

Review: Matrices and System of linear Equations.

Unit 1
Vector Spaces: Vector spaces - Sub spaces - Linear independence - Basis - Dimension - Inner products - Orthogonality - Orthogonal basis - Gram Schmidt Process - Change of basis.
Orthogonal complements - Projection on subspace - Least Square Principle

Unit 2
Linear Transformations: Linear transformation - Relation between matrices and linear transformations - Kernel and range of a linear transformation.

Unit 3
Eigen values and Eigen vectors: Definitions and properties of eigenvalues and Eigen vectors. Positive definite, negative definite and indefinite. Diagonalization and Orthogonal Diagonalization. Properties of Matrices. Symmetric and Skew Symmetric Matrices, Hermitian and Skew Hermitian Matrices and Orthogonal matrices. Diagonalisation and its applications, Jordan form and rational canonical form and introduction to singular value decomposition.

Text Book
Howard Anton and Chris Rorrs, "Elementary Linear Algebra", Ninth Edition, John Wiley & Sons, 2000.

Reference Books:
D. Poole, Linear Algebra: A Modern Introduction, 2nd Edition, Brooks/Cole, 2005.
Gilbert Strang, "Linear Algebraand its Applications", Third Edition, Harcourt College Publishers, 1988.
Kenneth Hoffman and Ray Kunze, Linear Algebra, Pearsons, 2015.

23ARE111	THERMO-FLUIDS	L-T-P-C: 3-0-0-3	S2

Course Objectives

- To provide fundamental knowledge on ideal gas behaviour and properties of pure substance
- To familiarize energy balance equation, apply to closed and open system
- To impart basic understanding of fluid properties, fluid statics, kinematics, and dynamics
- To highlight different modes of heat transfer

Course Outcomes

At the end of the course, the student will be able to
CO1: Apply energy balance equation on steady flow devices to solve real time problems
CO2: Solve fluid flow problems by applying conservation of mass and momentum equations
CO3: Solve steady state heat conduction problems with different boundary conditions
CO4: Solve convection and radiation heat transfer problems

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	1									3		
CO2	3	3	1	1									3		
CO3	3	3	1	1									3		
CO4	3	3	1	1									3		

Syllabus

Unit I
Thermodynamics: Properties of an ideal gas and pure substance, systems and control volumes, properties of a system, state and equilibrium, process and cycles, temperature and the **zeroth law of thermodynamics**, temperature and pressure measurement, different forms of energy, the **first law of thermodynamics**, energy transfer by heat, work and mass, energy balance analysis for closed and open systems - steady flow devices, Introduction to the second law of thermodynamics – Kelvin Planck and Clausius statement.

Unit II
Fluid Mechanics: Properties of fluids - vapour pressure and cavitation, viscosity, coefficient of compressibility and coefficient of volume expansion, surface tension and capillarity; **Fluid statics** – hydrostatic force and centre of pressure; **Fluid Kinematics:** Lagrangian and Eulerian descriptions, types of fluid deformation; **Fluid Dynamics:** conservation of mass and momentum – linear momentum analysis.

Unit III
Heat Transfer: Different modes of heat transfer – **Conduction** - Fourier law, thermal conductivity and thermal diffusivity, solving one-dimensional steady state heat conduction equation with different boundary conditions; **Convection -** Newton's law of cooling – Forced and free convection, heat transfer coefficient, Nusselt number, Prandtl number, Reynolds number and Grashoff number; **Radiation -** Stefan- Boltzmann Law, emissivity, black and grey body emissive power, irradiation and radiosity, absorptivity, reflectivity, and transmissivity.

Text Book
Yunus A. Cengel., Robert H. Turner & John M. Cimbala., "Fundamentals of Thermal-Fluid Sciences", 5/e, McGraw Hill Edition, 2016.

Reference Books
Michael J. Moran & Howard N. Shapiro., "Fundamentals of Engineering Thermodynamics", 8/e, Wiley & Sons, 2018.
Pritchard, P.J, Fox &McDonald, "Introduction to Fluid Mechanics", 10/e, Wiley & Sons, 2021.
Frank P. Incropera, David P. DeWitt, Theodore L. Bergman & Adrienne S. Lavine., "Principles of Heat and Mass Transfer", global edition, Wiley & Sons, 2017

23EEE102	BASIC ELECTRICAL AND ELECTRONICS ENGINEERING	L-T-P-C: 3-0-0-3	S2

Prerequisite: Nil
Nature of Course: Theory

Course Objectives

- 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

CO1: Familiarize the basic concepts of electrical circuits.
CO2: Comprehend the study on construction and working of various electrical machines.
CO3: Illustrate the working of basic electronic circuits.
CO4: Develop various logic circuits for real-world applications.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2													
CO2	3	2													
CO3	3	2	1		1										
CO4	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.

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

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.

Unit 4
Introduction to microprocessor and microcontrollers. Case study on applications of microprocessors and microcontrollers.

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

Reference Books:

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

23CHY107	ENGINEERING CHEMISTRY C	L-T-P-C: 2-1-0-3	S2

Course objectives

- To impart strong foundation in physical and inorganic chemistry on concepts like gases and liquids, solid state, chemical equilibrium, electrochemistry, thermochemistry, and thermodynamics. Potential industrial applications of these topics will also be addressed briefly.

Course Outcomes

After the completion of this course, student will be able to
CO1: Analyse and predict the properties of system existing in gas, liquid and solid phase.
CO2: Apply the fundamental principles of electrochemistry to illustrate the functioning of electrochemical systems.
CO3: Predict the type of chemical reaction and the change in energy involved during the reaction.

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1													
CO2	3	1													
CO3	3	1													

Syllabus

UNIT 1
Gases and Liquids
The ideal Gas law – Applications – molar volume, density- mass. Mixtures of Gases - Chemical reactions and Stoichiometry – Kinetic and molecular theory – Real Gases.
Intermolecular forces - Structure property relationship based on intermolecular forces – solids, liquids and gases – molecular comparison, forces that hold condensed states – dipole-dipole, dipole-induced dipole, ion-induced dipole, ion-dipole, dispersion, hydrogen bonding. Intermolecular forces in action – surface tension, viscosity, capillary action, vapour pressure, boiling point and melting point. – sublimation and fusion - Heating Curve for water - Phase diagrams.

UNIT 2
Solid state
Crystalline and amorphous solids – Molecular Solids, Ionic Solids, Atomic Solids. crystal structure – unit cells – identification of crystal planes- the seven crystal systems and their Bravais lattices, X-ray diffraction - Bragg's equation and experimental methods (powder method and rotating crystal technique), metallic and ionic crystals - close packing of spheres – hexagonal, cubic and body centred cubic packing. Molecular crystals. Band theory.

UNIT 3
Chemical equilibrium
Balancing chemical equations –acid-base reaction, precipitation, redox reactions. Reaction stoichiometry – mole to mole conversion and mass to mass conversion- limiting reagent- yield calculation- solution stoichiometry.
Chemical equilibrium – dynamic equilibrium – equilibrium constant - Relationships Between the Equilibrium Constant and the Chemical Equation- predicting the direction of a reaction – finding equilibrium concentration - Le Chatelier's Principle – effect of change in mass, volume, pressure and temperature.

UNIT 4
Electrochemistry
Faradays laws, origin of potential, electrochemical series, reference electrodes, Nernst equation, Balancing oxidation–reduction Equations - Voltaic (or Galvanic) Cells - Electrochemical Cell Notation - Standard Electrode Potentials - Predicting the Spontaneity - Cell Potential, Free Energy, and the Equilibrium Constant - Concentration Cells, Batteries -Dry-Cell Batteries, Li-MnO_2 cell, lead acid batteries. Ni-Cd battery, Lithium ion batteries. Fuel cell - construction and working of PEMFC. Electrolysis - Stoichiometry of Electrolysis – Corrosion.

UNIT 5

Thermochemistry and Thermodynamics

First law of Thermodynamics - Quantifying Heat and Work - Measuring **Δ***E* for Chemical reactions: Enthalpy: Exothermic and Endothermic Processes - Stoichiometry – Thermochemical Equations - Constant-Pressure Calorimetry: Hess's law and other relationships - Enthalpies of reaction - Standard Heats of Formation.

Spontaneous and Nonspontaneous Processes - Entropy and the Second law of - Thermodynamics - Heat Transfer and Changes in the Entropy of the Surroundings - Gibbs Free Energy - Entropy Changes in Chemical reactions - Free Energy Changes in Chemical Reactions - Free Energy Changes for Nonstandard States: Free Energy and Equilibrium.

Text Books

Principles of Chemistry: A molecular approach, 3rd Edition. Nivaldo J Tro, Pearson Education, Inc.2016.

Elements of Physical Chemistry, (5th Edition), Peter Atkins and Julio de Paula, Oxford University Press, 2009.

Reference Books

Chemistry: The Molecular Nature of Matter and Change With Advanced Topics, (8 nd Edition), Martin S. Silberberg and Dr., Patricia Amateis, McGrawHill, 2017.

Chemistry, (8th Edition), Steven S. Zumdahl, Susan A. Zumdahl, Brooks/Cole Cengage learning, 2010.

Electrochemical Methods second edition, A.J. Bard and L.R. Faulkner, John Wiley and Son, 2001

23CSE118	PROGRAMMING IN C++	L-T-P-C: 2-0-3-3

S2

Course Objectives

- Learn Object-Oriented software using the Unified Modelling Language
- Create objects and interact among objects using C++
- Using ADT and STL for implementing data structures
- Solve problems in Object-Oriented way using appropriate tools like JIVE

Course Outcomes

At the end of the course, the student will be able to
CO1: Understand the object-oriented concepts
CO2: Design object-oriented systems using UML
CO3: Understand the creation and access of class and objects
CO4: Understand inheritance with the usage of early and late binding, exception handling and generic programming
CO5: Develop computer programs that implement suitable algorithms for problem scenarios and applications performance

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1							2	2				1	1
CO2	2	3	2	1	3				2	2				1	1
CO3	1	2	2	1					2	2				1	1
CO4	1	2	2	1					2	2				1	1
CO5	2	3	2	2	3				2	2				1	1

Syllabus

Unit 1
Structured to Object Oriented Approach by Examples.
Overview of Object-Oriented concepts: Encapsulation – Data Hiding – Reading and writing objects – Inheritance – Polymorphism.
UML and Object-Oriented software development: Use case diagrams as a functional model – Simple class design using class diagram.
Programming in C++: Objects as a group of variables –Classes as a named group of methods and data – Morphing from structures to classes – Input and Output – Access specifiers – Static members – This keyword – Using imperative part of C a recap.

Unit 2
Member functions: Accessor –Mutator and Auxiliary – Constructors – Copy Constructors and Copy Assignment operator – Destructors – New and Delete Operators – Overloading – Constant variables and methods.
Generalization using Class Diagram.
Inheritance: Handling Access and Specialization through Overriding –Visibility – Types of inheritance – Friend function and class – Type casting.

Unit 3
Aggregation and Composition using Class Diagram.
Polymorphism: Virtual Functions – Abstract Class and Virtual Function Tables – Exception Handling.
Revisiting Pointers: Pointers to Pointers – Pointers and String Array – Void Pointers and Function Pointers. Standard Template Library: Implementation of Stack, Queue, Hash Table and Linked Lists with STL.

Text Book / Reference Books
Walter Savitch, "Problem Solving with C++: Global Edition", 10th edition, Pearson Education, January 2018.
Bjarne Stroustrup, "Programming: Principles and Practice Using C++", Second edition, Addison Wesley, 2014.
Stanley B Lippman, Josee Lajoie, Barbara E. Moo, C++ Primer, Sixth edition, Addison Wesley, 2015.

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

S2

Prerequisite: Nil
Nature of Course: Laboratory

Course Objectives

- 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 Laboratory course, students will be able to:
CO1: Analyze the performance of electrical machines
CO2: Develop basic electronic & digital circuits for real-world applications
CO3: Implement basic programs in microprocessor

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1						1	1		1			
CO2	3	2	3	1	1				1	1		2			
CO3	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:
Alexander C K and Sadiku M N O, "Fundamentals of electric circuits", 5th edition, New York, McGraw-Hill, 2013.
Adel S. Sedra, Kenneth Carless Smith, Tony Chan Carusone, "Microelectronic Circuits" 7th Edition, Oxford University Press, 2020
Edward Hughes. "Electrical Technology".7th Edition, Pearson Education Asia,2011

H. List of Equipment required for meeting the COs

S. No.	List of Equipment
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

I. List of Exercises

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

23ARE112	MANUFACTURING PROCESS I	L-T-P-C: 1-0-3-2

S2

Course Objectives

- To impart the fundamental concepts in metal casting, metal forming, and joining process.
- To enable preparation of sand mould with proper gating and riser system.
- To provide basic skills in performing TIG / MIG welding process with the preparation of weld joints.
- To familiarize the press working processes such as blanking, bending, forming operation, and computing load calculation.

Course Outcomes

At the end of the course, the student will be able to:
CO1: Design and develop sand mould with gating and riser system for a given component with simple geometries/features.
CO2: Evaluate simple calculations in the sheet metal forming process
CO3: Select and perform a suitable welding process based on the given material and geometry.
CO4: Identify various casting, welding, and forming defects and provide remedies to prevent such defects.
CO5: Follow safety rules and good practices in casting, welding, and metals forming operations.

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1			2			3	2		1			3
CO2	2	2	1			2			3	2		1			3
CO3	3	1	1			1			3				2	1	3
CO4	3	1				1			3	2				2	2
CO5						2	1	1				1	1		

Syllabus

Introduction to manufacturing processes, classifications.

Casting processes: Introduction to sand casting process- principle, process parameters, classifications, casting equipment and tools, moulding, melting, pouring, finishing processes -defects- other casting processes- applications and limitations.

Bulk and sheet metal forming processes: Introduction, fundamentals of hot and cold working processes, development drawing of simple sheet metal object, sheet forming processes – equipment and tools, process parameters, characteristics, defects, applications and limitations.

Metal joining processes: Principles of arc welding, brazing, soldering, solid state joining processes – equipment and tools, defects, applications and limitations.

Lab Components
List of experiments but not limited to

Metal Casting Lab
- Design a pattern for a given component drawing
- Preparation of a mould for single piece pattern
- Preparation of a mould for a split pattern for the given component
- Melting and casting of aluminum metal
- Inspection for macroscopic casting defects

Welding Lab
- Study and practices in TIG welding process
- Study and practices in MIG welding process
- Weld quality inspection (NDT / DT)

Sheet Metal Working **S2**

- Conduct Metal Forming Press working operation
- Deep Drawing Operations and calculations
- Sheet metal layout design

Text Books

Serope Kalpakjian and Steven R. Schmid – 'Manufacturing Engineering and Technology' - Prentice Hall - 2013 - 7th Edition.
Mikell P. Groover, Fundamentals modern manufacturing: materials, processes, and systems, John Wiley & Sons, 2010, 4th Edition.

Reference Books

Roy A. Lindberg - 'Processes and Materials for Manufacture' - Prentice Hall of India Private limited – 2000.
Amitabh A. Ghosh and Ashok Kumar Mallik - 'Manufacturing Science' - Affiliated East-West, Press Private Limited – 2010.
E.Paul Degarmo, J.T.Black, Ronald A. Kohser, J. Temple Black, Materials and Processes in Manufacturing, Prentice hall Publications ,1997.
P. N. Rao. Manufacturing Technology – Volume I: Foundry, forming and Welding, Tata McGraw-Hill Education 2017 5th Edition.
P C Sharma, Text Book of Production Technology, S. Chand and Company Pvt Ltd. Publications,2014, 8Th Edition.

22ADM111	GLIMPSES OF GLORIOUS INDIA	L-T-P-C: 2-0-1-2	S2

Course Objectives

- 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 mankind, the current stature of Indian in the geopolitics and Indian approach to science and ecology.

Course Outcomes

At the end of the course the student will be able to
CO1: Recognise the call of Upanishads and outstanding personalities for confronting the wicked in the real world while admiring the valour, pursuit and divinity in both classical and historical female characters of India.
CO2: Introduce Acharya Chanakya, his works, and his views on polity and nation to find synchrony between public and personal life, alongside understanding India's cultural nuances and uniqueness concerning the comprehension of God across major global communities.
CO3: Appreciate Bhagavad Gita as the source of the Indian worldview through the various Yogic lessons enshrined in it, making it one of India's numerous soft powers, and understand the faith-oriented mechanism of preserving nature.
CO4: informed about the enormous contribution of Indian civilisation over two and half millennia to humanity, develop awareness about India's approach toward science, devoid of dogmas, and rooted in humanism.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1			1	2				2							
CO2	2	1				1		3	1						
CO3	2		1	2	1	1		3							
CO4	2			3				3	2						

Syllabus

Unit 1
Face the Brutes
Role of Women in India
Acharya Chanakya
God and Iswara

Unit 2
Bhagavad Gita: From Soldier to Samsarin to Sadhaka
Lessons of Yoga from Bhagavad Gita
Indian Soft powers
Preserving Nature through Faith

Unit 3
Ancient Indian Cultures (Class Activity)
Practical Vedanta
To the World from India (For Continuous Assessment)
Indian Approach to Science

Text Book / Reference Book(s)
Reference Course material
Textbook Name: Glimpses of Glorious India- In-house publication

22AVP103	MASTERY OVER MIND	L-T-P-C: 1-0-2-2	S2

Course Objectives

- 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 MAOM 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

At the end of the course, the student will be able to
CO01: To be able to describe what meditation is and to understand its health benefits
CO02: To understand the causes of stress and how meditation improves well-being
CO03: To understand the science of meditation
CO04: To learn and practice MAOM meditation in daily life
CO05: To understand the application of meditation to improve communication and relationships
CO06: To be able to understand the power of meditation in compassion-driven action

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1								1	2	2		2			
CO2			2		2				2	2		2			
CO3					2			2	2	2		2			
CO4			3		3		2	3	3	3		3			
CO5			2		2			2	2	3		3			
CO6			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 of meditation in improving relationship quality in the family, at the university and in the workplace. (Pre-recorded video with Dr Shobhana Madhavan)
Reading 1: Seppala E (2022, June 30th) 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 Amritanandamayi Mission 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 prosocial behavior: What do we (not) know?. Current Opinion in Psychology, 44, 151-156.
Reading 2: 'Sympathy and Compassion.' Chapter 100 in Amritam Gamaya (2022). Mata Amritanandamyi Mission Trust

Text Books/Reference Books:

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

23MAT209	DIFFERENTIAL EQUATIONS AND NUMERICAL METHODS	L-T-P-C: 3-0-3-4

Course objectives

- To model mechanical systems using differential equations.
- To analyse and solve ordinary differential equations using analytical and numerical techniques.
- To understand Fourier series and integral transforms and their applications to differential equations.
- To model physical problems using PDEs and to solve them using analytical and numerical techniques.

Course Outcomes

At the end of the course the student will be able to
CO1: Model and solve homogeneous and non-homogeneous first order ordinary differential equations corresponding to different practical scenarios.
CO2: Solve homogeneous linear second order ordinary differential equations corresponding to different practical scenarios.
CO3: Solve system of order ordinary differential equations corresponding to different practical scenarios
CO4: Find the Fourier series of functions of arbitrary period and Fourier and Laplace transforms of functions.
CO5: Learn modeling the wave equation, heat equation as partial differential equations and use Fourier series to obtain solutions to them.
CO6: Understand the numerical techniques to solve ODEs and PDEs.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	1					1	1		1			
CO2	3	3	2	1					1	1		1			
CO3	3	3	2	1					1	1		1			
CO4	3	2	1	2					1	1		1			
CO5	3	1	2	2					1	1		1			
CO6	3	1	2	2	2				1	1		1			

Syllabus

Unit 1
First order ODE: Ordinary Differential Equations – Basic concepts, modelling, first order ODEs, exact ODEs, integrating factors.
Second order ODE: Homogeneous linear ODEs, Euler-Cauchy equations, existence and uniqueness of solution, Wronskian, non-homogeneous ODEs, variation of parameters. Modelling of free and forced oscillations of spring-mass system.

Unit 2
Higher order ODEs, homogeneous and nonhomogeneous linear ODEs. System of ODEs – Phase space. 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.

Unit 3
Partial differential equations – Basics of PDEs. Modelling of vibrating string, wave equation, solution by separation of variables, D'Alembert's solution, Heat flow modelling, heat equation, solution of heat equation by Fourier series, heat equation in very long bars.
Numerical methods for System of nonlinear equations. System of linear equations, LU, QR and SVD.
Numerical Solution of Differential Equations: Euler's method, Runge-Kutta method, systems of equations, Finite difference method, solution of Laplace equation by FDM, explicit methods for parabolic equations, simple implicit method, Crank-Nicolson method.

Text Book
Advanced Engineering Mathematics, Erwin Kreyszig, 10th Edition, Wiley, 2011.

Reference Books

Engineering Mathematics', Srimanta Pal and Subhodh C Bhunia, John Wiley and Sons, 2012, Ninth Edition.
Advanced Engineering Mathematics by Dennis G. Zill and Michael R.Cullen, second edition, CBS Publishers, 2012
Numerical Methods for Engineers, Steven Chapra and Raymond Canale, 7th Edition, McGraw Hill, 2015.
Numerical Methods in Engineering with Python, Jaan Kiusalaas, Cambridge University Press, 2010.

23ARE201	ROBOT KINEMATICS	L-T-P-C: 3-0-3-4

S3

Course Objectives

- Familiarize with fundamental definitions and classification of robotic arms
- Perform kinematic synthesis and analysis of planar mechanisms serial and parallel robotic manipulators
- Perform kinematic analysis using software package

Course Outcomes

At the end of the course the student will be able to
CO1: Classify and solve for mobility of planar mechanisms, and understand robot anatomy
CO2: Perform forward and inverse kinematics of serial robot manipulator
CO3: Compute Jacobian matrix and solve the singularity problems of serial robot manipulators
CO4: Analyse different types of gear trains
CO5: Model and analyse planar mechanisms using software package

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	1					1	1		1	2		
CO2	3	3	2	1	1				1	1		1	3	2	
CO3	3	3	2	1	1				1	1		1	3	2	
CO4	3	3	2	1					1	1		1	3	2	
CO5	3	3	2	1	3				1	1			2	2	

Syllabus

Unit 1
Review of kinematics of robotic systems, Robot classification, Robot anatomy.
Definitions- link, kinematic pair, kinematic chain. Degrees of freedom - mobility –Kutzbach criterion - Grashoff's law. Kinematic inversions - - mechanical advantage - transmission angle. Rotation matrix, Euler angles, Quaternions, Homogeneous transformation, DH parameters, Joint space and Operational space, forward and Inverse Kinematics of 2-link and 3-link robot manipulators, work volume simulation. Degrees-of-freedom of parallel mechanisms and manipulators, Active and passive joints.

Unit 2
Robot Statics: Geometric Jacobian, Jacobian Computation, kinematic singularities, Analysis of redundancy, Analytical Jacobian, Inverse Kinematics algorithms, Statics, Kineto-static duality, Velocity and force transformations.
Robotic Drives: Gears – terminology, fundamental law of gearing, involute profile. Interference and undercutting, minimum number of teeth, contact ratio, bevel helical, spiral and worm gears. Gear Trains – simple, compound and epicyclic gearbox for robotics. Cams – classification of cams and followers, nomenclature, description and analysis of follower motion, pressure angle.

Unit 3
Mechanisms - quick return - pantograph - straight line-Ackermann - Shaping machine- Hooke's joint - Toggle Analysis of slider crank and four bar mechanisms - Graphical method for position, velocity, and acceleration. Instantaneous centre - velocity analysis - Kennedy's theorem. - Coriolis component of acceleration – graphical approach for quick return mechanism. Analysis of complex mechanisms Loop closure method, Synthesis of mechanisms – dimensional and three-point synthesis computer programs for analysis of mechanisms – numerical solution of loop closure equations. Inverse kinematics of parallel manipulators and mechanisms, Direct kinematics of Gough-Stewart platform.

Lab session (ADAMS/RoboAnalyzer software/ MAKEIT Tool kit)
- Visualization of DH parameters and reach of manipulators
- Determination of work volume based on the DH parameters
- Singularity analysis using Robot simulator
- Verification of position and orientation of gripper
- Study of different R-P serial manipulator configurations of 3, 4, 5 and 6 dof robot
- Design and Motion study of Stewart platform using various configurations (Spherical, Planar, Rotation)

- Draw the work envelope for Five bar closed loop mechanisms (Parallel Manipulator)
- Modelling and analysis of mechanisms viz. slider crank mechanism and its inversions, four bar mechanism and its inversions, 6 bar chains, crank and slotted lever and Whitworth quick return mechanism
- Modelling and analysis of Cam mechanism, gear drives
- Demonstration of mechanism using the Tool kit

Text Books

Robert J. Schilling, Fundamentals of Robotics Analysis and Control, PHI Learning, 2009.
Craig J. J., Introduction to Robotics: Mechanics and Control, 3rd Edition, Addison-Wesley, Reading, MA, 2005
Uicker, John Joseph, Gordon R. Pennock, and Joseph Edward Shigley. Theory of machines and mechanisms. Vol. 1. New York, NY: Oxford University Press, 2011.
Norton, Robert L. Kinematics and dynamics of machinery. McGraw-Hill Higher Education, 2011.

Reference Books

Ghosh, Amitabha, and Asok K. Mallik.Theory of mechanisms and machines.Affiliated East-West Press Private Limited, 2002.
Rattan, Sarjit S. Theory of machines.Tata McGraw-Hill Education, 2014.

23ARE202	MECHANICS OF MATERIALS	L-T-P-C: 3-0-3-4	S3

Course Objectives

- Inculcate the theory of linear elastic response of materials
- Enable the student to understand, evaluate, and analyze strength and deformation of structures under various elastic loading conditions, like, axial, torsional, and bending
- Familiarize the student on various causes of instability in structures
- To equip students with the skills to determine the mechanical properties of engineering materials

Course Outcomes

At the end of the course, the student will be able to
CO1: Apply the fundamental principles to estimate the deformation and stress of linear elastic solids under axial loading.
CO2: Establish the stress -strain relationship for different materials and evaluate their mechanical properties using standard material testing procedures.
CO3: Estimate stress developed in shafts due to torsional loading and perform torsional test to determine the torsional strength.
CO4: Construct shear force and bending moment diagrams, to estimate the deflection and stress distribution in beams of various cross sections.
CO5: Analyze stresses at inclined planes and construct Mohr's circle to predict the principal and maximum shear planes.
CO6: Apply Euler's and Rankine's formulae to determine the buckling load of columns under different end conditions

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2						1	1		1	3	1	1
CO2	3	3	2						1	1		1	3	1	1
CO3	3	3	2						1	1		1	3	1	1
CO4	3	3	2						1	1		1	3	1	1
CO5	3	3	2						1	1		1	3		
CO6	3	3	2						1	1		1	3		

Syllabus

Unit 1
Introduction, Properties of Materials, Elastic deformation, stress-strain behaviour, stress strain diagram for structural steel and nonferrous materials, Hook's law, Poisson's Ratio, elastic properties of materials, tensile properties-tensile, yield and ductility, Hardness -Brinell, Knoop and Vickers hardness tests, correlation between hardness and tensile strength. Simple Stress and Strain: Principles of superposition, Stress and strain in composite and tapering sections, statically indeterminate structures, Thermal stresses. Torsion of circular shafts: Introduction – Pure torsion - torsion equation of circular shafts, Torsional rigidity and polar modulus, strength and stiffness considerations, Power transmitted by shaft of solid and hollow circular sections.

Unit 2
Bending moment -Types of beams loadings and supports, - Bending moment, Sign convention, Relationship between loading, shear force and bending moment, 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, theory of simple bending, bending stress in beams, Deflection of beams-basis of beam design.

Unit 3
Compound Stresses: Introduction, Stress components on inclined planes, General two-dimensional stress system, Principal planes and stresses, Mohr's circle of stresses. Buckling of columns-critical load, columns with various supports, concentric and eccentric loading.

Lab Exercises:
Tensile testing on metals - Impact tests - Test on springs (closed coil and open coil) – Torsion test on mild steel rods - Static bending test on beams - Tensile test on thin wires - Double shear test on mild steel rods - Compression test – Deflection Tests, Hardness Measurement.
Numerical computation of moments and stresses in beams- Introduction to finite element analysis, types of elements- simple applications using bar and beam elements.

Text / Reference Books

Ferdinand Beer & Russell Johnston - 'Mechanics of Materials' - Tata Mc Graw Hill – 2016, 7th Edition.
Callister W. D. - 'Materials Science and Engineering' - John Wiley & Sons – 2010 - 8th Edition
James M. Gere, Barry J. Goodno- 'Mechanics of Materials' - Cengage Learning Custom Publishing – 2014, 8th Edition.
R. C. Hibbeler, - 'Mechanics of Materials' - Prentice Hall - 2017 - 10th Edition
Egor. P. Popov -'Engineering Mechanics of Solids' - Pearson Edu. India - 1998 - 2nd Edition Mubeen - 'Mechanics of Solids' - Pearson India - 2012 - 2nd Edition,

23ARE203	MANUFACTURING PROCESSES II	L-T-P-C: 1-0-3-2	S3

Course Objectives

- To impart knowledge on metal cutting principles, mechanisms, and their influence on machining characteristics.
- To inculcate machining skill by operating the metal cutting machines independently and machining a given component using suitable machining processes like lathe, milling, slotting, shaping, and grinding machines.
- To imbibe interpretation skill on machining characteristic of machine tool based on outcome and measure the cutting forces using cutting tool dynamometers for a machining process.

Course Outcomes

At the end of the course, the student will be able to:
CO1: Explain the principle of operation, tooling required and interpret machining characteristics for a given machining process.
CO2: Perform machining of a component with proper selection of machining parameters, cutting tools, and accessories using a suitable machining process.
CO3: Measure the various geometry of machined surfaces using suitable measuring instruments.
CO4: Evaluate the power required for machining a given component by measuring cutting forces using tool dynamometers.
CO5: Follow safety rules and good practices in machining operations.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1			2			3	2		1			2
CO2	2	2	1			2			3	2		1			2
CO3	3	1	1			1			3	2			2		3
CO4	3	1				1			3	2			1		2
CO5						2	1	1	3	2		1			

Syllabus

Metal cutting Principles: Introduction**,** Types of metal cutting processes, Mechanism of chip formation - Forces and temperature in metal cutting, Tool wear, Tool life - Machinability and surface finish, cutting tool materials and cutting fluids. Study of machining characteristics like material removal rate, tool wear, surface finish and tolerances

Cylindrical Surface Machining: - Turning and drilling processes, machine tools, types, accessories and tools, process parameters, machining characteristics, applications and limitations,

Flat and Profile Machining: Milling, shaping and slotting processes, machine tools, types, accessories and tools, process parameters, machining characteristics, applications and limitations,

Finishing Processes: Theory of grinding process - fundamentals of abrasives – grinding wheels- grinding operations and machines, superfinishing processes, applications and limitations

Measuring instruments: Linear, angular and profile measuring instruments- types and its measurements, force measurement – lathe and milling tool dynamometers

Lab Component
List of experiments

- Development of process plan, selection of tooling for machining a given component
- Study and practice of metal cutting operations in lathe
- Study and practice of metal cutting operations in milling machines,
- Study and practice of metal cutting operations in drilling and Tapping
- Study and practice of metal cutting operations in slotting and shaping
- Study and practice of metal cutting operations in grinding process
- Selection of optimum process parameter for anyone manufacturing process based on surface finish and tool wear/Material Removal Rate (MRR)
- Measurement of cutting forces using cutting tool dynamometer

Text Books

Serope Kalpakjian and Steven R. Schmid - ''Manufacturing Engineering and Technology' - Prentice Hall - 2013 - 7th Edition
Mikell P. Groover, Fundamentals modern manufacturing: materials, processes, and systems, John Wiley & Sons,2010, 4th Edition.

Reference Books

Hajra Choudhury S. K., Hajra Choudhury A. K., Roy N. - 'Elements of Workshop Technology' Media Promotors & Publishers Pvt. Ltd. - 2010 - Vol.II: Machine Tools, 13e.
Jain R. K. and Gupta S. C. - 'Production Technology' - Khanna Publishers – 2008.
E.Paul Degarmo, J.T. Black, Ronald A. Kohser, J. Temple Black, Materials and Processes in Manufacturing, Prentice hall Publications ,1997.
Amitabh A. Ghosh and Ashok Kumar Mallik - 'Manufacturing Science' - Affiliated East-West, Press Private Limited – 2010
'H.M.T. Production Technology: Hand book` - Tata McGraw-Hill Publishing Company Limited – 1990.
P. N. Rao. Manufacturing Technology – Volume II: Metal Cutting and Machine tools, Tata McGraw-Hill Education 2013 4th Edition.

23ARE204	ACTUATORS AND DRIVES	L-T-P-C: 3-0-0-3	S3

Course Objectives

- 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

At the end of the course, the student will be able to
CO1: Understand the concepts of hydraulic, pneumatic and electrical actuators to industrial applications.
CO2: Determine the specifications of hydraulic, pneumatic actuators for a given application.
CO3: Evaluate the performance characteristics of electrical actuators.
CO4: Select suitable actuators and drives for robotics and automation applications.
CO5: Analyze the performance characteristics of drives for different actuators.

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3										1	1		
CO2	3	3							1			1	1		
CO3	3	3	1									1	1		
CO4	3	3	1						1			1	1		
CO5	3	3	2		1				1			1	1	1	1

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.

Text / Reference Books
S. R. Deb; Sankha Deb. Robotics Technology and Flexible Automation, Second Edition McGraw-Hill Education: New York, 2010.
Kothari D.P. and Nagrath I.J., "Electric Machines", Tata McGraw-Hill Publishing Company Limited, New Delhi, 2004.
Gopal K. Dubey, Fundamentals of Electrical Drives, Narosa Publishing House, 2016.
Nathan Ida, Sensors, Actuators, and Their Interfaces- A multidisciplinary introduction, 2nd Edition, IET Digital Library, 2020.
Pillay. S.K, A First Course on Electric Drives, Wilely Eastern Limited, Bombay, 2012
Stephen J. Chapman, 'Electric Machinery Fundamentals'4th edition, McGraw Hill Education Pvt. Ltd, 2010.
Jagadeesha T., "Hydraulics and Pneumatics", 1st edition, I K International Publishing House, New Delhi, 2015.

23CSE109	PYTHON PROGRAMMING	L-T-P-C: 0-0-3-1

S3

Course Objectives

- Introduce the python language, its modules system, its recommended programming styles and idioms
- Demonstrate problem solving using Python language
- Demonstrate principles of object oriented programming in a well-written modular code

Course Outcomes

At the end of the course, the student will be able to
CO1: Understand the given programming language constructs.
CO2: Develop simple programs with scripts and control statements.
CO3: Analyse the structures of list, tuples and maintaining dictionaries.
CO4: Apply advanced libraries for real-time applications.

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	0	3				1	1		1		1	
CO2	3	2	2	0	3				1	1		1		1	
CO3	3	2	2	0	3				1	1		1		1	
CO4	3	2	2	0	3				1	1		1		1	

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: variables, assignments; immutable variables; numerical types; arithmetic operators and expressions; comments in the program; understanding error messages; Conditions, boolean logic, logical operators: ranges; Control statements: if-else, loops (for, while); short-circuit (lazy) evaluation.

Unit 2
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). Lists, tuples, and dictionaries: basic list operators, replacing, inserting, removing an element; searching and sorting lists; dictionary literals, adding and removing keys, accessing and replacing values; traversing dictionaries.

Unit 3
Design with functions: hiding redundancy, complexity; arguments and return values; formal vs actual arguments, named arguments. Recursive functions. Use of popular Python packages for scientific computing: Exercises to understand usage of libraries like *Numpy, SciPy, Pandas, Scikit-learn* in interpreted and script modes.

Lab 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. Creating arrays and operations on arrays
5. Writing programs on file handling
6. Graph plot using libraries
7. Programs on Engineering applications using SCIPY
8. Python Class Project using libraries
9. Introduction to Data Science through PANDAS

Text Books & References

Guttag, John, Introduction to Computation and Programming Using Python: With Application to Understanding Data, Second Edition. MIT Press, 2016. ISBN:9780262529624.
William McKinney, Python for Data Analysis: Data Wrangling with Pandas, NumPy, and Ipython, Second edition, Shroff/O'Reilly, 2017. ISBN-10: 9789352136414.
Shai Shalev-Shwartz and Shai Ben-David, Understanding Machine Learning, First Edition, Cambridge University Press, 2014. ISBN-10: 1107057132.

22ADM211	LEADERSHIP FROM RAMAYANA	L-T-P-C: 1-0-0-1	S3

Course Objectives

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.

Course Outcomes

At the end of the course the student will be able to
CO1: Appreciate the significance of *Rāmāyaṇa* as an *itihāsa,* and important aspects of *Bālakāṇḍa*.
CO2: Understand the family values and ideal human relationships portrayed in the *Ayodhyakāṇḍa* and *Aranyakāṇḍa* of *Rāmāyaṇa*.
CO3: Understand *dharma* and its nuances, emphasizing its applicability in an individual's life through *Kishkindhakāṇḍa* and *Sundarakāṇḍa* of Ramayana.
CO4: Appreciate the triumph of *dharma* over *adharma* through *Yuddhakāṇḍa* of *Rāmāyaṇa*
CO5: Appreciate the spiritual values from *Rāmāyaṇa* in resolving personal and social conflicts through varied effective presentations of important episodes of the *Rāmāyaṇa.*

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1						2	2	3	3	3		3			
CO2						3	3	3	3	2		3			
CO3						3	2	3	3	3		3			
CO4						3		3	3	3		3			
CO5						3		3	3	2		3			

Syllabus

Unit 1
An overview of Valmiki's epic. Introdcution to the content and structure of the epic text and it's principal characters.
Bala-Kāṇḍa: Preparing for the renowned mission.

Unit 2
Ayodhya-Kāṇḍa: Harbinger of an Entire Tradition of Nobleness.
Araṇya-Kāṇḍa: Tale of the forest life.

Unit 3
Kishkindha-Kāṇḍa: The Empire of Holy Monkeys.
Sundara-Kāṇḍa: Heart of the Ramayana

Unit 4
Yuddha-Kāṇḍa:The most popular part of the Ramayana
Uttara-Kāṇḍa: An attempt to explain the untold stories.

Unit 5
Ramayana and Modern-day learning
Ecological Awareness in the Ramayana
Different Ramayana: Epic that connects the world.

Text Books / References
Leadership Lessons from the Ramayana, ASCSS
Rajagopalachari. C, The Ramayana
Valmiki, The Ramayana, Gita Press

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

S3

Course Objectives

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

Course Outcomes

At the end of the course, the student will be able to
CO1: Understand aspects of nature and environment
CO2: Analyse impact of environment on human world
CO3: Comprehend pollution control and waste management

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1						3	2	3				1			
CO2						3	2	3				1			
CO3						3	2	3				1			

Syllabus

Unit 1
Over view of the global environment crisis – Biogeochemical cycles – Climate change and related international conventions and treaties and regulations – Ozone hole and related International conventions and treaties and regulations – Overpopulation – energy crisis – Water crisis – ground water hydrogeology – surface water resource development.

Unit 2
Ecology, biodiversity loss and related international conventions – treaties and regulations – Deforestation and land degradation – food crisis – water pollution and related International and local conventions – treaties and regulations – Sewage domestic and industrial and effluent treatment – air pollution and related international and local conventions – treaties and regulations – Other pollution (land, thermal, noise).

Unit 3
Solid waste management (municipal, medical, e-waste, nuclear, household hazardous wastes) – environmental management – environmental accounting – green business – eco-labelling – environmental impact assessment – Constitutional – legal and regulatory provisions – sustainable development.

Text / Reference Books
R. Rajagopalan, "Environmental Studies – From Crisis to Cure", Oxford University Press, 2005,
G.T.Miller Jr., "Environmental Science", 11th Edition, Cenage Learning Pvt. Ltd., 2008.
Benny Joseph, "Environmental Studies", Tata McGraw-Hill Publishing company Limited, 2008.

23LSE201	LIFE SKILLS FOR ENGINEERS I	L-T-P-C: 1-0-2-P/F	S3

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

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1								2	3	3		3
CO2									2	3		3
CO3		3		2								
CO4		3		2								
CO5										3		3
CO6									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

23MAT223	PROBABILITY AND STATISTICS	L-T-P-C: 3-1-0-4	S4

Course Objectives

- To understand the concept of probability and to model engineering problems.
- To understand discrete and continuous random variables and to compute important measures.
- To carry out various statistical tests and to draw practical inferences.

Course Outcomes

At the end of the course the student will be able to
CO1: Understand the basic concepts probability theory.
CO2: Understand and apply various statistical distributions to the automation problems
CO3: Understand and apply the concepts of correlation and regressions for given data.
CO4: Gain knowledge about sampling distributions and estimations.
CO5: Understand the concepts of the testing of hypotheses for small and large samples.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	1											
CO2	3	3	1	1											
CO3	2	2	3	1											
CO4	2	2	1	1											
CO5	2	2	1	1											

Syllabus

Unit-1
Probability Theory: Probability concepts, conditional probabilities, Bayes' Theorem. Random Variable and Distributions: Introduction to random variable – discrete and continuous distribution functions- mathematical expectations – moment generating functions and characteristic functions. Binomial, Poisson, Exponential, Normal distribution functions (MGF, mean, variance and simple problems) – Chebyshev's theorem

Unit-2
Two Dimensional Random Variable: Joint, marginal and conditional probability distributions for discrete case. Simple linear Regression, Properties of least square estimators, least squares method for estimation of regression coefficients, Correlation, properties of correlation coefficient.

Unit-3
Sampling Distributions: Distributions of Sampling Statistics, Chi-square, t and F distributions (only definitions and use). Central Limit Theorem. Theory of estimation: Point Estimation, Unbiased estimator- Maximum Likelihood Estimator- Interval Estimation.
Testing of Hypothesis: Large and small sample tests for mean and variance – Tests based on Chi-square distribution.

Text Books
Douglas C. Montgomery and George C.Runger, Applied Statistics and Probability for Engineers, (2005) John Wiley and Sons Inc

Reference Books
J. Ravichandran, "Probability and Random Processes for Engineers", First Edition, IK International, 2015.
Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers and Keying Ye, Probability and Statistics for Engineers and Scientists, 8th Edition (2007), Pearson Education Asia.
Sheldon M Ross, Introduction to Probability and Statistical Inference, 6th Edition, Pearson.

23ARE211	SENSORS AND SIGNAL PROCESSING	L-T-P-C: 3-0-3-4	S4

Course Objectives

- To learn about the basics and performance of measurement systems
- To learn in detail about different sensors
- To learn about signal conditioning circuits
- To learn about various digital signal processing techniques

Course Outcomes

At the end of the course, the student will be able to
CO1: Identify the functional elements, concepts and performance of various measurement systems
CO2: Evaluate the performance characteristics of different types of sensors and transducers for robotic applications.
CO3: Perform preprocessing of signals for improving the quality of the sensor signature.
CO4: Analyze the sensor signatures in time domain and extract frequency components.
CO5: Select suitable sensor and associated signal processing methods for applications in robotics and automation.

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3							1	1					
CO2	3	3							1	1					
CO3	3	3	1						1	1					
CO4	3	3	1		1				1	1					
CO5	3	3	1	1	2				1	1			1	1	1

Syllabus

Unit 1
Measurements and measuring systems: Methods of Measurement-Instruments- Classification of Instruments-Functions of instruments and measurement Systems-Elements of a generalized measurement system. Measurement system performance: Static characteristics- Dynamic characteristics. Errors in measurement and their statistical analysis.

Unit 2
Sensors/Transducers: Definition, Types, Basic principle and applications. Potentiometers - Inductance transducers - Capacitance transducers - Piezoelectric transducers - Hall effect transducers - rotary encoders – Accelerometers – Gyroscope. Photo Diode/ Photo Transistor as sensors, LVDT, Strain Gauge, Tactile, IR and Ultrasonic sensors. Vision and motion Sensors. Digital transducers: Principle and Construction. Temperature, Flow, velocity, pressure, displacement, position, force and torque measurement.

Unit 3
Signal Conditioning: Need for pre-processing, identification of signal conditioning blocks and their characteristics. Analysis of DC and AC bridges. Offset and drift compensation circuits. Introduction to Active filters. First order, Second order and higher order filters. Necessity and applications of isolation amplifiers, Grounding and Shielding. Digital Signal Processing: Discrete Sequences and Systems, Periodic Sampling, Discrete Fourier Transform, Fast Fourier Transform. Analog to digital conversion.

Lab Experiments: Sensor and associated signal conditioning circuits for applications in robotics and automation will be studied through the following experiments on sensors as listed below:

1. Calibration curve and time constants (for sensors: mercury in glass thermometer, bimetal dial thermometer, RTD, thermistor and thermocouple)
2. Seebeck effect for thermocouple
3. Temperature transmitter and its calibration
4. Study and calibration of displacement sensors: LVDT and potentiometer
5. Study of Strain Gauge
6. Study of accelerometer and gyroscope
7. Vision based sensing
8. Ultrasonic, IR and Hall effect sensor-based proximity and range sensing

9. Analog to digital and digital to analog conversion.
10. Experimentation with Active Filters
11. Experimentation with DC bridge
12. Experimentation with AC bridge
13. Implementation of convolution and digital filters (Can be done with Raspberry Pi on any analog signal acquired using ADC)
14. Fourier Transforms (Can be done with Raspberry Pi on any analog signal acquired using ADC)

Text / Reference Books

Doebelin, E.O. and Manic, D.N., "Measurement Systems: Applications and Design", 7th Edition, McGraw Hill, 2019.
Richard G. Lyons, "Understanding Digital Signal Processing", 3rd Edition, Pearson, 2011.
A.K. Sawhney, "A Course in Electronic Measurements and Instrumentation", Dhanpat Rai & Co. (P) Limited, 2015.
Murthy, D.V.S., "Transducers and Instrumentation", 2nd Edition, Prentice Hall of India, 2011.
Nakra, B.C. and Chaudhry, K.K., "Instrumentation, Measurement and Analysis", 4th Edition, Tata McGraw Hill, 2016.
Curtis D Johnson, "Process Control Instrumentation Technology", 8th Edition, Pearson Education India, 2015.

23ARE212	ROBOT DYNAMICS	L-T-P-C: 3-0-0-3	S4

Course Objectives

- Learn the basic principles of Newtonian and Lagrangian dynamics
- Understand advanced principles in the kinematic and kinetic analysis of rigid bodies in planar motion
- Familiarize with the three-dimensional dynamics

Course Outcomes

At the end of the course, the students will be able to
CO1: Perform kinematic and kinetic analysis of particles
CO2: Perform kinematic and kinetic analysis of planar rigid bodies
CO3: Apply principles of three-dimensional dynamics of rigid bodies to solve engineering problems
CO4: Use multi-body dynamic approach to solve dynamics of rigid bodies.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	1	1							1	2	2	
CO2	3	3	2	1	1							1	2	2	
CO3	3	3	2	1	1							1	2	2	
CO4	3	3	2	1	1							1	2	2	

Syllabus

Unit 1
Kinematics of particles: Rectilinear and plane curvilinear motion- description in rectangular coordinate system-path coordinate (normal-tangential)- polar coordinates system, Space curvilinear motion – rectangular, spherical and cylindrical coordinates systems
Kinetics of particles: Newton's second law- constrained and unconstrained motion-rectilinear and curvilinear motion, Work Energy method - potential energy, Impulse momentum methods- Linear and angular impulse and momentum, Special cases-impact--Relative motion, D'Alembert's Principle

Unit 2
Introduction to Lagrangian dynamics: generalised coordinates and Generalised forces
Generalisation to a system of particles**:** Newtons' second law, Work energy method, Impulse-Momentum method, Conservation of energy and Momentum

Unit 3
Robot Dynamics: Lagrange formulation, Computation of kinetic and potential energies, link inertia Tensor, Jacobian inertia tensor, Newton-Euler and Lagrange-Euler Dynamic models, Dynamic model of 2-link and 3-link robot manipulators.
Plane kinetics of Rigid body: Equations of motion, Work-energy relations, Acceleration from Virtual work methods, Impulse and momentum-interconnected rigid bodies, conservation of momentum and impact of rigid bodies

Unit 4
3D Dynamics of rigid bodies: Kinematics – Translation, Fixed axis rotation, Parallel plane motion, Rotation about fixed point, general motion – translating and rotating reference axis., Kinetics – Angular Momentum, Momentum and Energy equations of motion, Gyroscopic Motion – Steady precession, Simplified approach, Direct dynamics and inverse dynamics, Operational space dynamic model of robotic manipulators.

Text / Reference Books
Engineering Mechanics Dynamics, J.L Meriam and L.G Kraige, 7Ed. John Wiley and Sons.
Engineering Mechanics, Statics and Dynamics, Irving H Shames, 4Ed., Pearson Education.
Engineering Mechanics, Statics and Dynamics, C.Lakshmana Rao, J. Lakshminarayanan, Raju Sethuraman, S.M. Sivakumar, 1Ed. PHI.
Computational dynamics, Shabana, Ahmed A, John Wiley & Sons, 2009.
Fundamentals of multibody dynamics: theory and applications, Amirouche, Farid. Springer Science & Business Media, 2007.

23ARE213	ADDITIVE MANUFACTURING	L-T-P-C: 1-0-3-2	S4

Course objectives

- To provide comprehensive knowledge of the wide range of additive manufacturing processes, capabilities and materials
- To make the students understand the various software tools and techniques that enable advanced/additive manufacturing and personal fabrication.
- To make the students learn to create physical objects that satisfies product development/prototyping requirements, using /additive manufacturing processes.

Course Outcomes

At the end of the course the students will be able to
CO1: Demonstrate appropriate levels of understanding on the principles of additive manufacturing processes
CO2: Select the suitable materials for different additive manufacturing processes and applications.
CO3: Apply suitable CAD tools for effective interfacing with additive manufacturing systems..
CO4: Identify suitable additive manufacturing process, define optimum process parameters, and develop physical prototypes using suitable additive manufacturing systems

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	1	1							1	2	2	
CO2	3	3	2	1	1							1	2	2	
CO3	3	3	2	1	1							1	2	2	
CO4	3	3	2	1	1							1	2	2	

Syllabus

Unit 1
INTRODUCTION: METHODS AND SYSTEMS: Introduction to layered manufacturing, Importance of Additive Manufacturing Additive Manufacturing in Product Development
Classification of additive manufacturing processes, Common additive manufacturing technologies; Fused Deposition Modeling (FDM), Selective Laser Sintering(SLS), Stereo Lithography(SLA), Selection Laser Melting (SLM), Jetting, 3D Printing, Laser Engineering Net Shaping (LENS), Laminated Object Manufacturing (LOM), Electron Beam Melting (EBM), Wire Arc Additive Manufacturing(WAAM), Electro Chemical AM, 4D Printing.
Capabilities, materials, costs, advantages and limitations of different systems.

Unit 2
MATERIAL AND PROCESS EVALUATION: Material science for additive Manufacturing-Mechanisms of material consolidation-FDM, SLS, SLM, 3D printing and jetting technologies. Polymers coalescence and sintering, photopolymerization,

Unit 3
CAD in Additive Manufacturing: AM Software: data formats and standardization, slicing algorithms: -uniform flat layer slicing, adaptive slicing, rasterization, part Orientation and support generation.

Laboratory
CAD Modeling: Introduction to CAD environment, Sketching, Modeling and Editing features, Different file formats, Export/Import geometries, Part orientation, Layer slicing, Process path selection, Printing,

References
Gibson, I., Rosen, D.W. and Stucker, B., "Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing", Springer, 2010.
Chua, C.K., Leong K.F. and Lim C.S., "Rapid prototyping: Principles and applications", second edition, World Scientific Publishers, 2010.
Liou, L.W. and Liou, F.W., "Rapid Prototyping and Engineering applications: A tool box for prototype development", CRC Press, 2011.
Kamrani, A.K. and Nasr, E.A., "Rapid Prototyping: Theory and practice", Springer, 2006.
Hilton, P.D. and Jacobs, P.F., Rapid Tooling: Technologies and Industrial Applications, CRC press, 2005.

23ARE214	DESIGN OF MACHINE ELEMENTS	L-T-P-C: 3-0-0-3	S4

Course Objectives

- Understand the basic concepts of design and various steps involved in the design process.
- Impart principles involved in evaluating the dimensions of a component to satisfy functional and strength requirements.
- Inculcate design principles for designing power transmission system

Course Outcomes

At the end of the course, the student will be able to
CO1: Estimate allowable loads in machine elements using failure theories and able to analyse steady and variable stresses induced in machine elements for different applications
CO2: Design shaft, keys, keyway, flange and coupling for specific applications
CO3: Select the type of bearing and estimate the size based on load carrying capacity in rotating machines
CO4: Select and design suitable power transmission systems for specific applications
CO5: Apply the design concepts for the design of specific robotic elements

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1					1					3	2	1
CO2	3	2	2	1				1					1	1	3
CO3	3	2	2					1					3		2
CO4	3	2	2					1					3		
CO5	3	2	2					1					3	1	1

Syllabus

Unit 1
Introduction to the design process – factors influencing machine design, selection of materials based on mechanical properties – Preferred numbers, Limits, fits and tolerances. Types of loading, Direct, Bending, and torsional stress equations theories of failure –Design based on strength and stiffness. Design for variable loading: Fatigue load stress cycle, Fluctuating load, reversed and repeated load, Endurance limit, Endurance strength, Endurance limit, S-N curves, Goodman and Soderberg relationship.

Unit 2
Design of Shafts, Keys and Couplings: Shafts -Types and application – Forces on shafts due to gears and belts, estimation of shaft size based on strength–Keys, types and applications, Design of keys – Couplings, types and applications, design of rigid and flexible couplings.
Bearings: Types and application, rolling contact bearings – Static and dynamic load capacity, Equivalent bearing load, probability of survival, Bearing life -Selection of deep groove ball bearings.

Unit 3
Belt Drives -Types and application – Selection of flat and timing belts for given power and velocity ratio – Chains -Types and application – Selection of roller chain for specific applications
Design of Gears: Gears – Types- Applications – Gear materials – Gear tooth failures - Nomenclature, interference, gear forces, backlash and lubrication, Design of spur gear and helical gears, Introduction to harmonic drives.
Gripper Design- Gripper force analysis and gripper design for typical applications, selection of gripper, Drivetrain Design- factors-differential drive and holonomic drive trains- case studies.

Text / Reference Books
Shigley and Mische, "Mechanical Engineering Design", McGraw Hill, Inc., New Delhi, 2003.
Robert L. Norton, Design of Machinery, McGraw-Hill College; 6th edition, 2019
Robert L Mortt, "Machine Elements in Mechanical Design", Pearson/Prentice Hall, 2004.
Design Data Book, PSG College of Technology, M/s. Kalaikathir Publishers, Coimbatore, 2017
Arthur H. Burr (Author), John B. Cheatham, Mechanical Analysis and Design, 2nd Edition, 1995.
Robert L Norton, "Machine Design - An Integrated Approach", Pearson Education, New Delhi, 2013.
V.B. Bhandari, "Design of Machine Elements", 4e, TMH, 2016

23ARE215	CONTROL SYSTEMS	L-T-P-C: 3-0-3-4

S4

Course Objectives

- Familiarize with the mathematical modelling of control systems
- Understand the concept of stability of control systems
- Design control strategies for different applications.

Course Outcomes

At the end of the course the student will be able to
CO1: Develop the mathematical model of the physical systems
CO2: Analyse the response and stability of the closed and open loop systems
CO3: Analyse the control systems using Root-locus and Frequency response methods.
CO4: Design controllers based on stability and performance requirements
CO5: Develop and analyse state space models
CO6: Design and analyse the multivariable control systems

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1						1	1			3	2	
CO2	3	2	1						1	1			2	3	1
CO3	3	2	2	1					1	1			1	1	3
CO4	3	2	2						1	1			3		2
CO5	3	2	2						1	1			3		
CO6	3	2	2						1	1			3		

Syllabus

Unit 1
Introduction: Motivation, examples of control systems, feedback control systems.
Mathematical modelling of control systems: Mathematical modelling of electrical systems, mechanical systems, electro-mechanical systems. Laplace transforms, transfer functions, electrical analogues of other dynamical systems. State-space modelling of dynamical systems. Block diagrams, block diagram reductions. Signal flow graph, Mason's gain formula. Linearity, time-invariance versus nonlinearity and time-variance. Linearization. Distributed parameter systems.
Transient and Steady-State Response Analyses: Obtaining solutions from mathematical models. Poles and zeros and their effects on solutions. Step response of standard second order systems, time domain specifications and their formulae.

Unit 2
Stability: Definition of stability. Routh-Hurwitz test. Lyapunov theory.
Control Systems analysis and Design: Root Locus Method, Bode plot, Nyquist plot, Nyquist stability criterion, Relative Stability – Gain and Phase Margins, Lead, Lag and Lag-Lead Compensation
PID Controllers: Basic idea of PID controllers, Error analysis, Ziegler–Nichols Rules for Tuning PID Controllers, Design of PID Controllers with Frequency-Response Approach, Design of PID Controllers with Computational Optimization Approach, Modifications of PID Control Schemes.

Unit 3
Control Systems Analysis in State Space: Introduction to state variable and state space, State-Space Representations of Transfer-Function System, Controllability and Observability
Control Systems Design in State Space: Design of controllers using root-locus, Pole placement with state feedback, Pole placement with output feedback, Robust control systems
Multivariable Control Systems: Modeling, analysis, and design of linear multi-input, multi-output control systems, are including both state space and transfer matrix approach, stability analysis of MIMO LTI system, controllability, stabilizability, observability, Realization and Model Order Reduction. Multivariable Control System Design.

The following lab exercises are performed to understand the closed-loop feedback control systems, transient response, steady state response, PID controllers, and stability.

Lab Exercises:

1. QNET Rotary Inverted Pendulum
2. Mechatronic Systems Board for position control
3. QNET DC Motor Control Trainer
4. Coupled Tanks
5. QNET Vertical take-off and landing trainer
6. Flow and Level control
7. MATLAB control system Toolbox
8. Ball and Beam system control for stability analysis
9. 2 DOF Ball Balancer for stability analysis

Text / Reference Books

Katsuhiko Ogata, "Modern Control Engineering", 5th Edition, Pearson Education, New Delhi, 2010
Richard C. Dorf and Robert H. Bishop, "Modern Control Systems", 12th Edition, Pearson Education, New Delhi, 2011
Norman S. Nise, "Control Systems Engineering", 7th Edition, John Wiley & Sons, New Delhi, 2015
Pedro Albertos and Sala Antonio, "Multivariable Control Systems: An Engineering Approach", 1st Edition, Springer, 2004.

23ARE281	DYNAMICS LAB	L-T-P-C: 0-0-3-1

S4

Course Objectives

- Understand and apply the principles of dynamics in the design and development of robotic systems.
- Familiarize students with the concepts of control and stability.

Course Outcomes

CO1: Analyse robotic systems for forward, inverse kinematics and stability.
CO2: Demonstrate the control and stability concepts using inverted pendulum.
CO3: Analyse forced vibration problem and balancing of rotating and reciprocating masses.
CO4: Demonstrate state feedback control using pole placement and perform vibration control

CO PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2					1	1		1	3	1	1
CO2	3	3	2	2					1	1		1	3	1	
CO3	3	3	2	2	1				1	1		1	3	1	1
CO4	3	3	2	2	1				1	1		1	3	1	

LIST OF EXPERIMENTS:

1. 2-DoF Robot Module to learn forward and inverse kinematics and position control.
2. 2-DoF inverted pendulum/Gantry to demonstrate dynamic stability of slender objects
3. Linear base with inverted pendulum
4. Linear double inverted pendulum
5. Gyro/Stable Platform to demonstrate angular momentum conservation
6. Multi-DoF Torsion to demonstrate flexible coupler effect
7. Rotary Flexible Link and Joint to demonstrate link and joint stiffness
8. Rotary Double Inverted pendulum
9. Forced vibration of a spring mass system
10. Balancing of reciprocating and rotating mass
11. Study of gyroscope effect and governors
12. Determination of Radius of gyration
13. Bifilar and Trifilar suspension

Reference
Lab Manual

23LSE211	LIFE SKILLS FOR ENGINEERS II	L-T-P-C: 1-0-2-2	S4

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

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1								2	3	3		3
CO2									2	3		3
CO3		3		2								
CO4		3		2								
CO5										3		3
CO6									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.**

22ADM201	STRATEGIC LESSONS FROM MAHABHARATA	L-T-P-C: 1-0-0-1	S4

Course Objectives

Through a study of the Mahabharata, 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

Course Outcomes

At the end of the course the student will be able to
CO1: Understanding the impact of itihasas on Indian civilization with a special reference to the Adiparva of Mahabharata
CO2: Enabling students to importance of fighting adharma for the welfare of the society through Sabha and Vanaparva.
CO3: Understanding the nuances of dharma through the contrast between noble and ignoble characters of the epic as depicted in the Vana, Virata, Udyoga and Bhishma parvas.
CO4: Getting the deeper understanding of the Yuddha Dharma through the subsequent Parvas viz., Drona, Karna, Shalya, Sauptika Parvas.
CO5: Making the students appreciative of spiritual instruction on the ultimate triumph of dharma through the presentations of the important episodes of the MB with special light on Shanti, Anushasana, Ashwamedhika, Ashramavasika, Mausala, Mahaprasthanika and Swargarohana Parvas.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1						1		3	1			3			
CO2						2	3	3	3	3		3			
CO3						3	3	3	3	3		3			
CO4						3		3	3	2		3			
CO5						3	1	3	1	1		3			

Syllabus
Unit 1
Introduction and Summary of the Mahabharata
A Preamble to the Great Itihasa
Unbroken Legacy

Unit 2
Dharmic Insights of a Butcher
The Vows We Take
Kingship and Polity Acumen

Unit 3
Karna – The Maestro that Went Wide off the Mark
Tactics of Krishna
Yajnaseni

Unit 4
Popular Regional Tales
Maha Prasthanam – The Last Journey.

Unit 5
Mahabharata - An All-Encompassing Text
Mahābhārata- Whats and WhatNots
Nyayas in Mahabharata

Text Books / References:
Leadership Lessons from the Mahabharat, ASCSS
Rajagopalachari. C, The Mahabharata

SEMESTER 5

23MAT306	GRAPH THEORY ALGORITHMS AND COMPLEX ANALYSIS	L-T-P-C: 3-1-0-4

Course Objectives

- Understand the concepts of various types of graphs and simple properties.
- Familiarize with basic results in graph algorithms and apply to networks for robotics.
- To perform calculus for complex variables.
- To understand the residues and poles and evaluate complex integrations.

Course Outcomes

At the end of the course the student will be able to
CO1: Understand various definitions in graph theory and simple properties.
CO2: Understand the shortest path and spanning tree algorithms.
CO3: Understand and apply graph connectivity for flow problems in networks.
CO4: To carry out differentiation for complex functions and check analyticity of complex functions
CO5: To perform integral calculus in complex variables and finding residues, zeros, poles and series representations of complex functions

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	1									1			
CO2	3	2	3									1			
CO3	2	2	2									1			
CO4	2	2	1									1			
CO5	2	1	1									1			

Syllabus

Unit 1
Graphs Theory: Graphs and Sub graphs, isomorphism, matrices associated with graphs, degrees, walks, connected graphs, shortest path algorithm.
Tree: Tree, properties, spanning trees and minimal spanning tree algorithms. Tree traversals.
Graph connectivity: Graph connectivity, maximal flow algorithm. Euler and Hamiltonian graphs. Travelling salesman algorithm.
Planar Graph: Planar graph, Euler theorem and applications of planar graphs. **Complex Analysis.**

Unit 2
Complex Functions: Complex Numbers, Complex Plane, Polar Form of Complex Numbers. Powers and Roots. Derivative: Analytic Functions, Cauchy - Riemann Equations, Laplace Equation, Conformal mapping, Exponential Function, Trigonometric Functions, Hyperbolic Functions, Logarthims, General Power, Linear Fractional Transformation.

Unit 3
Complex Integration: Complex Line Integral, Cauchy Integral Theorem, Cauchy Integral Formula, Derivatives of Analytic Functions. Power Series, Taylor Series and Maclaurin Series. Laurent Series, Zeros and Singularities, Residues, Cauchy Residue Theorem.

Text Books
J. A. Bondy and U. S. R. Murty, Graph Theory and Applications, Springer, 2008.
Advanced Engineering Mathematics, E Kreyszig, John Wiley and Sons, Tenth Edition, 2016.

References
Stanisław Zawiślak, Jacek Rysiński, Graph-Based Modelling in Engineering: 42 (Mechanisms and Machine Science), Springer, 2018.
Narsingh Deo, Graph Theory with Applications, PHI, 2008
Advanced Engineering Mathematics, Ray Wylie and Louis Barrett, McGraw Hill, Sixth Edition, 2016.
Engineering Mathematics, Srimanta Pal and Subodh Bhunia, Oxford press, 2015.

23ARE301	INTRODUCTION TO DATA SCIENCE	L-T-P-C: 2-0-3-3	S5

Course Objectives

- To understand the concept of data processing and data plotting methods.
- To understand various statistical measures for data science
- To understand the concepts of supervised and unsupervised learning techniques.
- To carry out various case studies with data sets from robotics and to draw practical inferences.

Course Outcomes

At the end of the course the student will be able to
CO1: Understand the various data processing and plotting techniques and apply to data sets.
CO2: Understand and apply various statistical measures on the given data sets.
CO3: Understand basic concepts of supervised and unsupervised learnings.
CO4: Understand the data clustering techniques through various case studies.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	1					2	2				1	
CO2	3	3	1	1					2	2				1	
CO3	2	2	3	1					2	2				1	
CO4	2	2	1	1					2	2				1	

Syllabus

Unit 1
Introduction, Causality and Experiments, Data Pre-processing: Data cleaning, Data reduction, Data transformation, Data discretization. Visualization and Graphing: Visualizing Categorical Distributions, Visualizing Numerical Distributions, Overlaid Graphs, plots, and summary statistics of exploratory data analysis and Randomness, Classification of data and representation of data- bar and pie charts – histogram frequency polygon – Box plot. Dashboard using Excel and power BI. Lab exercises for different data plots.

Unit 2
Analysis Measures of Central tendency and dispersion - Mean, median, mode, absolute, quartile and standard deviations, skewness and kurtosis for both grouped and ungrouped data. Association of attributes. Lab exercises for analysis of data and associated attributes.

Unit 3
Supervised Learning (Regression/Classification): Basic methods: Distance-based methods, Nearest-Neighbors, Decision Trees, Naïve Bayes. Linear models: Linear Regression, Logistic Regression, Generalized Linear Models. Support Vector Machines.
Unsupervised Learning: Clustering: K-means/Kernel K-means. Dimensionality Reduction: PCA and kernel PCA. Matrix Factorization and Matrix Completion.
Lab exercises for data sets related automations.

Text books/ References:
John Hopcroft and Ravi Kannan, "Foundations of Data Science", ebook, Publisher, 2013.
Artificial Intelligence for Robotics, Francis X. Govers, Packt publishing, 2018.
The Art of Data Science, Roger Peng and Elizabeth Matsui, null edition, 2020.
Kevin Murphy, Machine Learning: A Probabilistic Perspective, MIT Press, 2012
Data Science and big data analytics: Discovering, analyzing, visualizing and presentating data, EMC Education Services,John Wiley 2015.
Introduction to Data Science: A Python Approach to Concepts, Techniques and Applications. Laura Igual, Santi Seguí. Springer Publications (2016).

23ARE302	MICROCONTROLLERS AND EMBEDDED SYSTEMS	L-T-P-C: 3-0-0-3	S5

Course Objectives

- To understand microprocessors and microcontrollers
- To learn about typical peripherals of microcontrollers
- To learn about development of embedded systems for real world applications

Course Outcomes

At the end of the course, the student will be able to
CO1: Identify various hardware and software architectures in embedded systems
CO2: Explain the concepts of microprocessors and microcontrollers
CO3: Describe the detailed architecture, internal modules and addressing modes of ARM based processor
CO4: Analyse microcontroller peripherals and interfacing of sensors and actuators
CO5: Develop robotics and automation applications with microcontrollers

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2												
CO2	3	3	1												
CO3	3	3	1	2	1										
CO4	3	3	3	2	1									1	1
CO5	3	3	3	3	3							1	1	1	1

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.

Text / Reference Books
Saurabh Chandrakar Nilesh Bhaskarrao Bahadure, "Microcontrollers and Embedded System Design", First Edition, Dreamtech Press, 2019.
Joseph Yu, "The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors", Third Edition, Newness, 2013.
Steve Furber, "ARM System-on-chip Architecture", Second Edition, Addison Wesley, 2000.
Andrew Sloss, Dominic Symes and Chris Wright, "ARM System Developer's Guide: Designing and Optimizing System Software", Morgan Kaufumann Publisher, 2011.
William Hohl and Christopher Hinds, "ARM Assembly Language: Fundamentals and Techniques", Second Edition, CRC Press, 2016.
ARM Technical Reference Manual, NXP LPC 17xx datasheet.

23ARE303	FLUID POWER SYSTEMS FOR INDUSTRIAL AUTOMATION	L-T-P-C: 2-0-3-3	S5

Course Objectives

- To provide the student with basic skills helpful in identifying the concepts of automation in the production system and automation concepts using hydraulics and pneumatics.

Course Outcomes

At the end of the course the student will be able to
CO1: Identify the automation need, type, and method
CO2: Select the suitable material handling equipment for the given application
CO3: Demonstrate the functioning of fluid power components
CO4: Design a hydraulic / electro-hydraulic circuit for the given application
CO5: Design a pneumatic/ electro-pneumatic circuit for the given application

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	3						2	2		2	3		
CO2	3	2	3						2	2		2	3		
CO3	3	2	3		2				2	2		2	3		
CO4	3	2	3		2				2	2		2	3		
CO5	3	2	3		2				2	2		2	3		

Syllabus

Introduction to Automation: Automation in the production system, Principles, and strategies of automation, Basic elements of an automated system, Levels of automation, Material handling equipment: conveyors, part feeders, material transport systems. Conveyor system, Automated guided vehicle system, Automated Storage/Retrieval system. Automated Manufacturing Systems- Cellular manufacturing, Flexible manufacturing system, Automated assembly system.

Hydraulic Systems in Automation:
Hydraulics: Fluid properties, Pascal's Law and applications, Fluid power symbols, Hydraulic pumps, Sizing of Pumps, Pump Performance, Characteristics, and Selection. Control valves: Direction control valves, pressure control valves, Flow control valves, Hydraulic Proportional Valves, and Servo valves. Accumulator- types, application circuits. Electro-Hydraulics. Accessories used in fluid power systems. System maintenance and troubleshooting.

Pneumatics Systems in Automation: Gas laws, Preparation of air, Fluid conditioning elements, Actuators, Sizing of Actuators, Control valves: Direction control valves, pressure control valves, Flow control valves, shuttle valve, Time delay valve. Development of single and multiple actuator circuits. Valves for logic functions; Exhaust and supply air throttling, Pneumatic and Electro-pneumatic circuit design: Cascade method, step–counter method. Fluidics, MPL devices. Circuits using Fluid logic devices and applications.

The following lab experiments are performed to design and simulate the hydraulic, pneumatic and electro-pneumatic circuits.

Experiments:
1. Hydraulic circuit with control elements
2. Sequential circuit using a pressure sequence valve
3. Electro-hydraulic circuit for speed control of linear and rotary actuators.
4. Electro-hydraulic circuit for industrial application
5. Pneumatic circuit for the actuation of single and double-acting cylinders
6. Pneumatic circuit for supply air and exhaust air throttling system
7. A circuit for multiple cylinder sequences (cascade method with timer)
8. A circuit for multiple cylinder sequences with a pneumatic counter
9. An electro-pneumatic circuit for the actuation of single and double-acting cylinders
10. An electro-pneumatic circuit for multiple cylinders' sequence

Text Books

M.P.Groover, "Automation, Production Systems, and Computer Integrated Manufacturing," 5th Edition, Pearson Education, 2009.

Antony Esposito, "Fluid Power with Applications", Pearson, Sixth Edition., 2003.

W. Bolton, "Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering" - Prentice-Hall - 2013 - 5th Edition

Reference Books

Sullivan James A., "Fluid Power - Theory and Applications", Fourth Edition, Prentice-Hall International, New Jersey, 1998.

Watton, John. Fundamentals of fluid power control. Vol. 10. Cambridge University Press, 2009.

23ARE304	ROBOTICS AND CONTROL	L-T-P-C: 3-0-3-4

S5

Course Objectives

- 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

At the end of the course the student will be able to
CO1: Outline the fundamentals of robotics and its components
CO2: Solve for the manipulator dynamics using Lagrangian formulation
CO3: Implement the various trajectory planning algorithms and control techniques
CO4: Solve the forward and inverse dynamics problems of robotics
CO5: Apply different nonlinear and force control algorithms for robot control.

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3						1	1		1	3		
CO2	3	3	3		1				1	1		1	3		
CO3	3	3	3		1				1	1		1	3		
CO4	3	3	2		1				1	1		1	3		
CO5	3	3	3		1				1	1		1	3		

Syllabus

Unit 1
Introduction: Definition, Classification, Robot Components, Degree of Freedom, Mobile robots, Robot Characteristics, Robot Workspace, Robot specifications, and programming. Application of Robots. End Effectors-Grippers-Types: Pneumatic, Hydraulic, Magnetic, Vacuum Grippers, Spherical Wrist; Selection and Design Considerations, resolution, accuracy and repeatability of robot, applications.

Unit 2
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.

Lab Exercises:
1. Dynamic modelling of an industrial robot manipulator.
2. Inverse and forward dynamics of robot manipulator
3. Creating robot joint trajectories.
4. Trajectory Planning of 3R robot based on 3rd order polynomial trajectory
5. Computation of geometric Jacobian for robot manipulator.
6. Trajectory tracking control of industrial robotic arm using robot manipulator blocks
7. Rotational and transform trajectory analysis of robot manipulator
8. Trapezoidal velocity profile trajectory analysis of robot manipulator
9. Simulation of joint space trajectory tracking of robotic arm

10. Visualization of manipulator trajectory tracking in 3D.
11. Design and develop the manufacturing cell using virtual robot simulator.
12. Develop a TCP and work-object for Industrial Robot using Robot simulator.
13. Develop the robot programming for pick and place of objects, material handling and welding operations.
14. Singularity analysis using Robot simulator.
15. Interface and configure the vision system with Industrial Robot.
16. Part identification based on colour & pattern and separate the components using vision system and Robot.
17. Develop a program to draw a pattern using the manipulator.
18. Program the robot manipulator's end effector to travel along a complex 3D path.

Text Book / Reference Books

Craig, J.J., Introduction to Robotics: Mechanics and Control, 2nd Edition, Addison-Wesley, Reading, MA, 1989.
L. Sciavicco, B. Siciliano, Modeling and Control of Robot Manipulators, Springer, 2002.
Angeles, J., Fundamentals of Robotic Mechanical Systems, Springer-Verlag, New York, NY, 1997.
Fu, Gonzales, and Lee, Robotics: Control, Sensing, Vision, and Intelligence, McGraw-Hill, 1987.
Shames,I.H, "Engineering Mechanics-Statics and Dynamics", 4/e, Prentice-Hall of India Pvt. Ltd., 2005

23ARE381	MICROCONTROLLERS AND EMBEDDED SYSTEMS LAB	L-T-P-C: 0-0-3-1	S5

Course Objectives

- To familiarize with software and hardware modules for embedded system application development.
- To learn assembly and high-level language programming in microcontrollers.
- To develop embedded systems for real world applications.

Course Outcomes

At the end of the course, the student will be able to
CO1: Identify the software and hardware modules for embedded system application development.
CO2: Develop assembly program for various applications
CO3: Develop high-level language program for various applications
CO4: Develop robotics and automation applications with microcontrollers.

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	2					2	3					
CO2	3	3	3	3	3				2	3				1	
CO3	3	3	3	3	3				2	3				1	
CO4	3	3	3	3	3			1	2	3	1	1	1	2	3

Syllabus

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

Text / Reference Books

Yifeng Zhu, "Embedded Systems with ARM Cortex-M Microcontrollers in Assembly Language and C". Third Edition, E-Man Press LLC, 2017.
ARM Technical Reference Manual (https://developer.arm.com/documentation/)
ARM Architecture Reference Manual (https://developer.arm.com/documentation/)
NXP LPC 17xx user manual (https://www.nxp.com/docs/en/user-guide/UM10360.pdf)
Getting started with MDK Create applications with µVision® for ARM® Cortex®-M microcontrollers (https://www2.keil.com/docs/default-source/default-document-library/mdk5-getting-started.pdf?sfvrsn=2)

23ARE382	DESIGN THINKING - A	L-T-P-C: 0-0-3-1

S5

Course Objectives

- Introduce to the students, the concept of design thinking
- Make the students as a good designer by imparting creativity and problem solving ability
- Conceive, conceptualize, design and demonstrate innovative ideas using prototypes.

Course Outcomes

At the end of the course, the student will be able to
CO1: Examine critical theories of design, systems thinking, and design methodologies.
CO2: Produce great designs, be a more effective engineer, and communicate with high emotional and intellectual impact
CO3: Understand the diverse methods employed in design thinking and establish a workable design-thinking framework to use in their practices
CO4: Conceive, organize, lead and implement projects in interdisciplinary domain and address social concerns with innovative approaches

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	3	2	1	1			2	1	1	1		3	
CO2	3	2	3	2	1	1	1	1	2	3	2	1		3	
CO3	2	2	2	2	1	1			2	1	1	1		3	
CO4	3	2	3	3	1	1	2	1	2	1	2	1		3	

Syllabus

Design process: Traditional design, 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
Empathy: Customer Needs, Insight-leaving from the lives of others/standing on the shoes of others, Observation
Conceptualization: Visual thinking, Concept Generation Methodologies, Concept Selection, Concept Testing, Prototyping
Design projects for teams.

Text Book / Reference Books

Tim Brown, Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation, HarperCollins Publishers Ltd.
Idris Mootee, Design Thinking for Strategic Innovation, 2013, John Wiley & Sons Inc
Brenda Laurel Design Research methods and perspectives MIT press 2003
Terwiesch, C. & Ulrich, K.T., 2009. Innovation Tournaments: creating and identifying Exceptional Opportunities, Harvard business press.
Ulrich & Eppinger, Product Design and Development, 3rd Edition, McGraw Hill, 2004
Stuart Pugh, Total Design: Integrated Methods for Successful Product Engineering,
Bjarki Hallgrimsson, Prototyping and model making for product design, 2012, Laurence King Publishing Ltd
Kevin Henry, Drawing for Product designers, 2012, Laurence King Publishing Ltd

23LSE301	LIFE SKILLS FOR ENGINEERS III	L-T-P-C: 1-0-2-2	S5

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

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1									3	3	2	3
CO2										3	2	2
CO3		3		2								
CO4		3		2								
CO5										3		3
CO6									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.**

SEMESTER 6

23MEE306	OPTIMIZATION TECHNIQUES	L-T-P-C: 2-0-3-3

Course Objectives

- This course will introduce the students to the fundamentals of optimization theory and solving various types of optimization problems using traditional and modern methods.
- The course will involve significant number of computational assignments and a term project in the general area of engineering optimization

Course Outcomes

At the end of the course the student will be able to
CO1: Formulate the engineering problems as an optimization problem.
CO2: Apply necessary and sufficient conditions for a given optimization problem for optimality
CO3: Select appropriate solution methods and strategies for solving an optimization problem, interpret, and analyze the solution obtained by optimization algorithms
CO4: Justify and apply the use of modern heuristic algorithms for solving optimization problems
CO5: Solve Engineering Design and Manufacturing related optimization problem using software tools.

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	1	1	1				1	1		1	1		
CO2	1	3	2	1					1	1			1		
CO3	1	3	2	1	1				2	1					
CO4	2	2	2	2	2				2	1					
CO5	1	3	3	2	3				2	2		1			

Syllabus

Unit 1
Introduction - Engineering applications - Statement of an optimization problem – Classifications of Optimization problems - Optimal problem formulation - Optimality criteria - Classical optimization techniques - Kuhn-Tucker (KT) optimality conditions.

Unit 2
Introduction to Linear Programming Problem - Introduction – Standard form of a LPP problem - Graphical solution for LPP – Simplex Method – Revised Simplex method – Duality in LPP – Transportation problem.

Unit 3
Non-linear programming: One dimensional minimization method - Unconstrained optimization techniques -Constrained optimization techniques - Transformation methods - Interior and exterior penalty function method -Convergence and divergence of optimization algorithms - Complexity of algorithms.

Unit 4
Modern Methods in Optimization: Genetic Algorithm - Simulated Annealing - Particle Swarm Optimization – Neural Network based optimization - Optimization of Fuzzy systems – Introduction to Multi-Objective optimization

Lab Practice:
Implementing optimization algorithms in Matlab / R / Python environment and solving linear, non-linear, multi-objective unconstrained and constrained optimization problems.

Text / Reference Books
Rao, S.S., 2019. Engineering optimization: theory and practice. John Wiley & Sons.
Deb, K., 2012. Optimization for engineering design: Algorithms and examples. PHI Learning Pvt. Ltd.
Arora, R.K., 2019. Optimization: algorithms and applications. Chapman and Hall/CRC.

23ARE311	INTRODUCTION TO MACHINE LEARNING	L-T-P-C: 3-0-3-4	S6

Course Objectives

- To introduce students to the basic concepts and techniques of Machine Learning.
- To develop skills of using recent machine learning software for solving practical problems.
- To make students familiar with the application of machine learning in robotics

Course Outcomes

At the end of the course the student will be able to
CO1: Able to generate, analyze and interpret data summaries
CO2: Able to carry out analysis on machine learning algorithms
CO3: Able to design and implement classifiers for machine learning applications
CO4: Able to apply machine learning algorithm in robotics

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	2	1				2	2		2	2	3	3
CO2	3	3	3	2	1				2	2		2	2	3	3
CO3	3	3	3	2	1				2	2		2	2	3	3
CO4	3	3	3	2	1				2	2		2	2	3	3

Syllabus

Unit 1
Basic motivation, examples of machine learning applications, supervised and unsupervised learning – Review linear algebra, vector spaces, linear transformations, Eigen values and vectors – Review of probability theory, random variables, probability distributions – Linear Regression in one variable, Gradient descent, Regression in multiple variables – Linear models for classification, Discriminant functions, Logistic regression – Regularization, over and under fitting, Regularized linear regression, Regularized logistic regression.
Lab exercises on vector algebra, probability theory, regression analysis for use in supervised and unsupervised learning.

Unit 2
Neural networks model representation, Feed-forward network functions, Network training, Back-propagation algorithm – Clustering, Mixture densities, K-Means clustering, Expectation maximization, Spectral clustering – Dimensionality reduction, Principal component analysis, Singular value decomposition.
Lab exercises on network functions, back-propagation algorithm and spectral decomposition.

Unit 3
Reinforced learning – Fundamentals of deep learning – Application of machine learning in robotics.
Lab exercises on reinforced and deep learning applied to robotic systems.

Text / Reference Books
Tom M. Mitchell, Machine Learning, McGraw Hill, 1997.
Ethem Alpaydin, Introduction to Machine Learning, MIT Press, 2014.
C. M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006.
A. C. Muller and S. Guido, Introduction to Machine Learning with Python, O'Reilly Media, 2016.
A. C. Faul, A Concise Introduction to Machine Learning, CRC Press, 2020.

23ARE312	REAL TIME OPERATING SYSTEMS	L-T-P-C: 3-0-0-3	S6

Course Objectives

- To understand real-time operating system (RTOS).
- To learn various approaches to real-time scheduling and other kernel services.
- To familiarize Robot Operating System (ROS).

Course Outcomes

At the end of the course, the student will be able to
CO1: Identify the basic concepts in real time systems.
CO2: Describe various services provided by the RTOS Kernel
CO3: Analyse various algorithms of RTOS kernel services.
CO4: Develop real time applications using ROS framework.

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3										1			
CO2	3	3										1			
CO3	3	3	2									1			
CO4	3	3	3	1								1	1	1	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. Experiments - ROS launch, 3D visualization tool (RViz), Design and development of graphical user interface in ROS environment. Establish communication between robot client and server, and analysis of data packet loss Visualization of robot and their movements in Rviz ROS.

Text / Reference Books

Qing Li, Caroline Yao, "Real-Time Concepts for Embedded Systems" First Edition, CRC Press, 2010.
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.
Tanenbaum, "Modern Operating Systems," Fourth Edition, Pearson Edition, 2014.
Jane W.S. Liu, "Real -Time Systems", First Edition, Pearson Education, 2000.
Lentin Joseph, "Robot Operating System (ROS) for Absolute Beginners: Robotics Programming Made Easy", First Edition, Apress, 2018.
Kumar Bipin, "Robot Operating System Cookbook", First Edition, Packt Publishing, 2018.

23ARE313	INDUSTRIAL PROCESS AUTOMATION	L-T-P-C: 2-0-3-3	S6

Course Objectives

- To provide the student with the fundamentals of PLC, SCADA, and DCS and facilitate the design of automated system using software tools.

Course Outcomes

At the end of the course the student will be able to
CO1: Develop the PLC program for the given application
CO2: Interface the Input and output devices with PLC
CO3: Understand the concepts of SCADA and its applications
CO4: Understand the communications and networking of distributed control systems
CO5: Design a graphical system using Virtual Instrumentation software

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	3		2				1	1		2	3		
CO2	3	2	3		2				1	1		2	3		
CO3	3	2	3		2				1	1		2	3		
CO4	3	2	3		2				1	1		2	3		
CO5	3	2	3		2				1	1		2	3		

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 PLCs/RTUs, Database Connectivity and Report generating. 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.

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 Interfacing HMI with PLC
4. Interfacing PLC real-time TAG with SCADA
5. Flow and pressure measurement and control using SCADA
6. Develop a SCADA screen program for process plant operation
7. Develop a database and recipe TAG base in SCADA
8. Basic programming using Virtual Instrumentation software
9. Data acquisition and processing using Virtual instrumentation software
10. Graphical system design using Virtual Instrumentation software

Text Books

Lukas M.P, "Distributed Control Systems," Van Nostrand Reinhold Co., New York, 1986.
Petruzella, Frank D. Programmable logic controllers. Tata McGraw-Hill Education, 2005.
Gupta, Virtual Instrumentation Using LabVIEW 2E, Tata McGraw-Hill Education, 2010.

23LSE311	LIFE SKILLS FOR ENGINEERS IV	L-T-P-C: 1-0-2-2	S6

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

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1									3	3		2
CO2								2	3	3		2
CO3		3		2								
CO4		3		2								
CO5										3		3
CO6									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.

23ARE399	MINI PROJECT	L-T-P-C: 0-0-3-1	S6

Course Objectives

The Mini Project is a part of the coursework to demonstrate the abilities and specialization of the students. It provides the opportunity for the students to put into practice and develop a prototype/hardware/software solution for a real-world problem in an integrated manner by implementing some of the techniques that have been learned in the previous semesters. The Mini Project is important to specialize in specific areas of Automation and Robotics and will lead to identifying a clear problem statement for the Final year major project.

- The mini project should be on Hardware Design integrated software and/or Fabrication in any of the areas in Automation and Robotics.
- Mini project work can be carried out individually or by a group of a maximum of five students.
- The course progress will be monitored at regular intervals.
- There will be not any specific guide for a student or project group. The students must identify the project based on their interest and students can approach any faculty member of the department with a prior appointment if they need any guidance or suggestion.
- There will be a faculty coordinator for this course. Every week, the faculty coordinator will review the progress of the course and evaluate the Continuous Internal Examination (CIE) Components with the help of an additional faculty member.
- The end semester evaluation is based on design, working model, report, presentation, and viva-voce. A panel appointed by the department will review the Semester End Examination (SEE) Components.

Course Outcomes

At the end of the course the student will be able to
CO1: Design a hardware solution to a real-life problem/application.
CO2: Implement the hardware solution by developing a working model /prototype
CO3: Use software tools required for the design and implementation of hardware solutions.
CO4: Communicate the designs and work procedure through presentations and reports.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PS02	PSO3
CO1	3	1	1		2				2	2	1	1	1	1	1
CO2	3	1	1		2				2	2	1	1	1	1	1
CO3					2				2	2	1	1	1	1	1
CO4					2				2	2	1	1	1	1	1

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

S6

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

At the end of the course the student will be able to
CO1: Understand the functions of the Indian government
CO2: Understand and abide the rules of the Indian constitution
CO3: Understand and appreciate different culture among the people

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PS02	PSO3
CO1						3	2	3							
CO2						3	2	3							
CO3						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.

Text / Reference Books
Durga Das Basu, "Introduction to the Constitution of India ", Prentice Hall of India, New Delhi.
R.C.Agarwal, (1997) "Indian Political System", S.Chand and Company, New Delhi.
Sharma, Brij Kishore, "Introduction to the Constitution of India", Prentice Hall of India, New Delhi.

SEMESTER 7

S7

23ARE401	MOBILE ROBOTICS	L-T-P-C: 2-0-3-3

Course Objectives

- Familiarize with essential elements of robotic locomotion.
- Comprehend challenges in realizing robotic locomotion.
- Familiarize with the concepts of path planning and navigation.
- Impart knowledge on the basics of robot learning and collective robotics.

Course Outcomes

At the end of the course, the student will be able to
CO1: Understand the concepts of mathematical models and motion control methods.
CO2: Apply various models of localization and navigation.
CO3: Analyse locomotion challenges and select motion planning algorithms.
CO4: Design and develop autonomous mobile robots with obstacle avoidance.

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3						1	1			1	3	3
CO2	3	3	3		1				1	1			1	3	3
CO3	3	3	3		1				1	1			1	3	3
CO4	3	3	2		1				1	1			1	3	3

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.
Lab 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.

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.
Lab experiments:
1. Line-based Kalman filtering for mobile robot localization, 2. Simultaneous localization and mapping based on Extended Kalman Filtering.

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, etc., Mobile robots in practice, delivery robots, intelligent vehicles, mining automation, space robotics, underwater inspection, etc. .
Lab experiments:
1. Simulate a system of collective robots for arbitrary inputs and constraints, 2 Mobile robot path planning with global and local dynamic window approaches. 3. Noise rejection navigation simulation for mobile robot.

Text Books
Roland Siegwart, Illah R. Nourbakhsh, and Davide Scaramuzza. (2011). Introduction to Autonomous Mobile Robots. 2nd edition, The MIT Press.
Gregory Dudek, and Michael Jenkin. (2010). Computational Principles of Mobile Robotics. Second edition, Cambridge University press

Reference Books

Ulrich Nehmzow, (2012). Mobile Robotics: A Practical Introduction Second Edition. Springer.
Peter Corke (2017). Robotics, Vision and Control Fundamental Algorithms in MATLAB®. Second Edition. Springer
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.
Sebastian Thrun, Wolfram Burgard, Dieter Fox. (2002) Probabilistic Robotics. The MIT press.
Steven M. LaValle. (2006). Planning Algorithms, Cambridge University Press.

23ARE402	INTRODUCTION TO DEEP REINFORCEMENT LEARNING	L-T-P-C: 3-0-0-3	S7

Course Objectives

- Implement and use backpropagation algorithms to train deep neural networks
- Apply regularization techniques to training deep neural networks
- Apply optimization techniques to training deep neural networks

Course Outcomes

At the end of the course the student will be able to
CO1: Understand the architecture and parameters involved in deep learning networks.
CO2: Implement basic deep learning architectures.
CO3: Apply deep learning techniques to solve problems pertinent to signal and image processing in Robotics

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	1	2							1	2	2	
CO2	3	2	2	1	2							1	2	2	
CO3	3	2	2	1	2							1	2	2	

Syllabus

Unit 1
Deep Learning: Artificial Neurons - the Building Blocks of Deep Learning, Feed-Forward Deep Neural Networks (DNN), Architectural Considerations in Deep Learning: Activation Functions in Deep Learning, Loss Functions in Deep Learning, Optimizers in Deep Learning: Gradient Descent and Error Back-Propagation, Stochastic Gradient Descent and Adaptive Learning Rate, Hyper-Parameter Selection, Regularization; Convolutional Neural Networks: Convolutional Layer, Pooling Layer, Flattened and Fully Connected Layers; Recurrent Neural Networks, LSTM, Deep learning examples.

Unit 2
Reinforcement Learning: Agents, environments, State and action, Reward, Reinforcement learning as a Markov Decision Process (MDP), Value Functions & Bellman Equations, Prediction and Control by Dynamic Programing, Monte Carlo Methods for Model Free Prediction and Control, Temporal difference learning, Function Approximation Methods, Policy Gradients., Applications in industrial automation and Robotics

Unit 3
Deep Reinforcement Learning Algorithms: Policy-based Algorithms, Value-based Algorithms, Model-based Algorithms, Combined Methods, On-policy and Off-policy Algorithms, Deep Reinforcement Learning for the Control of Robotic Manipulation.

Reference / Text Books
Ian Goodfellow, Yoshua Bengio and Aeron Courville, Deep Learning, MIT Press, First Edition, 2016.
Richard S. Sutton and Andrew G. Barto, Reinforcement Learning: An Introduction, 2nd Edition, The MIT Press, 2018
Hao Dong, Zihan Ding, and Shanghang Zhang, Deep Reinforcement Learning: Fundamentals, Research and Applications, Springer, 2020
Laura Graesser and Wah Loon Keng, Foundations of Deep Reinforcement Learning: Theory and Practice in Python, Addison-Wesley, 2020
Sudharsan Ravichandiran, Hands-On Reinforcement Learning with Python: Master reinforcement and deep reinforcement learning using OpenAI Gym and TensorFlow, .2nd Edition, 2020

23ARE403	INDUSTRIAL INTERNET OF THINGS	L-T-P-C: 2-0-3-3	S7

Course Objectives

- To familiarize with insight and understanding of the 4th industrial revolution and its impact on the industry.
- To impart the basic knowledge on the drivers, enablers, and design principles of Industry 4.0.

Course Outcomes

At the end of the course, the students will be able to
CO1: Describe the concepts and characteristics of Industry 4.0.
CO2: List and comprehend the different enabling technologies and its role in establishing Industry 4.0.
CO3: Enumerate different communication technologies used in of Industry 4.0.
CO4: perform edge, cloud computing and visualize the data.
CO5: Apply IoT for the given applications.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1		2				1	1		1	2	2	2
CO2	3	2	1		2				1	1		1	3	3	2
CO3	3	2	2		2		1		1	1		1	3	3	2
CO4	3	2	3		2	2	2		1	1		1	3	3	2
CO5	3	2	2		2	2	2		1	1		1	3	3	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 twin.

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.

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 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

Text Books

Klaus Schwab, "The Fourth Industrial Revolution", Portfolio Penguin, 2017.
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

Alasdair Gilchrist, "Industry 4.0: The Industrial Internet of Things", Apress, 2016.
Kaushik kumar, DivyaZindani, J. Paulo Davim, "Digital manufacturing and assembly systems in Industry 4.0", CRC Press, Taylor and Francis group, 2020.
Antonio sartal, Diego Carou, J.PauloDavim, "Enabling technologies for the successful deployment of Industry 4.0, CRC press, 2020.
Alp Ustundag, Emrecavikcan, "Industry 4.0: Managing the digital transformation", Springer International publishing, 2018.
Christoph Jan Bartodziej, "The Concept Industry 4.0", Springer Gabler, 2017.

23ARE481	CNC AND SYSTEM SIMULATION LAB	L-T-P-C: 0-0-3-1

S7

CNC LAB - A

Course Objectives

- Understand the working principles and construction of a CNC machine tool
- Manual CNC programming concepts and CAD based programming

Course Outcomes

At the end of the course the student will be able to
CO1: Understand the working principles, tooling and construction of CNC Turning centre and CNC Machining centre
CO2: Generate simple CNC manual part programing codes for machining components in lathe and milling machines
CO3: Simulate and generate CNC codes for lathe and milling operations using CAM software

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	2	1	3				1	1		1	1	3	
CO2	2	1	2	1	3				1	1		1	1	3	
CO3	2	1	2	1	3				1	1		1	1	3	

Syllabus

CNC Machine: Tooling, construction and working
Understanding the working, construction, and tooling of CNC Turning centre and CNC Machining centre
CNC Manual part programming
Manual part programming exercises for simple part geometries
Computer Aided Manufacturing (CAM)
Introduction to CAD based CNC programming and modelling of part geometries in CAD software for generating CNC codes for machining
CNC code generation and simulation of machining process using CAM software.
Machining of component in CNC Turning/Machining centre using CNC code generated using CAM software

SIMULATION OF MANUFACTURING SYSTEMS LAB - B **S7**

Course Objectives

- To develop credible discrete event simulation models of a manufacturing environment
- To analyse and improve the performance of manufacturing systems using work study and lean techniques

Course Outcomes

At the end of the course the student will be able to
CO1: Appreciate the role of discrete event simulation and modelling and their application in manufacturing environment
CO2: Simulation modelling of manufacturing and service systems using discrete event simulation package
CO3: Interpret and analyze the results obtained by the simulation model and identify bottlenecks and improve the performance of the manufacturing systems
CO4: Apply work study principles and lean techniques to improve processes

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	1	1	1	1		1		1	1		1	1		1
CO2	1	1	1	1	3		2		1	1	1	1	2	3	
CO3	1	1	1	3	2	1	1		1	1	1	1	1	1	
CO4	1	1	1	1	1	1	1		1	1	3	1	1		2

Syllabus

Modelling and analysis of manufacturing and service systems using discrete event simulation package.
Analysis of simulation input data and fit the data into a suitable distribution.
Simulation output analysis
Performance Modelling of Flow-shops, Job shops, Assembly shops, FMS, and Kanban Controlled Manufacturing Systems
Simulation optimization.
Time and motion study experiments – use of software for calculating standard time.
Study and design of lean assembly lines using Lego kits.

23ARE300	RESEARCH METHODOLOGY	P/F	S7

Course Objectives

- To learn and practice the literature survey aspects of projects and prepare the scope and goals for the proposed project.
- To learn, practice and improve the research presentation skills and with latest tools
- To learn and understand the research publication ethics.
- To prepare plagiarism free quality reports and journal articles

Course Outcomes

At the end of this course, the students should be able to:
CO1: Identify appropriate research topics
CO2: Select and define appropriate research problem and parameters
CO3: Prepare a research proposal
CO4: Organize and conduct research
CO5: Write research articles and thesis

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2					1	1	1				1			
CO2	2	3			2			1				1			
CO3										3	3	1			
CO4	3		3	3	3						2	1			
CO5										3		1			

Syllabus

Unit 1
Problem definition, Objectives of Research, Approaches to Research, Importance of reasoning in research. Problem Formulation, Conducting Literature Review.

Unit 2
Development of Hypothesis, Measurement Systems Analysis, Statistical Design of Experiments, Numerical and Graphical Data Analysis: Sampling, Observation, Surveys, Inferential Statistics, and Interpretation of Results. Preparation of Dissertation and Research Papers. References, Citation and listing system of documents.

Unit 3
Intellectual property rights (IPR) – patents – copyrights – Trademarks - Industrial design geographical indication. Ethics of Research- Scientific Misconduct - Forms of Scientific Misconduct. Plagiarism, Unscientific practices in thesis work, Ethics in science

Text Books/ Reference Books
Bordens, K. S. and Abbott, B. B., "Research Design and Methods – A Process Approach", 8th Edition, McGraw-Hill, 2011
Davis, M., Davis K., and Dunagan M., "Scientific Papers and Presentations", 3rd Edition, Elsevier Inc.
Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New Technological Age". Aspen Law & Business; 6 edition July 2012

23ARE497	SUMMER INTERNSHIP	L-T-P-C: P/F

S7

Course objectives

- To impart the social, economic and administrative considerations that influence the working environment of industrial organizations.
- To familiarize with various materials, processes, products and their applications along with relevant aspects of quality control and recent technical developments.
- To expose students to the engineer's responsibilities and ethics.
- To upskill students to implement the technical knowledge in the real industrial situations.

Course Outcomes

At the end of the course, the student will be able to:
CO1: Apply theoretical knowledge and skill sets acquired from the course and workplace in the assigned job function (s).
CO2: Articulate career options by considering opportunities in company, sector, industry, professional and educational advancement.
CO3: Communicate and collaborate effectively and appropriately with different professionals in the work environment through written and oral means.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1		1		1	2		3	1		3		2	2	2
CO2	1							3	1	3					
CO3	1	2	1	2	1		1	3	1		3	3			

Guidelines

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. The internship is to be taken in a phased manner during the summer vacation starting from the end of sixth semester. The students are recommended to pursue the internship at Public Sector Undertaking (PSU) and private companies including MNC's, Small and Medium scale industries or Research labs/institutes or Academic Institutions. After the completion of the internship the students are instructed to submit the industry supervisors report according to the prescribed format for the external evaluation. Apart from these, the internal evaluation includes a presentation and report submission.

23ARE498	PROJECT PHASE I	6L-T-P-C: 0-0-6-2	S7

Course Objectives

The course should enable the students:

- 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

At the end of the course, the student will be able to:

CO1: Identify and define a problem based on the community/industry/research.

CO2: Plan project activities, considering their underlying requirements, constraints and deliverables.

CO3: Design the solution to the identified problem.

CO4: Communicate and document the project work through technical reports and presentations.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2			2	1	1	3		1	2	2	2	2
CO2	3	3	2			1	1	1	3		2	2	2	2	2
CO3	3	3	3			1	1		3		1	2	2	2	2
CO4									3	3	1	2			

Guidelines

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. 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

23ARE499	PROJECT PHASE II	L-T-P-C: 0-0-30-10

Prerequisite: Project Phase I

Course Objectives

The course should 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

At the end of the course, the student will be able to:
CO1: Develop and test the solution based on the methodology identified in the final year project phase 1.
CO2: Analyze and discuss the results to draw valid conclusions.
CO3: Demonstrate related deliverables needed to support and present the entire project effectively with written and oral means.
CO4: Understand and practice professional and ethical responsibilities for sustainable development of society in the chosen field of project.
CO5: Communicate and document the project work through technical report and presentations.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3		2	1		2	2	1	2	3	3	3
CO2	3	3	3	3		2	1		2	2		3	3	3	3
CO3	2	2				2	1		2	2		3	3	3	3
CO4	2	2	1			2	2	2		2		3	3	3	3
CO5									3	3	1	3			

Guidelines

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 methodology in phase 1. 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. The final evaluation and viva-voce will be conducted after submission of the final project report in the prescribed form. Students have to make a presentation on the work carried out, before the departmental committee, as part of project evaluation.

DEPARTMENT OF MECHANICAL ENGINEERING

MINOR: ROBOTICS AND AUTOMATION

Preamble:

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

List of courses for Minor in Robotics and Automation:

Minimum of 18 credits required for Minor programme

S.No.	Course Code	Name of the Course	Semester	L-T-P	Credits
Mandatory Courses (13 credits)					
1	23MEE231M	Actuators and Drives	3	3-0-0	3
2	23MEE232M	Robot Kinematics and Dynamics	-	3-0-0	3
3	23MEE233M	Microcontrollers and Embedded Systems	-	2-0-3	3
4	23MEE234M	Robotics and Control	-	3-0-3	4
Any two of the following courses can be selected in addition to above four courses for the minor program **(6 credits)**					
5	23MEE235M	Industrial Internet of Things	-	2-0-3	3
6	23MEE236M	Industrial Process Automation	-	2-0-3	3
7	23MEE237M	Mobile Robots	-	2-0-3	3
8	23MEE238M	Real Time Operating Systems	-	2-0-3	3
9	23MEE239M	Drone Technology	-	2-0-3	3

23MEE231M	ACTUATORS AND DRIVES	L-T-P-C: 3-0-0-3

Prerequisite: Nil
Nature of Course: Theory

Course Objectives

- 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:
CO1: Understand the concepts of hydraulic, pneumatic and electrical actuators to industrial applications
CO2: Determine the specifications of hydraulic, pneumatic actuators for a given application
CO3: Evaluate the performance characteristics of electrical actuators
CO4: Select suitable actuators and drives for robotics and automation applications
CO5: Analyze the performance characteristics of drives for different actuators

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3										1				
CO2	3	3							1			1				
CO3	3	3	1									1				
CO4	3	3	1						1			1				
CO5	3	3	2		1				1			1				

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:
S. R. Deb; Sankha Deb. Robotics Technology and Flexible Automation, Second Edition McGraw-Hill Education:New York, 2010.
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:
Nathan Ida, Sensors, Actuators, and Their Interfaces- A multidisciplinary introduction, 2nd Edition, IET Digital Library, 2020.
Pillay. S.K, A First Course on Electric Drives, Wilely Eastern Limited, Bombay, 2012
Stephen J. Chapman, 'Electric Machinery Fundamentals'4th edition, McGraw Hill Education Pvt. Ltd, 2010.
Jagadeesha T., "Hydraulics and Pneumatics", 1st edition, I K International Publishing House, New Delhi, 2015

23MEE232M	ROBOT KINEMATICS AND DYNAMICS	L-T-P-C: 3-0-0-3

Prerequisite: Nil
Nature of Course: Theory

Course Objectives

This course is expected to 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:
CO1: Understand the frame representation and spatial transformation
CO2: Derive the DH parameters and perform forward kinematic analysis
CO3: Perform inverse kinematic analysis of robots
CO4: Compute Jacobian matrix and solve the singularity problems of serial robot manipulators
CO5: Apply the Lagrange's equation to derive the equations of motion
CO6: Analyse the dynamics of robot manipulator using Newton-Euler formulation

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2		1							1				
CO2	3	3	2	1	1							1				
CO3	3	3	2	1	1							1				
CO4	3	3	2		1							1				
CO5	3	3	2		1							1				
CO6	3	3	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:
Niku, Saeed B. Introduction to robotics: analysis, control, applications. John Wiley & Sons, 2020.
Craig, John J. Introduction to Robotics. Pearson Higher Ed, 2021.

Reference Books:
Spong, Mark W., and Mathukumalli Vidyasagar. Robot dynamics and control. John Wiley & Sons, 2008.
Shabana, Ahmed A. Computational dynamics. John Wiley & Sons, 2009.
Schilling RJ. Fundamentals of robotics: analysis and control. New Jersey: Prentice Hall; 1990 Jan.

23MEE233M	MICROCONTROLLERS AND EMBEDDED SYSTEMS	L-T-P-C: 2-0-3-3

Prerequisite: Nil
Nature of Course: Laboratory Integrated

Course Objectives

- 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:
CO1: Identify various hardware and software architectures in embedded systems
CO2: Articulate the concepts of microprocessors and microcontrollers
CO3: Describe the detailed architecture, internal modules and addressing modes of ARM based processor
CO4: Analyze microcontroller peripherals and interfacing of sensors and actuators
CO5: Develop robotics and automation applications with microcontrollers

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2						1	1						
CO2	3	3	1						1	1						
CO3	3	3	1	2	1				1	1						
CO4	3	3	3	2	1				1	1						
CO5	3	3	3	3	3				1	1		1				

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:
Familiarization of IDE, simulator, development boards and kits
Assembly Language Programs
Embedded C Program to configure and use Input/output ports & Timers
Embedded C Program to configure and use ADC and DAC
Embedded C Program to configure and use PWM
Embedded C Program to configure and use UART
Embedded C Program to configure and use SPI
Embedded C Program to configure and use I2C
Interfacing of sensors and actuators to microcontroller
Development of robotic and automation applications

Text Books

Yifeng Zhu, "Embedded Systems with ARM Cortex-M Microcontrollers in Assembly Language and C". Third Edition, E-Man Press LLC, 2017.
Saurabh Chandrakar Nilesh Bhaskarrao Bahadure, "Microcontrollers and Embedded System Design", First Edition, Dreamtech Press, 2019.
Joseph Yu, "The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors", Third Edition, Newness, 2013.

Reference Books

ARM Technical Reference Manual (https://developer.arm.com/documentation/)
ARM Architecture Reference Manual (https://developer.arm.com/documentation/)
NXP LPC 17xx user manual (https://www.nxp.com/docs/en/user-guide/UM10360.pdf)
Getting started with MDK Create applications with µVision® for ARM® Cortex®-M microcontrollers (https://www2.keil.com/docs/default-source/default-document-library/mdk5-getting-started.pdf?sfvrsn=2)
Steve Furber, "ARM System-on-chip Architecture", Second Edition, Addison Wesley, 2000.
Andrew Sloss, Dominic Symes and Chris Wright, "ARM System Developer's Guide: Designing and Optimizing System Software", Morgan Kaufumann Publisher, 2011.
William Hohl and Christopher Hinds, "ARM Assembly Language: Fundamentals and Techniques", Second Edition, CRC Press, 2016.
ARM Technical Reference Manual, NXP LPC 17xx datasheet.

23MEE234M	ROBOTICS AND CONTROL	L-T-P-C: 3-0-3-4

Prerequisite: Nil
Nature of Course: Laboratory Integrated

Course Objectives

- 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:
CO1: Outline the fundamentals of robotics and its components
CO2: Solve for the manipulator dynamics using Lagrangian formulation.
CO3: Implement the various trajectory planning algorithms and control techniques
CO4: Solve the forward and inverse dynamics problems of robotics
CO5: Apply different nonlinear and force control algorithms for robot control.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3	3						1	1		1				
CO2	3	3	3		1				1	1		1				
CO3	3	3	3		1				1	1		1				
CO4	3	3	2		1				1	1		1				
CO5	3	3	3		1				1	1		1				

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.

Unit 2
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:
Dynamic modelling and analysis of an industrial robot manipulator.
Trajectory Planning of 3R robot based on 3rd order polynomial trajectory
Computation of geometric Jacobian for robot manipulator.
Trajectory tracking control of industrial robotic arm using robot manipulator blocks
Rotational and transform trajectory analysis of robot manipulator
Trapezoidal velocity profile trajectory analysis of robot manipulator
Visualization of manipulator trajectory tracking in 3D.

Design and develop the manufacturing cell using virtual robot simulator.
Develop a TCP and work-object for Industrial Robot using Robot simulator.
Develop the robot programming for pick and place of objects, material handling and welding operations.
Singularity analysis using Robot simulator.
Interface and configure the vision system with Industrial Robot.
Part identification based on colour & pattern and separate the components using vision system and Robot.
Develop a program to draw a pattern using the manipulator.
Program the robot manipulator's end effector to travel along a complex 3D path.

Text Book

Craig, J.J., Introduction to Robotics: Mechanics and Control, 2nd Edition, Addison-Wesley, Reading, MA, 1989.

Reference Books

L. Sciavicco, B. Siciliano, Modeling and Control of Robot Manipulators, Springer, 2002.
Angeles, J., Fundamentals of Robotic Mechanical Systems, Springer-Verlag, New York, NY, 1997.
Fu, Gonzales, and Lee, Robotics: Control, Sensing, Vision, and Intelligence, McGraw-Hill, 1987.
Shames,I.H, "Engineering Mechanics-Statics and Dynamics", 4/e, Prentice-Hall of India Pvt. Ltd., 2005

23MEE235M	INDUSTRIAL INTERNET OF THINGS	L-T-P-C: 2-0-3-3

Prerequisite: Nil
Nature of Course: Laboratory Integrated

Course Objectives

- 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:
CO1: Describe the concepts and characteristics of Industry 4.0.
CO2: Comprehend different enabling technologies and their role in establishing Industry 4.0.
CO3: Understand different communication technologies used in Industry 4.0.
CO4: Perform edge, cloud computing, and visualize the data.
CO5: Apply IoT for the given applications.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1		2				1	1		1				
CO2	3	2	1		2				1	1		1				
CO3	3	2	2		2		1		1	1		1				
CO4	3	2	3		2	2	2	1	1	1		1				
CO5	3	2	2		2	2	2	1	1	1		1				

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:
Introduction to Arduino, and ESP8266 (Node MCU)
Introduction to Raspberry Pi and Installation of OS
Modules and Sensors Interfacing (LM35, DHT 11, POT, IR sensor, Ultrasonic sensors) using Raspberry Pi/Node MCU
Modules and Actuators Interfacing (Relay, Motor, Buzzer) using Raspberry Pi/Node MCU
Measurement of temperature & pressure values of the process using Raspberry Pi/Node MCU
Demonstration of MQTT communication
Demonstration of LoRa communication
Visualization of diverse sensor data using dashboard (part of IoT's 'control panel')
Sending alert message to the user (ways to control and interact with environment)

Device control using mobile Apps or through Web pages
Machine to Machine communication

Textbooks:

Klaus Schwab, "The Fourth Industrial Revolution", Portfolio Penguin, 2017.
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:

Alasdair Gilchrist, "Industry 4.0: The Industrial Internet of Things", Apress, 2016.
Kaushik kumar, DivyaZindani, J. Paulo Davim, "Digital manufacturing and assembly systems in Industry 4.0", CRC Press, Taylor and Francis group, 2020.
Antonio sartal, Diego Carou, J.PauloDavim, " Enabling technologies for the successful deployment of Industry 4.0, CRC press, 2020.
Alp Ustundag, Emrecavikcan, "Industry 4.0: Managing the digital transformation", Springer International publishing, 2018.
Christoph Jan Bartodziej, "The Concept Industry 4.0", Springer Gabler, 2017.

23MEE236M	INDUSTRIAL PROCESS AUTOMATION	L-T-P-C: 2-0-3-3

Prerequisite: Nil
Nature of Course: Theory

Course Objectives

- 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:
CO1: Develop the PLC program for the given application
CO2: Interface the Input and output devices with PLC
CO3: Apply the concepts of SCADA for industrial automation
CO4: Analyze the communications and networking of distributed control systems
CO5: Design a graphical system using Virtual Instrumentation software

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1		2				1	1		1				
CO2	3	2	1		2				1	1		1				
CO3	3	2	2		2		1		1	1		1				
CO4	3	2	3		2	2	2	1	1	1		1				
CO5	3	2	2		2	2	2	1	1	1		1				

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:
Ladder programming for boolean operations & math operations
Interfacing of Electro-Pneumatic system with PLC
Speed control of DC motor using PLC
Interfacing HMI with PLC
Interfacing PLC real-time TAG with SCADA
Flow and pressure measurement and control using SCADA
Develop a SCADA screen program for process plant operation

Develop a database and recipe TAG base in SCADA
Basic programming using Virtual Instrumentation software
Data acquisition and processing using Virtual instrumentation software
Graphical system design using Virtual Instrumentation software

Textbooks

Lukas M.P, "Distributed Control Systems," Van Nostrand Reinhold Co., New York, 1986.
Petruzella, Frank D. Programmable logic controllers. Tata McGraw-Hill Education, 2005.
Gupta, Virtual Instrumentation Using LabVIEW 2E, Tata McGraw-Hill Education, 2010

Reference Books

Elshafei, M., 2016. Modern Distributed Control Systems: A comprehensive coverage of DCS technologies and standards. CreateSpace Independent Publishing Platform.
Mehra, R., 2012. PLCs & SCADA: Theory and Practice. Laxmi Publications.
Jennings, R. and De La Cueva, F., 2020. LabVIEW graphical programming. McGraw-Hill Education.

23MEE237M	MOBILE ROBOTS	L-T-P-C: 2-0-3-3

Prerequisite: Nil
Nature of Course: Laboratory Integrated

Course Objectives

- 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:
CO1: Derive the mathematical models and describe motion control methods
CO2: Apply various models of localization and navigation.
CO3: Analyze locomotion challenges and select motion-planning algorithms.
CO4: Design and develop autonomous mobile robots with obstacle avoidance.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3	3						1	1		1				
CO2	3	3	3		1				1	1	1	1				
CO3	3	3	3		1				1	1	1	1				
CO4	3	3	2		1				1	1	1	1				

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
Design and simulation of a biped robot.
MATLAB/Python programming for kinematic control of differential drive vehicle.
Line fitting and range data feature extraction.
Line-based Kalman filtering for mobile robot localization,
Simultaneous localization and mapping based on Extended Kalman Filtering.
Simulate a system of collective robots for arbitrary inputs and constraints,
Mobile robot path planning with global and local dynamic window approaches.
Noise rejection navigation simulation for mobile robot

Textbooks

Roland Siegwart, Illah R. Nourbakhsh, and Davide Scaramuzza. (2011). Introduction to Autonomous Mobile Robots. 2nd edition, The MIT Press.
Gregory Dudek, and Michael Jenkin. (2010). Computational Principles of Mobile Robotics. Second edition, Cambridge University press

Reference Books

Ulrich Nehmzow, (2012). Mobile Robotics: A Practical Introduction Second Edition. Springer.
Peter Corke (2017). Robotics, Vision and Control Fundamental Algorithms in MATLAB®. Second Edition. Springer
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.
Sebastian Thrun, Wolfram Burgard, Dieter Fox. (2002) Probabilistic Robotics. The MIT press.
Steven M. LaValle. (2006). Planning Algorithms, Cambridge University Press.

23MEE238M	REAL TIME OPERATING SYSTEMS	L-T-P-C: 2-0-3-3

Prerequisite: Nil
Nature of Course: Laboratory Integrated

Course Objectives

- 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:
CO1: Identify the basic concepts in real time systems
CO2: Apply various services provided by the RTOS Kernel
CO3: Analyze various algorithms of RTOS kernel services.
CO4: Develop real time applications using ROS framework.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3			1				1	1		2				
CO2	3	3			1				1	1		2				
CO3	3	3	2		1				1	1		2				
CO4	3	3	3	1	1				1	1		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, Pre-emption - 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:
ROS launch
3D visualization tool (RViz)
Design and development of graphical user interface in ROS environment.
Establish communication between robot client and server
Analysis of data packet loss Visualization of robot and their movements in Rviz ROS.

Text Books
Qing Li, Caroline Yao, "Real-Time Concepts for Embedded Systems" First Edition, CRC Press, 2010.
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

Tanenbaum, "Modern Operating Systems," Fourth Edition, Pearson Edition, 2014.
Jane W.S. Liu, "Real -Time Systems", First Edition, Pearson Education, 2000.
Lentin Joseph, "Robot Operating System (ROS) for Absolute Beginners: Robotics Programming Made Easy", First Edition, Apress, 2018.
Kumar Bipin, "Robot Operating System Cookbook", First Edition, Packt Publishing, 2018.

23MEE239M	DRONES TECHNOLOGY	L-T-P-C: 2-0-3-3

Prerequisite: Nil
Nature of Course: Laboratory Integrated

Course Objectives

- 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:
CO1: Solve the kinematics and dynamics of fixed wing drones
CO2: Solve the kinematics and dynamics of multi rotor micro drones.
CO3: Design the flight controls of drones.
CO4: Design and develop path planning algorithms for drones

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3		3	2				1	1		1				
CO2	3	3		3	2				1	1		1				
CO3	3	3	3	3	3				1	1	1	1				
CO4	3	3	3	3	3				1	1	1	1				

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.

Text Books:
R. Beard, and T. W. McLain, "Small Unmanned Aircraft: Theory and Practice", Princeton University Press, 2012
R. C. Nelson, "Flight Stability and Automatic Control", McGraw Hill, New York, 1998.

Reference Books:
L.R. Newcome, Unmanned Aviation, a Brief History of Unmanned Aerial Vehicles, American Institute of Aeronautics and Astronautics, Reston, 2004.
Kuo, B. C., "Automatic Control Systems", Prentice Hall, 1991

ELECTIVES

STREAM 1 – FIELD/SERVICE ROBOTS

23ARE331	BIO-INSPIRED ROBOTS	L-T-P-C: 3-0-0-3

Course Objectives

- To familiarize the knowledge of the biological systems with reference to robotic systems.
- To inculcate the development of biologically inspired robotic applications.

Course Outcomes

At the end of the course the student will be able to
CO1: Explain the bio-inspired sensing and formulate the bioinspired motion.
CO2: Explain the Soft and Hard Robotics.
CO3: Analyze the control architecture and behavior with reference to kinematics.
CO4: Evaluate collective and bio-hybrid robotics/create electromechanical robotic system.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2		1								1	3		
CO2	3	1		1								1	3		
CO3	3	2	2	2	3							1	3		
CO4	3	2	1	2	3							1	3		

Syllabus

Unit 1
Fundamentals of Traditional Robots, Biologically-inspired Robots, Introduction, Bio-inspired morphologies, Bio-inspired sensors, Vision, Audition, Touch, Smell, taste, Idiothetic sensors. Fundamentals of Biologically Inspired Robots, Bio-inspired actuators, locomotion, crawling, walking, wall climbing, jumping, swimming, flying, grasping, drilling

Unit 2
Soft Robotics, Structural Difference between Hard and Soft Robots, Bio-inspiration in Soft Robotics, Hydrostatic Skeletons, Muscular Hydrostats, Soft Active Plant Structure, Soft Robots, Actuators, Pneumatic Artificial Muscles, Electroactive Polymers, Shape Memory Alloys

Unit 3
Bio-inspired control architectures, Behavior-based robotics, learning robots, evolving robots, developing robots, Bio-inspired Robot Design Considering Load-bearing and Kinematic Ontogeny of Sea Turtles. Energetic anatomy, Collective robotics, Biohybrid robots. Case studies and mini projects in Design and Fabrication of Biologically Inspired Robots.

Text Books /Reference books
Thomas R. Consi and Barbara Webb, Biorobotics - Methods and Applications, MIT Press, 2001.
Yunhui Liu and Dong Sun, Biologically Inspired Robotics, CRC Press, 2012.
Ralf Simon King, BiLBIQ: A Biologically Inspired Robot with Walking and Rolling Locomotion, Springer, 2013.
Karl Williams, Amphibionics - Build Your Own Biologically Inspired Robot, McGraw-Hill Education, 2003.

23ARE332	HUMANOID ROBOTS	L-T-P-C: 3-0-0-3

Course Objectives

- To familiarize the knowledge of the kinematics and dynamics of Humanoid Robots.
- To familiarize the generation of biped walking patterns and control.
- To impart the design of different methods for generation of Whole-Body Motion Patterns.
- To inculcate the methods for simulating humanoid robot dynamics.

Course Outcomes

At the end of the course the student will be able to
CO1: Explain the kinematics and dynamics of Humanoid Robots.
CO2: Apply the knowledge of design in generating the biped walking patterns and control.
CO3: Analyze the different methods for generation of Whole-Body Motion Patterns.
CO4: Analyze the methods for simulating humanoid robot dynamics.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	1								1	3		
CO2	3	3	2	2	1							1	3		
CO3	3	3	2	2	2							1	3		
CO4	3	3	2	2	2							1	3		

Syllabus

Unit 1
Introduction, Kinematics: Coordinate Transformations, Characteristics of Rotational Motion, Velocity in Three-Dimensional Space, Robot Data Structure and Programming, Kinematics of a Humanoid Robot. Zero Moment Point (ZMP) and Dynamics: ZMP and Ground Reaction Forces, Measurement of ZMP, Dynamics of Humanoid Robots, Calculation of ZMP from Robot's Motion

Unit 2
Biped Walking: How to Realize Biped Walking? Two-Dimensional Walking Pattern Generation, 3D Walking Pattern Generation, ZMP Based Walking Pattern Generation, Stabilizer, Pioneers of Dynamic Biped Walking Technology, Additional Methods for Biped Control

Unit 3
Generation of Whole-Body Motion Patterns: How to Generate Whole Body Motion, Converting Whole Body Motion Patterns to Dynamically Stable Motion, Remote Operation of Humanoid Robots with Whole Body Motion Generation, Reducing the Impact of a Humanoid Robot Falling Backwards
Dynamic Simulation: Dynamics of Rotating Rigid Body, Spatial Velocity, Dynamics of Rigid Body, Dynamics of Link System: Forward and Inverse Dynamics, Featherstone's Method.

Text/Reference Books
Shuuji Kajita, Hirohisa Hirukawa, Kensuke Harada and Kazuhito Yokoi, Introduction to Humanoid Robotics, Springer, 2014.
Dragomir N. Nenchev, Atsushi Konno, Teppei Tsujita, Humanoid Robots: Modelling and Control, Butterworth-Heinemann, 2019
Matthias Hackel, Humanoid Robots: Human-like Machines, I-Tech Education and Publishing, 2007.
Ben Choi, Humanoid Robots, In-Tech, 2019.

23ARE333	MEDICAL ROBOTS	L-T-P-C: 3-0-0-3

Course Objectives

- To familiarize the knowledge of medical robots in computer integrated minimally invasive surgery.
- To inculcate the diverse applications of robotics in surgery.
- To familiarize the importance of robotics in Rehabilitation and medical care.
- To familiarize the methodologies for design of medical robots.

Course Outcomes

At the end of the course the student will be able to:
CO1: Explain the application of medical robots in computer integrated minimally invasive surgery.
CO2: Apply the robots in general surgery.
CO3: Apply robots in rehabilitation and medical care.
CO4: Design, develop the methodologies for medical robots.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2		1								1	3		
CO2	3	3	1	2	1							1	3		
CO3	3	3	1	2	1							1	3		
CO4	3	3	3	3	3							1	3		

Syllabus

Unit 1
Types of medical robots: Navigation, Motion Replication, Imaging, Rehabilitation and Prosthetics, State of art of robotics in the field of healthcare; Localization and Tracking: Position sensors requirements, Tracking, Mechanical linkages, Optical, Sound-based, Electromagnetic, Impedance-based, In-bore MRI tracking, Video matching, Fiber optic tracking systems, Hybrid systems.

Unit 2
Applications of Surgical Robotics: Radiosurgery, Orthopaedic Surgery, Urologic Surgery and Robotic Imaging, Cardiac Surgery, Neurosurgery, ENT surgery; Robots in rehabilitation: Rehabilitation for Limbs, Brain-Machine Interfaces, Steerable Needles.

Unit 3
Robots in Medical Care: Assistive robots – types of assistive robots – case studies; Design of Medical Robots: Characterization of gestures to the design of robots, Design methodologies- Technological choices – Security

Text/Reference Books
Paula Gomes, Medical robotics: Minimally invasive surgery, Woodhead Publishing Limited, 2012.
Achim Schweikard and Floris Ernst, Medical Robotics, Springer, 2015
Jocelyne Troccaz, Medical Robotics, John Wiley & Sons, 2012.
Pedro Encarnação and Albert M. Cook, Robotic Assistive Technologies: Principles and Practice, CRC Press, 2017.
Roberto Colombo and Vittorio Sanguineti, Rehabilitation Robotics: Technology and Application, Academic Press, 2018.

23ARE334	UNDERWATER ROBOTS	L-T-P-C: 3-0-0-3

Course Objectives

- To familiarize the building blocks and principles of marine robotics.
- To impart the knowledge in designing the marine robots.

Course Outcomes

At the end of the course the student will be able to:
CO1: Explain the basics elements of marine robots.
CO2: Apply the knowledge of thruster system, trajectory methods to navigate the marine robot.
CO3: Analyze the methods to predict the motion and control the marine robot.
CO4: Design the marine robot replicas from bio-mimetics and bio-inspired systems.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3		1								1	3		
CO2	3	3	1	2								1	3		
CO3	3	3	2	3	2							1	3		
CO4	3	3	3	3	3							1	3		

Syllabus

Unit 1
Introduction to marine robotics and robotics configurations, autonomous underwater glider (AUGs), autonomous underwater vehicles (AUVs), and remotely operated underwater vehicles. Actuation and sensing systems; communication; manipulation; interaction; guidance, navigation and control; and mission control systems.

Unit 2
Algorithms for SLAM, fault detection/tolerance systems; multiple coordinated vehicle; and networked vehicle. Signature detection, analysis, and optimization; sensor networks for radars, sonar and navigation; design of propulsion system; and trajectory measurements and simulations. Design and analysis of thrusters for AUGs/AUVs.

Unit 3
Motion prediction and control system, and co-operative adaptive sampling techniques. Design of variable buoyancy systems for UVs. Design of DCDM based controllers for UVs. Remote sensing and environmental monitoring with AUGs/AUVs, underwater vehicle-manipulator system, bio-mimetic underwater robotics, and bio-inspired robotics systems. Case studies from India, Republic of Korea, Japan and USA.

Text Books
T. Fossen, "Guidance and control of ocean vehicles", Chichester New York, USA, 1994
N. Newman, "Marine Hydrodynamics", MIT Press, USA, 1997
T. Fossen, "Marine Control Systems: Guidance, Navigation, and Control of Ships, Rigs, and Underwater Vehicles", Marine Cybernetics, Trondheim, Norway

Reference Books
K. D. Do, and J. Pan, "Control of ships and underwater vehicles: Design for underactuated and Non-linear Marine Systems", Advances in Industrial Control, 1e, Springer, 2009.
G. Griffiths, "Technology and applications of autonomous underwater vehicles", Ocean science and technology, vol. 2, CRC Press, USA, 2002.
R. Suttons, G Roberts, "Advances in unmanned marine vehicles", IEEE Control Series, Institution of Engineering and Technology, USA, 2006.

23ARE335	COGNITIVE ROBOTS	L-T-P-C: 3-0-0-3

Course Objectives

- To impart the basic knowledge of robot cognition, human brain and neuro transmissions
- To familiarize the concepts of robot cognitive models, robot perceptions and 3D digital reconstruction
- To inculcate the cognitive and intelligent robotic models

Course Outcomes

At the end of the course the student will be able to
CO1: Explain the human psychology, neuroscience and data transmission through nerves
CO2: Apply the cognitive intelligence and soft computing tool in the robot models.
CO3: Apply the 3D digital reconstruction for the robot perception and map building
CO4: Integrate the path planning and navigation tools with robot models

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2								1	3		
CO2	3	3	2	2	2							1	3		
CO3	3	3	2	2	2							1	3		
CO4	3	3	2	2	3							1	3		

Syllabus

Unit 1
Introduction to human robot interaction, smart materials. Brain physiology and neural signal transmission, architecture of the brain and nerve cells. Neural modeling: Introduction to synchronization modeling, electroencephalography. Intelligent architecture: Theories of intelligence, Kuramoto model, Child-Robot interaction.

Unit 2
Introduction to the model of cognition, visual perception and recognition, Machine learning, soft computing tools, and robot cognition. Necessity for 3D Reconstruction – Building Perception – Imaging Geometry – Global Representation – Transformation to Global Co-ordinate System. Map building: 2D world map, data structure for map building, Procedure map building, procedure traverse boundary, robot simulation and robot map building programming.

Unit 3
Robot Parameter Display, Program for BotSpeak, Program for Sonar Reading Display, Program for Wandering Within the Workspace, Program for Tele-operation, A Complete Program for Autonomous Navigation.

Text Books
Patnaik, Srikanta, "Robot Cognition and Navigation - An Experiment with Mobile Robots", SpringerVerlag Berlin and Heidelberg, 2007.
Howie Choset, Kevin LynchSeth Hutchinson, George Kantor, Wolfram Burgard, Lydia Kavraki, and Sebastian Thrun, "Principles of Robot Motion-Theory, Algorithms, and Implementation", MIT Press, Cambridge, 2005.

Reference Books
Sebastian Tharun, Wolfram Burgard, Dieter Fox, "Probabilistic Robotics", MIT Press, 2005.
Margaret E. Jefferies and Wai-Kiang Yeap, "Robotics and Cognitive Approaches to Spatial Mapping", Springer-Verlag Berlin Heidelberg 2008.
HoomanSomani," Cognitive Robotics", CRC Press, 2015.
Jared Kroff,"Cognitive Robotics: Intelligent Robotic Systems", Wilford Press, 2016.
Lidia Ogiela, Marek Ogiela, "Advances in Cognitive Information Systems", Springer, 2012.

23ARE336	DRONE TECHNOLOGY	LTPC-2-0-3-3

Course Objectives

- To familiarize with the basic concepts of drones, propellers, and controls of drones.
- To impart the state estimations and path planning of drones.

Course Outcomes

At the end of the course the student will be able to
CO1: Solve the kinematics and dynamics of fixed wing drones.
CO2: Solve the kinematics and dynamics of fixed wing drones multi rotor micro drones.
CO3: Design the flight controls of drones.
CO4: Design and develop path planning algorithms for drones.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3		3	2				1	1		1	3		
CO2	3	3		3	2				1	1		1	3		
CO3	3	3	3	3	3				1	1		1	3		
CO4	3	3	3	3	3				1	1		1	3	1	

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.

Text Books
R. Beard, and T. W. McLain, "Small Unmanned Aircraft: Theory and Practice", Princeton University Press, 2012
R. C. Nelson, "Flight Stability and Automatic Control", McGraw Hill, New York, 1998.

Reference Books
L.R. Newcome, Unmanned Aviation, a Brief History of Unmanned Aerial Vehicles, American Institute of Aeronautics and Astronautics, Reston, 2004.
Kuo, B. C., "Automatic Control Systems", Prentice Hall, 1991

23ARE337	AUTONOMOUS VEHICLES 1	L-T-P-C: 3-0-0-3

Course Objectives

- To understand the hardware and software components of an autonomous vehicle
- To design and develop state estimation and localization techniques for an autonomous vehicle
- To design and develop convolutional neural networks for visual perception of an autonomous vehicle

Course Outcomes

At the end of the course the student will be able to
CO1: Understand hardware and software components in an autonomous vehicle
CO2: Develop state estimation and localization techniques for an autonomous vehicle
CO3: Build, compare and contrast feedforward neural networks
CO4: Build, compare and contrast convolutional neural networks for visual perception of an autonomous vehicle

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3													
CO2	3	3	2	2	2								1	1	1
CO3	3	3	1	1									1	1	1
CO4	3	3													

Syllabus

Unit 1
Introduction – Terminology, Design consideration, Safety assessment. Commonly used hardware, main components of software stack, Vehicle modelling and control, safety frameworks and current industry practices.

Unit 2
State Estimation and Localization – Least squares – Vehicle localization sensors – GPS and IMU – Extended Kalman filter, unscented Kalman filter – LIDAR scan matching, Iterative Closest Point Algorithm – Multiple sensor fusion for vehicle state estimation and localization.

Unit 3
Feedforward neural networks – Review of Deep Learning, Multilayer Perceptron, Optimization, Stochastic Gradient Descent, Back propagation - Introduction to Convolutional Neural Networks (CNN): Architecture, Convolution/Pooling layers – Understanding and Visualizing CNN.

Text Books/References:
Lipson, H & Kurman, M, Driverless: Intelligent Cars on the Road Ahead, MIT Press, 2016
Dan Simon, "Optimal State Estimation: Kalman, H∞, and Nonlinear Approaches", John Wiley & Sons, 2006
Ian Goodfellow, Yoshua Bengio, Aaron Courville, "Deep Learning", MIT Press 2016

23ARE338	AUTONOMOUS VEHICLES 2	L-T-P-C: 3-0-0-3

Course Objectives

- To design and develop intrinsic and extrinsic camera models for visual perception of an autonomous vehicle
- To design and develop convolutional neural networks for visual perception of an autonomous vehicle
- To understand path planning algorithms for an autonomous vehicle

Course Outcomes

At the end of the course the student will be able to
CO1: Model and calibrate camera for visual perception of an autonomous vehicle
CO2: Build, compare and contrast convolutional neural networks for 2 D Object detection, Semantic segmentation
CO3: Understand mission planning in driving environments and dynamic object interactions
CO4: Understand the principles of behaviour planning and reactive planning in static environments

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3													
CO2	3	3	2	2	2								1	1	1
CO3	3	3	1	1									1	1	1
CO4	3	3													

Syllabus

Unit 1
Visual Perception – Visual Perception - Pinhole camera model, intrinsic and extrinsic camera calibration, monocular and stereo vision, projective geometry - CNNs for 2 D Object detection, Semantic segmentation, Motion Planning - Driving Missions, Scenarios, and Behaviour, Motion Planning Constraints,

Unit 2
Objective Functions for Autonomous Driving, Hierarchical Motion Planning - Occupancy Grids, Populating Occupancy Grids from LIDAR Scan Data, Occupancy Grid Updates, High Definition Road Maps, Creating a Road Network Graph,

Unit 3
Dijkstra's Shortest Path Search, A* Shortest Path Search, Motion Prediction, Map-Aware Motion Prediction, Time to Collision

Text Books/References
David A. Forsyth, Jean Ponce, "Computer Vision: A Modern Approach", Pearson, 2003
Ian Goodfellow, Yoshua Bengio, Aaron Courville, "Deep Learning", MIT Press 2016
S. Thrun, W. Burgard, and D. Fox, "Probabilistic robotics", MIT Press, 2010

23ARE339	AGRICULTURAL ROBOTS	L-T-P-C: 3-0-0-3

Course Objectives

- To provide basic conceptual understanding of the principles of automation in agriculture
- To get familiarized on the technologies for precision and site-specific farming.
- To equip with the skills and abilities for selecting robotic systems for agriculture.
- To enhance awareness of the cyber physical system for precision farming.

Course Outcomes

At the end of the course the student will be able to
CO1: Analyse and select an automation strategy for agricultural applications.
CO2: Understand different sensors and actuators used for agriculture.
CO3: Apply motion planning techniques for robots in agriculture.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PS02	PSO3
CO1	2	3	3	3	3	1	1					3			
CO2	2	3	3	3	3	1	1					3			
CO3	2	3	3	3	3	1	1					3			

Syllabus

Unit 1
Introduction - Concepts and definitions for digital farming, precision agriculture, Sensing and situation, Intelligent decision-making, challenges, and opportunities. Smart cameras, 3D and spectral sensing techniques, crop scouting for precision agriculture. Robotics for unstructured agricultural environments. Manual and robotic farming. Robotic grippers and manipulation optimization in agriculture.

Unit 2
Mechatronics for Agriculture. Mechatronic design optimization for agricultural operations, such as weeding, sowing, harvesting, composting, etc., Field robotics and digital farming. Control techniques of heterogeneous agricultural robots and algorithms for interaction. Advanced learning and classification techniques for agriculture.

Unit 3
Collaborative robotic systems in agriculture, adaptive model predictive control in agriculture. Model reference adaptive control for uncertain dynamical systems with disturbances. Drones and satellite guidance-based agriculture for crop management and soil fertility. Case studies: automatic infield sorting and handling of apples, harvesting in tree fruit crops.

Text / Reference Books
Manoj Karkee and Qin Zhang Editors Fundamentals of Agricultural and Field Robotics, Springer (2021)
Dan Zhang, Bin Wei, Robotics and Mechatronics for Agriculture, CRC Press (2017)
Andrey Ronzhin, Tien Ngo, Quyen Vu, Vinh Nguyen. Ground and Air Robotic Manipulation Systems in Agriculture Springer (2022)
K R Krishna, Push Button Agriculture Robotics, Drones, Satellite-Guided Soil and Crop Management, AAP (2016)
K.R. Krishna, Aerial Robotics in Agriculture Parafoils, Blimps, Aerostats, and Kites, AAP (2021)

23ARE341	ROBOT NAVIGATION AND OBSTACLE AVOIDANCE	L-T-P-C: 3-0-0-3

Course Objectives

- To familiarize with the mathematical concepts involved in robot navigation.
- To impart knowledge of concepts on obstacle detection, obstacle avoidance.

Course Outcomes

At the end of the course the student will be able to
CO1: Differentiate kinematic models based on vehicle steering and explain robot attitude.
CO2: Explain the basics of robot navigation concepts.
CO3: Compute receiver location using Global positioning systems.
CO4: Calculate regions of confidence for sensors and applying remote sensing algorithms.
CO5: Apply obstacle mapping and its application to robot navigation.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	3									1	3		
CO2	3											1	3	1	
CO3	3	3	3	3	3							1	3	1	
CO4	3	2	3	3	3							1	3	1	1
CO5	3	2	3	3	3							1	3	1	

Syllabus

Unit 1
Kinematics models for mobile robots, Vehicles with front-wheel steering, vehicles with differential drive steering, Definition of Yaw, Pitch and Roll, Rotation matrix for yaw, pitch and roll, Homogeneous transformation, rotating a Vector.

Unit 2
Robot Navigation, Coordinate systems, Earth-Centered Earth Fixed Coordinate systems, Associated coordinae systems, Global positioning system, Computing receiver location using GPS, Numerical methods, Newton's method, Minimization of a performance index, Gimbaled inertial navigation systems, Strap-down inertial navigation systems, Dead reckoning navigation, inclinometer.

Unit 3
Remote sensing: Camera type sensors, Stereo vision, Radar sensing: Synthetic Aperture Radar, Pointing of Range sensor at detected object, detection sensor in scanning mode, Regions of Confidence for sensor, Model of target location, inventory of detected targets, Sensors for obstacle detection and geo-registration, use of previously detected obstacles for navigation, simultaneous corrections of coordinates of detected obstacles and of the robot.

Text Book
Cook G. and Zhang F. "Mobile Robots: Navigation, control and sensing, surface Robots and AUVs", 2nd Edition, IEEE Press, Wiley, 2020.

Reference Books
Nurmaini S. "Intelligent navigation for Embedded mobile robot: The application of embedded controller", LAP Lambert Academic Publishing 2012.
Cuesta F. and Ollero A. "Intelligent mobile robot navigation" Springer, Berlin, Heidelberg, 2005.
Matveev A. S., Savkin A. V., Hoy M. and Wang C. "Safe Robot Navigation Among Moving and Steady Obstacles" Butterworth-Heinemann, 2016.

23ARE342	ROBOT OPERATING SYSTEM	L-T-P-C: 2-0-3-3

Course Objectives

- To familiarize the students with the basic understanding of robot operating system and their architecture.
- To visualize and simulate the robot environment with simulators.

Course Outcomes

At the end of the course the student will be able to
CO1: Explain the basics of ROS and their architectures.
CO2: List the existing ROS commands for interfacing, and establish the communication with the robot.
CO3: Design and simulate the robot in robot simulation software.
CO4: Design and develop hardware software interfacing kernel to modify ROS.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3			1	3				1	1		1	3		1
CO2	3			1	3				1	1		1	3		1
CO3	3	3	3	2	3				1	1		1	3		1
CO4	3	3	3	3	3				1	1		1	3		1

Syllabus

Unit 1
Introduction –The ROS Equation - History - distributions -difference from other meta-operating systems– services - ROS framework – operating system – releases. UNIX commands - file system – redirection of input and output - File system security - Changing access rights– process commands – compiling, building and running commands – handling variables

Unit 2
File system - packages – stacks – messages – services – catkin workspace – working with catkin workspace – working with ROS navigation and listing commands. Navigation through file system -Understanding of Nodes – topics – services – messages – bags – master – parameter server.

Unit 3
Debugging of Nodes – topics – services – messages – bags – master – parameter – visualization using Gazebo– Rviz – URDF modeling – Xacro – launch files. Hardware Interface: Sensor Interfacing – Sensor Drivers for ROS – Actuator Interfacing – Motor Drivers for ROS.

Lab Components
- Experiment on Creating, building, modifying packages and Writing, building source code and nodes
- Creating and Running Publisher and Subscriber Nodes
- Creating and Running Service Servers and Client Nodes
- Writing and Running the Action Server and Client Node
- Programming experiment on nodes with setting, reading, building, running, displaying parameters list
- Experiment of ROS launch
- Experiment on 3D visualization tool (RViz)
- Design and development of graphical user interface in ROS environment
- Establish communication between robot client and server, and analysis of data packet loss
- Visualization of robot and their movements in Rviz ROS

Text Books

Lentin Joseph, "Robot Operating Systems (ROS) for Absolute Beginners, Apress, 2018.
Aaron Martinez, Enrique Fernández, "Learning ROS for Robotics Programming", Packt Publishing Ltd, 2013.

Reference Books

Jason M O'Kane, "A Gentle Introduction to ROS", CreateSpace, 2013.
Anis Koubaa, "Robot Operating System (ROS) – The Complete Reference (Vol.3), Springer, 2018.
Kumar Bipin, "Robot Operating System Cookbook", Packt Publishing, 2018.
Wyatt Newman, "A Systematic Approach to learning Robot Programming with ROS", CRC Press, 2017.
Patrick Gabriel, "ROS by Example: A do it yourself guide to Robot Operating System", Lulu, 2012.

23ARE343	INTELLIGENT CONTROL SYSTEMS FOR ROBOTS	L-T-P-C: 3-0-0-3

Course Objectives

- To familiarize the student with knowledge of various soft computing tools.
- To impart knowledge regarding the theory and application of fuzzy logic controller design.
- To impart understanding of various Nonlinear controller strategies.

Course Outcomes

At the end of the course the student will be able to:
CO1: Explain the principles of soft computing tools like neural networks and fuzzy logic.
CO2: Apply neural networks and fuzzy logic for system identification.
CO3: Develop understanding of various non-linear control strategies.
CO4: Design fuzzy logic controllers.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3			1							1		2	
CO2	3	3	2	2	1							1		2	
CO3	3	3	1		1							1		2	
CO4	3	3	2	2	1							1		2	

Syllabus

Unit 1
Basic Concepts for Intelligent Systems - Artificial Neural Networks - Perceptral Networks - Radial Basis Function Networks - Back-propagation Networks and Recurrent Networks - System Identification Using Neural Networks - Fuzzy logic - Knowledge Representation - Fuzzy Sets - Fuzzy Rules and Reasoning - Fuzzy Logic Control - Mamdani Model - Takagi-Sugeno Model - System Identification using T-S Fuzzy Models.

Unit 2
Nonlinear Control - Nonlinear State-space Model - Lyapunov Stability Theory - Lyapunov's Indirect Method - Nonlinear Control Strategies Direct Adaptive Control Using Neural Networks - Direct Adaptive Control - SISO and MIMO Systems - Back-stepping Control.

Unit 3
Fuzzy Model Based Control - T-S Fuzzy model - Linear Matrix Inequality (LMI) Technique - Fixed Gain State Feedback Controller Design Technique - Variable Gain Controller Design using Single Linear Nominal Plant and each Linear Subsystem as Nominal Plant - Controller Design using Discrete T-S Fuzzy System.

Text book
Behera L., Kar I., "Intelligent Systems and Control: Principles and Applications", Oxford University Press, 2009.

Reference Books
Gopal M., "Digital Control and State Variable Methods", Tata McGraw Hill, third Edition, 2008.
Zi-Xing C., "Intelligent Control: Principles, Techniques and Applications", World Scientific Publishing Co. Pvt. Ltd., 1997.
Jang J. S. R., Sun C. T., Mizutzni E., "Neuro-Fuzzy and Soft Computing", Prentice Hall India Private Limited, 2002.

23ARE344	OPTIMIZATION FOR ROBOT MODELLING	L-T-P-C: 2-0-3-3

Course Objectives

- To impart the basic knowledge in optimizing the design and performance of robots in kinematics, dynamics and trajectory modelling.
- To impart the concepts of meta-heuristic algorithms in the optimization of robot manipulators.

Course Outcomes

At the end of the course the student will be able to
CO1: Formulate Homogeneous Transformation Matrix (HTM) of rigid body and compute optimal values of Roll, Yaw and Pitch.
CO2: Develop solutions using optimization procedure for the forward kinematics and inverse kinematics of the robot manipulator.
CO3: Compute optimum path and trajectory of the robot using optimization methods.
CO4: Optimize the dimensions of the physical components of the robot using meta-heuristic approaches.
CO5: Identify an appropriate robot type with minimum dimensionality for a given specific task using optimization procedure.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	1	2				1	1	1		3		
CO2	3	3	2	1	2				1	1	1		3		
CO3	3	3	2	1	2				1	1	1		3		
CO4	3	3	2	1	2				1	1	1		3		
CO5	3	3	2	1	2				1	1	1		3		

Syllabus

Unit I
Introduction –traditional gradient based Optimization algorithms – Optimality criterion for unconstrained and constrained optimization problems –Heuristic, Meta-heuristics, and Evolutionary algorithms: selective algorithms specific to robotic applications.

Unit 2
Spatial representation of a rigid body: Position - Rotational Matrix - Euler angles: problem formulation to find best Euler angles - Roll, Pitch and Yaw angles - Homogeneous transformation matrix – Finding optimal values of Roll, Pitch and Yaw. Kinematic Synthesis: Introduction – Type synthesis – Dimensional Synthesis - Evolutionary method – Graph theory approach. Structural Optimization: Topology optimization - Dimensional synthesis using optimization algorithms – Stiffness analysis and optimization.

Unit 3
Manipulator Kinematics: Introduction – Manipulator – Formulating objective function of the forward and inverse kinematics, identify optimum joint angle for the given position vector - Manipulator Jacobian: Finding optimum Jacobian of a manipulator. Path and Trajectory Planning: Introduction – Path Planning algorithms: Identifying optimal path using heuristic approach, Collision detection algorithms – Trajectory Planning: Algorithms, identifying optimum velocity and acceleration along the path.

Note: MATLAB will be used for teaching and learning

Text/Reference Books
Ghafil, Hazim Nasir, and Károly Jármai. Optimization for Robot Modelling with MATLAB. Springer International Publishing, 2020.
Koubâa, Anis, Hachemi Bennaceur, Imen Chaari, Sahar Trigui, Adel Ammar, Mohamed-Foued Sriti, Maram Alajlan, Omar Cheikhrouhou, and Yasir Javed. Robot Path Planning and Cooperation. Vol. 772. Springer International Publishing, 2018.
Jha, Panchanand, and Bibhuti Bhusan Biswal. "Optimization Approach for Inverse Kinematic Solution." In Kinematics. IntechOpen, 2017.
Rao, Singiresu S. Engineering optimization: theory and practice. John Wiley & Sons, 2019.
Arora, Rajesh Kumar. Optimization: algorithms and applications. Chapman and Hall/CRC, 2019.

23ARE345	COMPUTER VISION AND IMAGE PROCESSING	L-T-P-C: 3-0-0-3

Course Objectives

- To familiarize with the principles of nonlinear systems
- To impart the nonlinear system theory to design control systems

Course Outcomes

At the end of the course the student will be able to
CO1: Explain the methods for digital image processing and analysis and relate or apply them to different applications.
CO2: Explain the algorithms for vision related tasks and apply them to solve practical problems.
CO3: Analyse in-depth analysis of the digital image data with different image data models, pattern recognition algorithms and learning theory.
CO4: Design and develop image processing and machine learning algorithms.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3			3							2	2		2
CO2	3	3			3							2	2		2
CO3	3	3	2	3	3							2	2	2	2
CO4	3	3	3	3	3							2	2	2	2

Syllabus

Unit 1
Introduction to Computer Vision and Basic Concepts of Image Formation: Introduction and Goals of Computer Vision and Image Processing, Image Formation Concepts; Fundamental Concepts of Image Formation: Radiometry, Geometric Transformations, Geometric Camera Models, Camera Calibration, Image Formation in a Stereo Vision Setup, Image Reconstruction from a Series of Projections.

Unit 2
Image Processing Concepts: Image Transforms, Image Enhancement, Image Filtering, Colour Image Processing, Image Segmentation; Image Descriptors and Features: Texture Descriptors, Colour Features, Edges/Boundaries, Object Boundary and Shape Representations, Interest or Corner Point Detectors, Histogram of Oriented Gradients, Scale Invariant Feature Transform, Saliency

Unit 3
Fundamentals of Machine Learning: Linear Regression, Basic Concepts of Decision Functions, Elementary Statistical Decision Theory, Parameter Estimation, Clustering for Knowledge Representation, Dimensionality Reduction, Linear Discriminant Analysis; Applications of Computer Vision: Artificial Neural Network for Pattern Classification, Convolutional Neural Networks, Autoencoder, Machine Learning Algorithms and their Applications in Image Segmentation, Gesture Recognition, Object recognition, template matching, classification; Object detection and tracking: background modeling, kernel-based tracking, particle filters.

Text Books / References
David A. Forsyth and Jean Ponce, Computer Vision: A Modern Approach, 2nd Edition, Pearson Education India, 2015.
Manas Kamal Bhuyan, Computer Vision and Image Processing - Fundamentals and Applications, CRC Press, 2020.
Richard Szeliski, Computer Vision: Algorithms and Applications, Springer, 2011.
Rafael C. Gonzalez and Richard E. Woods, Digital Image Processing, 4th Edition, Pearson, 2018

23ARE346	ADVANCED MATERIALS FOR ROBOTICS	L-T-P-C: 3-0-0-3

Course Objectives

- To impart the basic concepts of cell biology, evolutionary systems, neuroscience and immune systems in relation to robotics.
- To familiarize the connection between biology and robotics and how biology inspires robotics.
- To familiarize the different types of robots developed based on biology.

Course Outcomes

At the end of the course, the student will be able to
CO1: Explore the knowledge about thermodynamics of nucleation and strengthening mechanisms.
CO2: Analyze metallic, functional and polymer materials and its processing.
CO3: Explain knowledge in high performance materials and techniques for robotics.
CO4: Analyze structure properties, and performance using advanced material characterization technique.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3										1	3		
CO2	3	3	3	3	3							1	3	1	
CO3	3	3		2								1	3	1	
CO4	3	3	3	3	3							1	3	1	

Syllabus

Unit 1
Advanced metallic materials- Fundamental principles of advanced materials and application of advanced materials to robotics using a multidisciplinary science-based approach. Liquid-solid transformation-Nucleation and kinetics of growth, interface morphologies, nonequilibrium freezing, segregation. Nucleation in the solid state- transformations, diffusion in solid state, diffusion equations for steady state and transient conditions, Strengthening methods and mechanisms.
Structural Materials for Robots – Aluminium, copper, magnesium, steel, nickel and titanium alloys. Recent advances in materials development- Hi-Entropy alloys, functionally gradient materials, shape memory alloys, metallic composite for soft robotics, computational metamaterials.

Unit 2
Composites in robotics- Types of matrices and reinforcements, principles, properties and applications, stretchable elastomeric sensor and ionic polymer for robotics, Kevlar, biodegradable smart materials, macroscopic composites, three-dimensional, periodic cellular architecture. Special processing techniques of material for robotics.

Unit 3
Introduction to thin film sand sensor material, energy material and refractory materials and characterization. Materials characterization techniques for advanced and robotic material – Recap of mechanical, metallurgical, chemical and thermal methods. Instrumentational methods – Scanning electron microscopy, transmission electron microscopy and energy dispersive analyses, X-ray diffraction, atomic force microscopy, Field array NDT techniques for futuristic materials, surface patterning techniques.

Text Books / References
Bhushan Bharat, "Springer Handbook of Nanotechnology", Springer, 2017.
Sohel Rana and Raul Fangueiro, "Advanced Composite Materials for Aerospace Engineering: Processing, Properties and Applications", Woodhead Publishing, 2016.
Rowe Jason, "Advanced Materials in Automotive Engineering", Woodhead Publishing, 2016.
Cantor Brian, Hazel Assender and Patrick Grant, "Aerospace Materials", CRC Press, 2015.
Park Joon and Roderic S. Lakes, "Biomaterials: an Introduction", Springer Science & Business Media, 2007.
Cao Guozhong, "Nanostructures & Nanomaterials: Synthesis, Properties & Applications", Imperial College Press, 2004.
Michio Inagaki Feiyu Kang Masahiro Toyoda Hidetaka Konno, "Advanced Materials Science and Engineering of Carbon", 1st Edition, Butterworth-Heinemann, 2013, ISBN: 9780124077898.
Gaskell, David R., "Introduction to Metallurgical Thermodynamics", McGraw Hill, 1973.
W. D. Callister, "Materials Science and Engineering: An Introduction", John Wiley & Sons, 2007.

C. Kittel, "Introduction to Solid State Physics" Wiley Eastern Ltd, 2005.
Michael Shur, "Physics of Semiconductor Devices", Prentice Hall of India, 1995.
Charles P Poole Jr., and Frank J. Ownes, "Introduction to Nanotechnology", John Wiley Sons, Inc., 2003.
M. H. Loretto, "Electron Beam Analysis of Materials", Chapman and Hall, 1984.
Seymour and Carraher, "Polymer chemistry", Marcel Dekker, 2003.
Sam Zhang, Lin Li and Ashok Kumar, "Materials Characterization Techniques", CRC Press, (2008).

23ARE347	ADVANCED ROBOTICS AND ANALYSIS	L-T-P-C: 3-0-0-3

Course Objectives

- To impart the knowledge of advanced topics of the robot manipulators.
- To inculcate mathematical modelling, numerical analysis and problem-solving techniques of robot manipulators.

Course Outcomes

At the end of the course the student will be able to
CO1: Explain the advanced elements of serial and parallel robot manipulators.
CO2: Explain the algorithms and advanced mathematical formulation of manipulators.
CO3: Apply the mathematical models and algorithms in simulation and analysis.
CO4: Design and develop own robot through analysis, simulation and fabrication.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3		2								1	3		
CO2	3	3		2								1	3		
CO3	3	3	2	3	2							1	3		
CO4	3	3	3	3	3							1	3		

Syllabus

Unit 1
Review of robot manipulator (Serial and Parallel), D-H convention, Forward and Inverse kinematics, Workspace, Analytical and numerical solutions, vibration isolation.

Unit 2
Redundancy and resolution of redundancy in robots, minimizing joint rotations and cartesian motion, Tractrix based approach (resolution, planar and spatial). Experimental 8-link hyper-redundant manipulator, Dynamic equations of motion, derivation & simulation, Recursive inverse dynamics: Newton-Euler formulation, Articulated body algorithm, Chaos and non-linear dynamics, Pseudo-inverse approach, modal approach for straight and circular trajectory.

Unit 3
Simulation on linear control, motion planning, nonlinear position and force control of 6 DOF robot manipulator, partitioning of tasks. Numerical and analytical solutions, Over-constrained and deployable structures – modelling and analysis, Cable driven & pneumatically actuated flexible robots.

Text Book
Ghosal, A., Robotics: Fundamental Concepts and Analysis, Oxford University Press, 2006.

Reference Books
R.K. Mittal and I.J. Nagrath, "Robotics and Control", Tata McGraw Hill.
John J Craig, "Introduction to Robotics: Mechanics and control", Printice Hall of India.
S. K. Saha, "Introduction to Robotics", Tata McGraw Hill.
K.S.Fu, R.C.Gonzalez and C.S.G.Lee, "Robotics: Control, Sensing, Vision and Intelligence", McGraw Hill.
M.W.Spong and M. Vidyasagar, "Robot Dynamics and Control", Wiley India.

23ARE348	COMPOSITE MATERIALS FOR ROBOTICS APPLICATIONS	L-T-P-C: 3-0-0-3

Course Objectives

- To impart the knowledge of composite materials and applications.
- To inculcate the development and analysis of smart materials for robotic applications

Course Outcomes

At the end of the course the student will be able to
CO1: Understand the basic fiber, resin and types of composite materials
CO2: Identify various manufacturing process involved for fabrication of composite materials
CO3: Demonstrate various testing methods involved in the evaluation of properties of composite materials
CO4: Underline different types of smart materials and its manufacturing process

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	3	1	1		3		1			2	2	3	2
CO2	2	2	3	1	1		3		2			2	1	3	1
CO3	3	2	2	1	1		3		2			2	2	2	2
CO4	3	2	2	2	1		3		2			3	3	3	3

Syllabus

Unit 1
Introduction to composites: Characteristics and classifications of composites – study of fibers-flake and particulate composites- Manufacturing methods: Production of various fibers – matrix materials and surface treatments – fabrication of composites – fabrication of thermosetting resin matrix composites – fabrication of thermoplastic resin matrix composites – short fiber composites – fabrication of metal matrix and ceramic matrix composites-

Unit 2
Testing aspects of composites: Experimental characterization of composites – uniaxial tension- compression and shear tests – determination of inter laminar fracture toughness – damage identification through non-destructive evaluation techniques – ultrasonic- acoustic emission and radiography-Special laminates: Symmetric laminates- unidirectional- cross-ply and angle-ply laminates- quasi-isotropic laminates- Recent trends in composite materials – carbon composites- Bucky Paper- Application of composite materials in aerospace- automotive- defense and industry with reference to robotics.

Unit 3
Overview of smart materials, Piezoelectric Ceramics, Piezo-polymers, Magnetostrictive Materials, Electroactive Polymers, Shape Memory Alloys, Electro and Magneto Rheological Fluids ,introduction to composite smart materials, Smart sensors based on high bandwidth low strain smart materials, Low-bandwidth high strain smart actuators, Micro-electro mechanical Smart Systems, Intelligent devices based on smart materials, Applications of Smart Actuators: Active and Hybrid Vibration Control, Active Shape Control, Distributed Sensing and Control of Smart Beams.

Text / Reference Books
R. F. Gibson, Principle of Composite Material Mechanics, McGraw Hill
M. M. Schwartz, Composite Materials Handbook, McGraw Hill. Inc.
R. M. Jones, Mechanics of Composite Materials, McGraw Hill. Inc
S. W. Tsai, Introduction to Composite Materials, Technomic Publishing Company.
Brian Culshaw, Smart Structures and Materials, Artech House, 2000
Gauenzi, P., Smart Structures, Wiley, 2009
Cady, W. G., Piezoelectricity, Dover Publication

23ARE351	SMART SENSORS	L-T-P-C: 3-0-0-3

Course Objectives

- To familiarize the available physical phenomena behind the operation of different types of sensors and micro systems.
- To design sensors with appropriate electronic interface as a complete system.
- To inculcate the applications of sensors in robotics and automation.

Course Outcomes

At the end of the course the student will be able to
CO1: Explain the available physical phenomena behind the operation of different types of sensors and micro systems.
CO2: Design the sensors with appropriate electronic interface as a complete system.
CO3: Analyze and apply sensors in robotics and automation.
CO4: Design and fabricate the process of MEMS fabrication.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1	1								1	2		
CO2	3	3	3	3	3							1	2		1
CO3	3	3	3	3	2							1	3		3
CO4	3	3	3	3	3							1	1		1

Syllabus

Unit I
Sensor Characteristics and Physical Principles of Sensing - Example of Smart Sensors in nature (Vision –Hearing –touch - and smell) - Classification and Terminology of sensors – Measurands - Physical principles of sensing - electric charges – fields - and potentials Capacitance - magnetism - Induction – resistance - Piezoelectric effect - pyroelectric effect - Hall effect - Seebeck and Peltier effects.

Unit 2
Acoustic Sensors - Magnetic Sensors and Mechanical Sensors - Acoustic waves, piezoelectric materials - Acoustic sensing, -saw sensor - Sensor applications and future trends - Magnetic sensors - effects and materials - Integrated Hall sensors – Magneto-transistors - other magnetics transistor and future trends, Mechanical sensors - piezoresistivity - Piezoresistive sensors - Capacitive sensors. Radiation Sensors Thermal Sensors and Chemical Sensors - Radiation basics - HgCdTe infrared sensors - Visible-light color sensors - high-energy photodiodes - Heat transfer - thermal structures – Thermal sensing elements - Thermal and temperature sensors - Interaction of gaseous species at semiconductor Surfaces - Catalysis - the acceleration of chemical reactions - Thin-film sensors - FET devices for gas and ion sensing.

Unit 3
Micro-and Nanotechnologies or Sensors - Fundamentals of MEMS fabrication - introduction and description of basic processes - MEMS fabrication technologies - bulk micromachining - Surface micromachining - High-aspect-ratio (LIGA and LIGA-Like) technology microfluidics microsystem components Microfluidics microsystem components Nanotechnology - product prospects - application trends Procedures and techniques - the making of ultrathin films Creation of lateral nanostructures - clusters and Nano crystalline materials and principles of self-organization and Future trends.

Text Books
Jacob Fraden, "Handbook of Modern Sensors: Physics, Designs, and Applications", Springer; 4th ed. 2010.
S. M. Sze, "Semiconductor Sensors", Wiley-Interscience, 1994.

Reference Books
Gerard Meijer, "Smart sensor systems", Wiley, 2008.
W Gopel, J. Hesse, J. N. Zemel, "Sensors A Comprehensive Survey", Vol. 9, Wiley-VCH, 1995.

23ARE352	MACHINE-TO-MACHINE COMMUNICATIONS	L-T-P-C: 3-0-0-3

Course Objectives

- To introduce the evolution of Machine-to-Machine communications and their standards.
- To summarize the architecture and protocols for Machine-to-Machine communication.
- To illustrate the applications of Machine-to-Machine communications in different cases.
- To establish the communication between two machines with suitable protocols.

Course Outcomes

At the end of the course, the student will be able to
CO1: Understand and describe the evolution of Machine-to-Machine communications and their standards.
CO2: Discuss the architecture and protocols for Machine-to-Machine communication.
CO3: Demonstrate the applications of Machine-to-Machine communications in different cases.
CO4: Experiment the communication between two machines with suitable protocols.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	2	2				2							
CO2	2	2	2	3				2							
CO3	2	2	3	3	3			2	3	3	3		3	3	3
CO4	2	2	3	3	3			3	3	3	3		3	3	3

Syllabus

Introduction- Services and protocols –Edge and core – OSI and TCP/IP models – Overview of ETSI and 3GPP architecture– M2M communication Technologies -Cellular technology- Satellite communication – Short range Technologies- LPWAN Technology- GPS/GNSS and positioning technology- Vehicle telemetry services – Smart meters – Smart asset tracking – Supply chain management solutions- Wearable technologies – Internet protocol stack – Ipv6 abd IoT- Application protocols –CoAP- MQTT – LoRA WAN -M2M communication in constrained devices – Gateway- PAN- WSN- SUN- Routing protocols- CoRE- Basics of V2x - Security in M2M.

LIST OF EXPERIMENTS

Lab Component (with Arduino / RPi)
Serial communication for machine control, Wireless Interface through Bluetooth/wifi, Wireless control of wheeled robot using Bluetooth/wifi, M2M communication MQTT and LoRA, Visualization of diverse sensor data using dashboard through Thing Speak, Android app development using MIT inventor for M2M.

Text Books
Veena S. Chakravarthi, Internet of Things and M2M Communication Technologies Architecture and Practical Design Approach to IoT in Industry 4.0, Springer International Publishing, 2021.
Machine-to-machine (M2M) Communications Architecture, Performance and Applications, Elsevier Science, 2014

References
M2M Communications A Systems Approach, Wiley, 2012.
Machine-to-Machine Communications Architectures, Technology, Standards, and Applications, Taylor & Francis, 2014.
Cellular V2X for Connected Automated Driving, Wiley, 2021.

23ARE353	HUMAN COMPUTER INTERACTION	L-T-P-C: 3-0-0-3

Course Objectives

- To familiarize the basic of human computer interaction (HCI)
- To impart the basic concepts of models and theories of HCI
- To enable the students to acquire knowledge to develop the HCI for solving real world problems.

Course Outcomes

At the end of the course the student will be able to
C**O1**: Describe the basics of concepts of HCI process.
CO2: Explain the HCI models and theories.
CO3: Analyse the different concepts in Existing HCI systems.
CO4: Design and develop HCI using user interface systems.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	3		2							1	2	3	
CO2	3	2										1	2	3	
CO3	3	3	3		2							1	2	3	1
CO4	3	3	3	3	2	2	2	2				1	2	3	1

Syllabus

Introduction of HCI- HCI Guidelines- HCI Design Process- Human Factors of HCI Design - Models and Theories- Users Interface Layers, HCI concepts of: Cognitive models- Brain-Computer Interaction- Human Behaviors Analysis- Motion Based learning- Object Based Modeling- Human-Robot Interactions- Interactive System developments- HCI Tools and Visualization- Camera and Sensors- Case studies of HCI Applications.

Text Books

Dix, Alan, et al. "Human-computer interaction." Harlow ua, 2000.
Kim, Gerard Jounghyun. Human-computer interaction: fundamentals and practice. CRC press, 2015.
Shneiderman, Ben, et al. Designing the user interface: strategies for effective human-computer interaction. Pearson, 2016.
Johnson, Jeff. Designing with the mind in mind: simple guide to understanding user interface design guidelines. Morgan Kaufmann, 2020.

Reference Books

Tan, Desney S., and Anton Nijholt, eds. Brain-computer interfaces. Springer-Verlag London Limited, 2010.
Magnenat-Thalmann, Nadia, et al., eds. Context aware human-robot and human-agent interaction. Springer International Publishing, 2016.
Jacko, Julie A., ed. Human computer interaction handbook: Fundamentals, evolving technologies, and emerging applications. CRC press, 2012.

23ARE354	UAV NETWORKS	L-T-P-C: 3-0-0-3

Course Objectives

- To illustrate the UAV types and their missions for swarm communication.
- To familiarize the basics of data link communication for UAV.
- To explore the network platforms for UAV based systems.
- To enable students to analyze the security issues and challenges in UAV Networks.

Course Outcomes

At the end of the course the student will be able to
CO1: Summarize the types of UAV and their missions for swarm communication.
CO2: Describe the basics of data link communication for different interfacing of UAV.
CO3: Enumerate the types of network platforms for UAV based systems.
CO4: Analyze about the security and privacy issues in UAV Networks.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2									1	2	2	
CO2	3	2	2									1	2	2	2
CO3	3	2	2									1	2	2	1
CO4	3	2	2									1	2	2	1

Syllabus

Unit 1
Introduction – UAV Types and Missions – Swarming and Miniaturization- Air to Ground and Air to air data link communication – Air to ground communication for manned aviation – Practical and UAV and MUAV links – Terrestrial wideband solutions.

Unit 2
Aerial Wifi Networks – Characteristics- Communication demands –requirements – Airborne Networks and protocols – Aeronautical protocol architecture – UAV platform systems and UAV Networked systems.

Unit 3
UAV detection and identification – Cellular connected UAVs – Safety security and privacy in UAV.

Text Books / References
Jae H. Kim , UAV Networks and Communications, Cambridge University Press, 2018.
UAV Communications for 5G and Beyond, Wiley, 2020.
Unmanned Aerial Vehicles for Internet of Things (IoT) Concepts, Techniques, and Applications, Wiley, 2021.
Hailong Huang, Andrey V. Savkin, Chao Huang, Wireless Communication Networks Supported by Autonomous UAVs and Mobile Ground Robots, Elsevier Science, 2022.

23ARE355	WIRELESS SENSOR NETWORKS	L-T-P-C: 3-0-0-3

Course Objectives

- To understand the characteristics and architecture of wireless sensor network
- To understand different layers and protocols of sensor protocol stack
- To analyse wireless sensor network design in different applications scenarios.

Course Outcomes

At the end of the course, the student will be able to
CO1: Identify the characteristics and architecture of wireless sensor network
CO2: Explain the role and algorithms of Physical and MAC layers in sensor network protocol stack
CO3: Describe the role and algorithms in routing and data gathering operations of sensor networks
CO4: Design different wireless sensor network applications with operating systems.

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3													
CO2	3	3			1										
CO3	3	3			1										
CO4	3	3	2	2	1								1	1	1

Syllabus

Unit 1
Introduction to WSN - Characteristic requirements and challenges for WSNs – WSN vs Adhoc Networks – Sensor node architecture – Commercially available sensor nodes. Wireless Sensor Network Protocol Stack. Physical layer and transceiver design considerations in WSNs - Energy usage profile - Choice of modulation scheme - Dynamic modulation scaling.

Unit 2
Medium Access Control Protocols - Fundamentals of MAC protocols - Low duty cycle protocols and wakeup concepts – Contention based protocols - Schedule-based protocols - SMAC - BMAC - Traffic-adaptive medium access protocol (TRAMA) - The IEEE 802.15.4 MAC protocol.
Routing and Data Gathering Protocols - Routing Challenges and Design Issues in Wireless Sensor Networks - Flooding and gossiping – Data centric Routing – SPIN – Directed Diffusion – Energy aware routing – Gradient based routing - Rumor Routing – COUGAR – ACQUIRE – Hierarchical Routing - LEACH, PEGASIS – Location Based Routing – GF – GAF – GEAR - GPSR – Real Time routing Protocols – TEEN - APTEEN – SPEED – RAP.

Unit 3
Data aggregation - data aggregation operations - Aggregate Queries in Sensor Networks - Aggregation Techniques – TAG, Tiny DB.
Operating Systems for Wireless Sensor Networks – Operating System Design Issues - Examples of Operating Systems. WSN Applications – Home/Building Automation - Industrial Automation - Medical Applications.

Text / Reference Books
Holger Karl and Andreas Willig, "Protocols and Architectures for Wireless Sensor Networks", John Wiley & Sons, Ltd, 2005.
KazemSohraby, Daniel Minoli and TaiebZnati, "Wireless Sensor Networks Technology, Protocols, and Applications", John Wiley & Sons, 2007.
K. Akkaya and M. Younis, "A survey of routing protocols in wireless sensor networks", Elsevier Ad Hoc Network Journal, Vol. 3, no. 3, pp. 325—349.
Anna Ha´c, "Wireless Sensor Network Designs", John Wiley & Sons Ltd., 2003.

23ARE356	NEURAL NETWORKS	L-T-P-C: 3-0-0-3

Course Objectives

- To impart the fundamental concepts of Neural Networks
- To familiarize with artificial learning processes.
- To introduce different neural network architectures and selection process.

Course Outcomes

At the end of the course the student will be able to
CO1: Understand the basic ideas behind most common learning algorithms for multilayer perceptrons, radial-basis function networks, and Kohonen self-organising maps
CO2: Understand the motivation for different neural network architectures and select the appropriate architecture for a given problem
CO3: Understand deep learning networks through convolutional networks and its applications
CO4: Apply neural networks to classification and recognition problems.

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3			3				2	1		2		2	2
CO2	3	3			3				2	1		2		2	2
CO3	3	3			3				2	1		2		2	2
CO4	3	3			3				2	1		2		2	2

Syllabus

Introduction to Neural Networks: History, Artificial and biological neural networks, Artificial intelligence and neural networks; Neurons and Neural Networks: Biological neurons, Models of single neurons, Different neural network models
Single Layer Perceptrons: Least mean square algorithm, Learning curves, Learning rates, Perceptron; Multilayer Perceptrons: The XOR problem, Back-propagation algorithm, Heuristic for improving the back-propagation algorithm, Examples
Radial-Basis Function Networks: Interpolation, Regularisation, Learning strategies; Kohonen Self-Organising Maps: Self-organising map (SOM), The SOM algorithm, Learning vector quantisation;
Introduction to deep learning, convolutional Neural Networks: Motivation, Convolutional layers, Pooling layers, Fully connected layers, examples of classification.

Text / Reference Books

Kevin Gurney, An Introduction to Neural Networks, CRC Press, 1997.
R Beale and T Jackson, Neural Computing - An Introduction, CRC Press, 1990.
Simon O. Haykin, Neural Networks: A Comprehensive Foundation, 2nd Edition, Pearson, 1999.
Charu C. Aggarwal, Neural Networks and Deep Learning - A Textbook, Springer International Publishing AG, 2018.
Christopher M. Bishop, Neural Networks for Pattern Recognition, Clarendon Press, 1995

23ARE361	ADVANCED MANUFACTURING PROCESSES	L-T-P-C: 3-0-0-3

Course Objectives

- To impart the fundamental concepts in powder metallurgy
- To familiarize various non-traditional machining processes and advanced inspection systems
- To introduce the advanced machining and finishing processes like CNC, mico and nanomachining processes, abrasive finishing processes etc.

Course Outcomes

At the end of the course, the student will be able to
CO1: Understand the need of powder metallurgy and the steps involved in manufacturing a powder metallurgycomponent.
CO2: Apply the knowledge on various energy based non-traditional machining processes and suggest a suitableprocess based on the situations.
CO3: Develop Programming skills to generate or edit a CNC program emphasis to G and M codes.
CO4: Identify and estimate measurement errors and suggest suitable techniques to minimize them.
CO5: Select a specific Material addition, Micro and Nano and super finish process.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2						1							1	
CO2	2	1					1					2		1	
CO3	2	2	2									2		1	
CO4	2	2	1		1							2		1	
CO5	3	1			1		1					2		1	

Syllabus

Powder Metallurgy (PM): Stages in powder metallurgy -production of metal powders - characteristics of metal powders- Mixing of metallic powders -compaction - Mechanism of sintering - applications. Impregnation and Infiltration Advantages, disadvantages and specific applications of PM.

Non-conventional machining processes: Comparison between traditional and non-traditional machining process. Abrasive Jet Machining, Electrical Discharge Machining, Electrochemical Machining, Ultrasonic Machining, Laser Beam Machining, Electron Beam machining. Introduction to Rapid Prototyping & Rapid Tooling, Green manufacturing.

CNC machines: Overview, types, construction, tool and work holding devices, feedback devices, part programming - examples. Data exchange between CAD/CAM - Concepts of native and neutral file formats for data exchange, Interfacing with manufacturing systems. Computer aided process planning

Computer Aided Inspection: High precision measurements – interfacing - software metrology - Automated visual inspection in manufacturing, contact and non - contact type inspection methods, Electrical field techniques, radiation techniques, ultrasonic - Atomic Force Microscopes (AFM), Talysurf instruments. Coordinate Measuring Machine: CMM Types, Applications - Non-contact CMM using Electro optical sensors for dimensional metrology - Non-contactsensors for surface finish measurements – Measurements / programming with CNC CMM – Performance evaluations –Measurement integration. Machine Vision: Image Acquisition and Processing - Binary and gray level images, image segmentation and labelling, representation and interpretation of colours.

Advanced finishing processes: Abrasive Flow Machining, Magnetic Abrasive Finishing. Magnetorheological AbrasiveFlow Finishing, Magnetic Float Polishing, Elastic Emission Machining.

Material addition process: Rapid prototyping, stereo-lithography, selective laser sintering, 3D Printing, fused deposition modelling, laminated object manufacturing, laser engineered net-shaping, laser welding, LIGA process.

Micro & Nano machining process: Diamond turn mechanism, material removal mechanism, applications. Concepts of reverse engineering.

References

Serope Kalpakjian and Steven Schmid, Manufacturing Engineering and Technology, 8th Edition, Pearson, 2020.
Ibrahim Zeid and R Sivasubramanian, CAD/CAM Theory and Practice, Tata McGraw Hill, 2010.
Benedict. G.F. Nontraditional Manufacturing Processes, Marcel Dekker Inc., New York,1987.
Jagadeesha T, Non-Traditional Machining Processes, I K International Publishing House 2016.
V. K. Jain, Introduction to Micromachining, Second Edition, Narosa Publishing House 2019.

23ARE362	INDUSTRY 4.0	L-T-P-C: 3-0-0-3

Course Objectives

- To familiarize with insight and understanding of the 4th industrial revolution and its impact on the industry.
- To impart the basic knowledge on the drivers, enablers, and design principles of Industry 4.0.

Course Outcomes

At the end of the course, the students will be able to
CO1: Describe the concepts and characteristics of Industry 4.0.
CO2: List and comprehend the different enabling technologies and its role in establishing Industry 4.0.
CO3: Enumerate different design principles of Industry 4.0.
CO4: Understand and describe the impact of Industry 4.0 in different sectors with case studies.
CO5: Evaluate the opportunities and the challenges brought through Industry 4.0.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1									1	2	2	2
CO2	3	2	1									1	3	3	2
CO3	3	2	2	1			1			1		1	3	3	2
CO4	3	2	3	2		2	2					1	3	3	2
CO5	3	2	2	2		2	2			1		1	3	3	2

Syllabus

Unit 1
Introduction to Industry 4.0: The various industrial revolutions, digitalization and the networked economy, drivers, enablers, comparison of industry 4.0 factory and today's factory, trends of industrial big data and predictive analytics for smart business transformation.
Road to Industry 4.0: Internet of Things (IoT) & Industrial Internet of Things (IIoT) & Internet of Services, Big data, Value chains in Manufacturing companies, Smart factories, Smart Devices and Products, Smart Logistics, Smart Cities, smart services, Predictive Analytics, Case studies.

Unit 2
Technologies for Enabling Industry 4.0
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 twin, 3D printing, Case studies.
Industry 4.0 Design Principles: Introduction to Industry 4.0 design principles – Interoperability, Communication systems and standards for Industry 4.0, virtualization, Decentralization, Modularity, real time capability, information transparency – Foundation of Industry 4.0 - Cloud Manufacturing and the connected factories.

Unit 3
Impact of Industry 4.0: Impact of Industry 4.0 on – service and business models, IT security, manufacturing, machine safety, product life cycle, socio economic factors, textile industries, healthcare industries, real estate industries, maritime industries, tourism industries - Compelling Forces and Challenges in implementing Industry 4.0. Case studies.

Text Books
Klaus Schwab, "The Fourth Industrial Revolution", Portfolio Penguin, 2017.
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
Alasdair Gilchrist, "Industry 4.0: The Industrial Internet of Things", Apress, 2016.
Kaushik kumar, DivyaZindani, J. Paulo Davim, "Digital manufacturing and assembly systems in Industry 4.0", CRC Press, Taylor and Francis group, 2020.
Antonio sartal, Diego Carou, J.PauloDavim, "Enabling technologies for the successful deployment of Industry 4.0, CRC press, 2020.
Alp Ustundag, Emrecavikcan, " Industry 4.0 : Managing the digital transformation", Springer International publishing, 2018.
Christoph Jan Bartodziej, "The Concept Industry 4.0", Springer Gabler, 2017.

23ARE363	SMART MANUFACTURING	L-T-P-C: 3-0-0-3

Course Objectives

- To provide the concept of smart manufacturing systems
- To familiarize various methods by which the smart manufacturing implemented
- To provide case studies on implementation of Smart manufacturing in various industries

Course Outcomes

At the end of the course, the student will be able to
CO1: Explain the principles of smart manufacturing.
CO2: Describe the various elements of Smart Manufacturing and its role in the system.
CO3: Different model driven approach for sustainable and smart manufacturing.
CO4: Evaluate the trends and issues in implementing smart manufacturing through case studies.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3											3			3
CO2	3	2		2								3			3
CO3	3	2	1	2								3	2	2	3
CO4	3	2	1	2								3	2		3

Syllabus

Unit 1
Introduction to Smart Manufacturing, Smart Sensors and Smart Tooling, Smart machines and intelligent machining, digital and smart factories, implementing smart manufacturing across an industrial organization, cyberinfrastructure for the democratization of smart manufacturing, the role of hardware and software in smart manufacturing Infrastructure changes, Reinvigorating the manufacturing workforce, benefits of smart manufacturing to value chain.

Unit 2
Measuring, managing, and transforming data for operational insights, the role of advanced process modelling in smart manufacturing, Industrial AI and predictive analytics for smart manufacturing systems, A systems engineering-driven decomposition approach for large-scale industrial decision-making processes, Model-predictive safety: A new evolution in functional safety, Inferential modelling and soft sensors, A decision support framework for sustainable and smart manufacturing.

Unit 3
Case studies: Smart Manufacturing in the Food Industry, Advancing Smart Manufacturing in the Pharmaceutical Industry, Smart Reservoir Management in the Oil and Gas Industry Smart Manufacturing in the Paints and Coatings Industry, Smart Manufacturing in Additive Manufacturing, Smart Manufacturing in Industrial Gas Production: A Digital Transformation, Smart Manufacturing: Machine Learning-Based Economic MPC and Preventive Maintenance.

Text Books / Reference Books
Masoud Soroush, McKetta Michael Baldea, Thomas Edgar, Smart Manufacturing -Concept and Methods, Elsevier Publications Ist Edition, August 4, 2020.
Masoud Soroush, McKetta Michael Baldea, Thomas Edgar, Smart Manufacturing: Applications and Case Studies, Elsevier Publications, 1st Edition, August 4, 2020.
Jim Davis, Denise Swink, Julie Tran, white paper, CMTC's Guide to Smart Manufacturing, 2015.

23ARE364	MICRO AND NANO ELECTROMECHANICAL SYSTEMS	L-T-P-C: 3-0-0-3

Course Objectives

- To introduce the concepts of micro and nano electromechanical devices.
- To familiarize the fabrication process of Microsystem.
- To provide information on various nanofabrication techniques currently in practices.

Course Outcomes

At the end of the course, the student will be able to:
CO1: Interpret the basics of micro/nano electromechanical systems including their applications and advantages**.**
CO2: Identify and describe micro fabrication technique based on the materials and applications.
CO3: Application of micro/nano sensors and actuators in development of MEMS/NEMS**.**
CO4: Choose appropriate nano fabrication process based on various principles like various etching, lithography, template and other advanced techniques.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3											3	2		2
CO2	3	2										3	2		2
CO3	3	2	1									3	2		2
CO4	3	2	1									3	2		2

Syllabus

Unit 1
Introduction, overview and applications of Micro Electro Mechanical Systems (MEMS) and Nano Electro Mechanical Systems (NEMS). Materials for MEMS and NEMS: Silicon, silicon compounds, polymers, metals. Mechanical components in MEMS. Design concepts of mechanical components. Working Principles of Microsystems. Engineering Science for Microsystems design and Fabrication. Scaling laws – Scaling in geometry, rigid body dynamics.

Unit 2
Fabrication technologies – Photolithography – Ion implantation – diffusion – oxidation – CVD – Physical Vapor Deposition – Etching. Micro manufacturing – Bulk and surface micro machining – LIGA. Applications of Microsensors and Microactuators for MEMS, Microsystems Design – Design considerations – Process design – Mechanical Design – CAD – Micro system packaging – Levels – Bonding – Interfaces – Assembly.

Unit 3
Nano Electro Mechanical Systems (NEMS) Introduction- Nano machining of NEMS based lithography techniques, Nano electromechanical systems fabrication, nano imprint lithography, polymeric nano fibre templates, focused ion beam doping and wet chemical etching, stencil lithography and sacrificial etching, Scanning-probe techniques, Scanning-probe techniques, Self-assembly for NEMS, nanometrology and applications of nano sensors for NEMS- ZnO nanorods based NEMS device: Gas sensor, future challenges.

Text Books / Reference Books
Tai–Ran Hsu,'Mems & Microsystems Design and Manufacturing', John Wiley & Sons, 2008, 2nd Edition.
Sergey Edward Lyshevski, MEMS and NEMS: Systems, Devices, and Structures‖ CRC Press, 2002.
S.A. Campbell: The Science and Engineering of Microelectronic, Fabrication, Oxford Univ. Press, New York 2001.
Marc J Madou, 'Fundamentals of Microfabrication', CRC Press, 2002, 2nd Edition.
Mohamed Gad-el-Hak – 'The MEMS Handbook', CRC Press, 2002.
Muameer Koç "Micro Manufacturing: Design and Manufacturing of Micro-Products", John Wiley & Sons.
Karl Goser, Peter Glosekotter, Jan Dienstuhl, Nanoelectronics and Nanosystems, From Transistors to Molecular and Quantum Devices, Springer, 2004.
Kourosh Kalantar-zadeh, Benjamin Fry, Nanotechnology, Enabled Sensors, springer, 2008.

23ARE365	INTELLIGENT MANUFACTURING SYSTEMS	L-T-P-C: 3-0-0-3

Course Objectives

- To provide fundamental concepts on intelligent manufacturing system (IMS) to achieve flexible, smart, and reconfigurable manufacturing processes.
- To familiarize various supporting technologies required to implement IMS.

Course Outcomes

At the end of the course, the student will be able to
CO1: Explain the various concepts of intelligent manufacturing systems.
CO2: Elaborate the various components features and its integration for IMS.
CO3: Choose suitable supporting technologies to enable IMS implementation.
CO4: Discuss the real time issues in implementations of IMS with suitable case studies.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2											3		2	3
CO2	2	2										3			3
CO3	2	2	1									3	2	2	3
CO4	2	2	1									3	2	2	3

Syllabus

Introduction to Manufacturing systems, various subsystems in manufacturing systems, procurement, design, manufacturing, inspections, assembly, prototyping, material handling, storage systems, concept of Intelligent manufacturing: Internet of Things enabled manufacturing, cloud manufacturing. Characteristics of Intelligent manufacturing systems: Intelligent decision making, Application of Artificial Intelligence and Machine learning in developing intelligent manufacturing systems.

Component of Intelligent Manufacturing Technologies, Development of Intelligent systems for Design, Process planning, Controls, Scheduling, Quality Management, Maintenance and Diagnostics.
Supporting technologies for IMS: Industry Internet of Things, Cyber Physical Systems, Cloud computing, RFID Technologies, Data Analytics, other Information and Communications Technology.

Framework for intelligent manufacturing: Smart design, Smart machines, Smart control, Smart scheduling, Human-Machine collaboration, collaborative robots and other enabling technologies such as AR and VR, Data-driven intelligent manufacturing models, Autonomous intelligent manufacturing units.

Applications and case studies in intelligent manufacturing systems implementation, limitation of technologies and other real time issues in implementations of IMS.

Text Books / Reference Books

Andrew Kusiak, Intelligent Manufacturing Systems, Prentice Hall international series- industrial & systems engineering, 1990.
Intelligent Manufacturing in the Context of Industry 4.0: A Review, Engineering, Elsevier Publications, Volume 3, Issue 5, October 2017, Pages 616-630.
Peigen Li, Special Issue: Intelligent Manufacturing, Engineering, Elsevier Publications, 3, 2017, 575.
Yubao Chen, Integrated and Intelligent Manufacturing: Perspectives and Enablers, Engineering, Engineering 3, 2017, Pages 588–595.
Hamid R. Parsaei and Mohammad Jamshidi, Design and Implementation of Intelligent Manufacturing Systems: From Expert Systems, Neural Networks, to Fuzzy Logic, Prentice Hall Series Publication, 1995.
Jongwon Kim, Manufacturing Systems 1997 - IFAC Proceedings Volumes, Elsevier publications, 1997.

23ARE366	SIMULATION MODELLING OF MANUFACTURING SYSTEMS	L-T-P-C: 3-0-0-3

Course Objectives

- 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

At the end of the course, the student will be able to
CO1: Understand the basic concepts and applications of discrete event simulation
CO2: Analyze the simulation input data
CO3: Verify and validate simulation models using statistical techniques
CO4: Analyze and interpret the simulation output results
CO5: Build credible simulation models for real-time applications

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1		2	2						1	1			
CO2	1	1	1	1	3						1	1	2		
CO3	1	1	1	3	2						1	1	1		
CO4	1	1	1	3	1						1	1	1		
CO5	1	1	1	3	1						1	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.

Text Books
Law A. W. and Kelton D. W. - 'Simulation Modeling and Analysis' - McGraw Hill - 2010 - 5th Edition.
Kelton D. W., Sadowski R. P. and Sasowski D. A. - 'Simulation with ARENA' - McGraw Hill – 2009.

Reference Books
Banks J., Carson J. S., Nelson B. L. and Nicol D. M. - 'Discrete Event System Simulation' - Pearson Education - 2001 - 3rd Edition.
Viswanathan N. and Narahari Y. - 'Performance Modeling of Automated Manufacturing Systems' - Prentice Hall 1998.

23ARE367	SUSTAINABLE MANUFACTURING	L-T-P-C: 3-0-0-3

Course Objectives

- To familiarize the concept of sustainability manufacturing with tools and techniques.
- To inculcate knowledge on performing life cycle analysis.

Course Outcomes

At the end of the course, the student will be able to
CO1: Understand the concept of sustainable manufacturing.
CO2: Utilize tools and techniques of sustainable manufacturing.
CO3: Perform life cycle assessment and assess environmental impacts of manufacturing processes.
CO4: Perform sustainability analysis using software packages.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3				1		3					2	2		
CO2	3				1		3					2	2		
CO3	3				1		3					2	2		
CO4	3				1		3					2	2		

Syllabus

Unit 1
Concept of sustainability, manufacturing operations, resources in manufacturing. Concept of 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-Remanufacture and disposal, tools for LCA, optimization for achieving sustainability in manufacturing, value analysis, analysis for carbon footprint-software packages for sustainability analysis.

Text Books
Atkinson G, Dietz S, Neumayer E, "Handbook of sustainable manufacturing" Edward Elgar Publishing limited, 2007.
Rodick, D, "Industrial Development for the 21 st century: Sustainable development perspectives" UN New York, 2007.

Reference Books
Lawn.P, "Sustainable development indicators in ecological economics", Edward Elgar Publishing limited, 2006.
Asefa, "The economics of sustainable development", WE Upjohn institute for employment research, 2005.
Dornfeld, David (Ed), "Green manufacturing: fundamentals and applications", Springer Science & Business Media, 2012.
Klemes J, "Sustainability in the process industry", McGraw Hill, 2011.

23ARE368	DIGITAL TWINS	L-T-P-C: 2-0-3-3

Prerequisite: Nil
Nature of Course: Laboratory Integrated

Course Objectives:
The course is aimed at
- 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

At the end of the course, the student will be able to
CO1: Introduce the concept of Digital Twins in manufacturing the industry.
CO2: Acquire knowledge of Digital Twins and their importance.
CO3: Design Digital Twins for discrete and process industries.
CO4: Analyze the performance of Digital Twins.
CO5: Discover the advantages and applications of Digital Twins.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3	3	2	1				1	1		1	2			1
CO2	3	3	3	2	1				1	1		1	2			1
CO3	3	3	3	2	1				1	1		1	2			1
CO4	3	3	3	2	1				1	1		1	2			1
CO5	3	3	3	2	1				1	1		1	2			1

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:

Alp Ustundag and Emre Cevikcan, "Industry 4.0: Managing The Digital Transformation", Springer Series in Advanced Manufacturing., Switzerland, 2017.

Andrew Yeh Chris Nee, Fei Tao, and Meng Zhang, "Digital Twin Driven Smart Manufacturing", Elsevier Science., United States, 2019

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:

Enis Karaarslan, Moharram Challenger, Ömer Aydin, Ümit Cali, "Digital Twin Driven Intelligent Systems and Emerging Metaverse", Springer Nature Singapore, 2023

Christoph Jan Bartodziej, "The Concept Industry 4.0 An Empirical Analysis of Technologies and Applications in Production Logistics", Springer Gambler., Germany, 2017.

23ARE431	CRYPTOGRAPHY AND NETWORK SECURITY	L-T-P-C: 3-0-0-3

Course Objectives

- This course focuses towards the introduction of network, email and web security
- The course introduces various cryptographic algorithms, hash functions and authentication protocols.

Course Outcomes

At the end of the course, the student will be able to
CO1: Explain various encryption techniques
CO2: Identify the requirements of number theory in cryptographic schemes
CO3: Illustrate various authentication protocols
CO4: Analyse various software threats and counter measures

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3													
CO2	3	3													
CO3	3	3	1	1	1										
CO4	3	3			1										

Syllabus

Unit 1
Classical Encryption Techniques – Symmetric Cipher Model – Steganography – AES Cipher -Symmetric Cipher – Multiple Encryption and triple DES – Blocks Cipher – stream Cipher – Confidentiality using symmetric encryption – Placement of encryption function.

Unit 2
Random number generation – Introduction to number theory – Cryptosystems – message authentication and Hash functions – requirements – functions – course – Hash and MAC algorithms – secure Hash algorithms – Digital signatures and authentication protocols – standard – authentication applications.

Unit 3
Electronic mail security – S/MIME-IP security – overview architecture – web security - socket layer and transport layer security – Intruders – Detection – Malicious software – viruses and related threats – counter measures – firewalls – design principles – trusted systems.

Text / Reference Books
William Stallings, "Cryptography and Network Security – Principles and Practices", Seventh Edition, Prentice Hall, 2017.
Douglas R Stinson, "Cryptography: Theory and Practice", Fourth Edition, Chapman and Hall/CRC, 2018.
Arshdeep Bahga, Vijay Madisetti, "Internet of Things – A hands-on approach", Universities Press, 2015
Mark Ciampa, "Security+ Guide to Network Security Fundamentals", Fifth Edition, Cengage Learning, 2014.

23ARE432	INTRODUCTION TO BIG DATA ANALYSIS	L-T-P-C: 3-0-0-3

Course Objectives

- The aim of this course is to provide an introduction to big data technologies and tools used for big data
- Basics of relational databases and its implementation strategy using SQL are discussed in the first phase
- The second phase discusses on concepts big data and its architecture, storage and processing of data in parallel and distributed system
- In the last phase retrieval and analysis of unstructured data are done using NOSQL databases

Course Outcomes

At the end of the course, the student will be able to
CO1: Identify fundamental concepts of Databases and SQL
CO2: Apply SQL for data storage and retrieval
CO3: Explain fundamental concepts of Big Data and its technologies
CO4: Apply Map reduce programming for big data
CO5: Analyse appropriate NoSQL database techniques for storing and processing large volumes of structured and unstructured data

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3													
CO2	3	3	2	1	1								1	1	1
CO3	3	3													
CO4	3	3	2	1	1								1	1	1
CO5	3	3	2	1	1								1	1	1

Syllabus

Unit 1
Introduction - Overview of DBMS - File vs DBMS - elements of DBMS - Relational Data Model - Introduction to relational model - Structure of relational mode – domain – keys - tuples to relational models - SQL – table creation - relationships - basic queries DML and DDL – Joins– Grouping.

Unit 2
Introduction to Big Data - Types of Digital Data - Characteristics of Data – Evolution of Big Data - Definition of Big Data - Challenges with Big Data-3Vs of Big Data -Terminologies in Big Data - CAP Theorem - BASE Concept – NoSQL - Types of Databases – Advantages – NewSQL - SQL vs. NOSQL vsNewSQL - Introduction to Hadoop - Features – Advantages – Versions.

Unit 3
Overview of Hadoop Eco systems - Hadoop distributions - Hadoop vs. SQL – RDBMS vs. Hadoop - Hadoop Components – Architecture – HDFS - Map Reduce: Mapper – Reducer - Map Reduce - Mapper – Reducer – Combiner – Partitioner - Hadoop 2 (YARN) - Architecture - Interacting with Hadoop Eco systems. No SQL databases - Cassandra: Introduction – Features - Data types – CQLSH - Key spaces - CRUD operations – Collections – Counter – TTL - Alter commands - Import and Export - Querying System tables.

Text / Reference Books
Seema Acharya, Subhashini Chellappa, "Big Data and Analytics", Wiley Publication, 2015.
Hurwitz JS, Nugent A, Halper F, Kaufman M. "Big data for dummies", John Wiley & Sons; 2013.
White T., "Hadoop: The definitive guide". O'Reilly Media, Inc."; 2012.
Bradberry R, Lubow E., "Practical Cassandra: a developer's approach", Addison-Wesley; 2013.

23ARE433	MOBILE APPLICATION DEVELOPMENT	L-T-P-C: 3-0-0-3

Course Objectives

- To introduce basics of application development in smart phone operating systems such as Android.
- To learn techniques for Android application development

Course Outcomes

At the end of the course, the student will be able to
CO1: Interpret Android programming
CO2: Develop Android programs
CO3: Develop mobile applications with cloud services
CO4: Analyse various services of mobile applications development and its usage

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	1	1								1	1	1
CO2	3	3	3	2	1								1	1	1
CO3	3	3	3	2	1								1	1	1
CO4	3	3	3	2	1								1	1	1

Syllabus

Unit 1
Introduction to mobile application development platforms, Application development - Layouts, Views, Resources, Activities, Intents, Background tasks, connecting to the Internet, Fragments, Preferences.

Unit 2
User Interaction – input, menu items, custom views, User Experience – themes and styles, lists and adapters, material design, adaptive layouts, accessibility, localization, debugging the UI Storing Data, SQLite database, Sharing Data, content resolvers and providers, loaders to load data.

Unit 3
Services, background work, alarms, broadcast receivers, Notification, widgets, location-based services and Google maps. Transferring data efficiently, publishing app, multiple form factors, sensors, Google cloud messaging, monetizing mobile app.

Text / Reference Books
Tejinder Randhawa, "Mobile Applications Design, Development and Optimization" Springer International Publishing, 2021.
Phillips, Stewart, Hardy and Marsicano "Android Programming (Big Nerd Ranch Guide)", Fourth Edition, Big Nerd Ranch Guides, 2019.
Hellman, "Android Programming – Pushing the limits", First Edition, Wiley, 2013.
Joseph Annuzzi Jr., Lauren Darcey, and Shane Conder, "Advanced Android Application Development", Fourth Edition, Addison-Wesley Professional, 2014.

23ARE434	VIRTUAL AND AUGMENTED REALITY	L-T-P-C: 3-0-0-3

Course Objectives

- To facilitate the complete understanding of VR and AR.
- To familiarize the motion tracking in real and virtual cases with suitable devices and components.
- To enable students to analyze the applications of VR and AR in different domains.

Course Outcomes

At the end of the course, the student will be able to
CO1: Describe the basics of VR and AR.
CO2: Determine the motions in real and virtual cases with suitable orientation methods.
CO3: List and comprehend the suitable components and devices required for AR.
CO4: Conduct an inter disciplinary research in health care and manufacturing system through AR and VR.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2									1	2	2	
CO2	3	2	2									1	2	2	2
CO3	3	3	2	2								1	2	3	2
CO4	3	2	3	2								1	2	3	2

Syllabus

Introduction- History of VR and AR- Difference between VR and AR – Commercial VR – Motion tracking- human behind the lenses – Motion in real and virtual – Vestibular system – Tracking 2D and 3D orientation – Tracking position- Tracking attached bodies – Audio interaction with virtual – Ambisonics- HRTF.
Augmented Reality – AR components and devices - Displays for AR – Audio, Haptic and Visual displays – Tracking with sensors –Computer vision for AR- AR & VR applications in health care- Robotics- Manufacturing. Introduction to GHOST (General Haptics Open Software Toolkit).

Text Books
Virtual Reality, Steven M. LaValle, Cambridge University Press, 2016
Understanding Virtual Reality: Interface, Application and Design, William R Sherman and Alan B Craig, (The Morgan Kaufmann Series in Computer Graphics)". Morgan Kaufmann Publishers, San Francisco, CA, 2002

Reference Book
Smith, Craig. The car hacker's handbook: a guide for the penetration tester. No Starch Press, 2016.

23ARE435	WEB TECHNOLOGIES AND APPLICATIONS	L-T-P-C: 3-0-0-3

Course Objectives

- To introduce client server architecture
- To derive ability to develop a web application.

Course Outcomes

At the end of the course, the student will be able to
CO1: Apply the concepts of responsive web design to customize pages for users' demand.
CO2: Design dynamic web pages with markup and scripting languages.
CO3: Evaluate the appropriateness of client/server applications.
CO4: Develop client/server applications with database.

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	1	1								1	1	1
CO2	3	3	2	1	1								1	1	1
CO3	3	3	2	1	1								1	1	1
CO4	3	3	2	1	1								1	1	1

Syllabus

Unit 1
Web essentials: Creating a website – Working principle of a website – Browser fundamentals – Authoring tools – Types of servers: Application Server – Web Server – Database Server; Scripting essentials: Need for Scripting languages – Types of scripting languages – Client-side scripting

Unit 2
Server-side scripting – PHP – Working principle of PHP – PHP Variables – Constants – Operators – Flow Control and Looping – Arrays – Strings – Functions – File Handling – PHP and MySQL – PHP and HTML – Cookies – Simple PHP scripts. XML-Documents and Vocabularies-Versions and Declaration-Namespaces- DOM based XML processing Event-oriented Parsing: XML-Documents and Vocabularies-Versions and Declaration - Namespaces - DOM based XML processing Event-oriented Parsing

Unit 3
Application essentials: Creation of simple interactive applications – Simple database applications – Multimedia applications – Design and development of information systems – Personal Information System – Information retrieval system – Social networking applications.

Text / Reference Books
Robin Nixon, "Learning PHP, MySQL, JavaScript, CSS & HTML5", Fifth Edition, O'REILLY, 2018.
Jeffrey C. Jackson, "Web Technologies--A Computer Science Perspective", Pearson Education, 2006. 2. Robert. W. Sebesta, "Programming the World Wide Web", Eighth Edition, Pearson Education, 2015 3. Bates, "Web Programming: Building Internet Applications", Third Edition, Wiley, 2010
R. Kelly Rainer, Casey G. Cegielski, Brad Prince, Introduction to Information Systems, Eighth Edition, Wiley Publication, 2019

23ARE371	FINITE ELEMENT METHOD	L-T-P-C: 3-0-0-3

Course Objectives

- Familiarize with the fundamental concepts of finite element method
- Inculcate the formulation of finite element models by selecting a suitable element, developing element matrices & vectors, and incorporating boundary conditions
- Familiarize with finite element procedures to solve structural, thermal, and fluid flow problems using commercial finite element packages

Course Outcomes

At the end of the course the student will be able to
CO1: Understand the fundamental concepts of finite element method and the various available FE techniques to solve engineering problems.
CO2: Formulate finite element models using appropriate element selection, development of stiffness & force matrices, and application of boundary conditions.
CO3: Solve one- and two- dimensional structural, thermal, and time-dependent problems using the developed finite element formulations.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	1	1							3	1	1	
CO2	3	3	2	2	3							3	2	3	1
CO3	3	3	2	2	3							3	3	3	1

Syllabus

Unit 1
Basic Concepts: Introduction to Finite Element Concept, Review of Linear Algebra and Gaussian Elimination Method, Fundamental Governing and Constitutive Equations of Solid Mechanics & Heat Transfer, Finite Element Applications, Boundary and Initial conditions, Euler-Lagrange equations, Generic Finite Element Procedure, Finite Element Discretization, Interpolation Models, Direct Stiffness Approach, Principle of Minimum Potential Energy, Principle of Virtual Work, Weighted Residual and Variational Approaches.

Unit 2
Element Types, their Shape Functions, and Properties – Line elements (spring, bar, truss, beam, and frame elements), Plane elements – Constant Strain Triangle, Rectangular, Quadrilateral elements, Solid elements – Tetrahedron and Hexahedron, Higher order elements – Quadratic, Cubic elements. Isoparametric Formulation: Isoparametric elements. Numerical Integration: Gaussian Quadrature.

Unit 3
Structural Applications – Solution of 1D and 2D Structural problems: Line elements, Two-dimensional Stress Analyses (Plane Stress, Plane Strain, and Axisymmetric Elements), Three-dimensional Stress Analyses.
Heat Transfer Applications – Solution of 1D and 2D Heat Transfer problems involving Conduction and Convection.
Introduction to Applications in Structural Dynamics and Transient Heat transfer.

Text / Reference Books
Rao, S. S., "The Finite Element Method in Engineering", 6/e, Butterworth-Heinemann Publisher, 2018.
Logan, D. L., "A First Course in the Finite Element Method", 5/e, Cengage Learning, 2012.
Reddy J. N, "An Introduction to Finite Element Method", McGraw-Hill International Education, 3/e., 2005.
Chandrupatla, T. R., and Belegundu, A. D., "Introduction to Finite Element in Engineering", 4/e, Prentice Hall of India Pvt. Ltd.', New Delhi, 2012.
Hutton, D. V., "Fundamentals of Finite Element Analysis", McGraw-Hill, 2017.
Jacob Fish and Ted Belytschko, "A First Course in Finite Elements", Wiley, 2007.
Cook, R. D., Malkus, D. S., and Plesha, M. E., "Concepts and Application of Finite Element Analysis", 4/e, John Wiley & Sons, 2007.

23ARE372	STOCHASTIC PROCESSES	L-T-P-C: 3-0-0-3

Course Objectives

- To introduce the probability functions and functions of random variables
- To impart the knowledge of random processes in engineering applications.

Course Outcomes

At the end of the course the student will be able to
CO1: Apply the concepts of probability, random variable, probability distribution and density function in calculating probabilities of events.
CO2: Develop an understanding of discrete and continuous random variables, sets of random variables and how they relate to engineering.
CO3: Extend the concept of a random variable to that of a random process as they apply in engineering disciplines.
CO4: Understand the classifications of random processes and concepts such as strict stationarity, wide-sense stationarity and Ergodicity.
CO5: Define and use Markov chains in discrete and continuous time

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2				1										
CO2	2				1							1			
CO3	2				1										
CO4	2				1							1			
CO5	2				1							1			

Prerequisite: A basic course on Calculus and Linear Algebra

Syllabus

Unit 1
Basics of probability- Random experiments, sample space, axioms, probability space, conditional abd total probability Bayes' theorem. Random Variables- definition and types, cumulative distribution function, probability mass function, probability distribution function, distribution of functions of random variables, Mean and variance, higher order moments and moment inequalities, generating functions, standard discrete and continuous distributions.

Unit 2
Random vector and joint distribution, joint pmf, joint pdf, independent random variables, Functions of several random variables, important results, order statistics, conditional distributions, random sum, Moments and covariance, variance Covariance matrix, multivariate normal distribution, probability generating function and moment generating function, correlation coefficient, conditional expectation, Methods of convergence, law of large numbers, central limit theorem

Unit 3
Stochastic process -Motivation, definition, classification, examples, Bernoulli process, Poisson process, simple random walk, time series and related definitions, stationary processes, Discrete time markov chain, examples, Chapman-Kolmogrov(C-K) equations and N-step transition matrix, classification of states, calculations, limiting and stationary distributions, Continuous-time Markov Chains, state transition diagram and C-K equation, Infinitesimal generator and Kolmogrov differential equations, limiting and Stationary distributions, Birth death process, Poisson process, Non homogenous and compound Poisson process

Text / Reference Books
Castañeda, L.B., Arunachalam, V. and Dharmaraja, S., 2012. Introduction to probability and stochastic processes with applications. John Wiley & Sons.
Shu, H.P., 2011. Probability, Random variables and Random Processes. Second edition, Schaum's Outlines.
Dobrow, R.P., 2016. Introduction to stochastic processes with R. John Wiley & Sons.
Grami, A., 2019. Probability, random variables, statistics, and random processes: Fundamentals & applications. John Wiley & Sons.
O'Flynn, M., 1982. Probabilities, random variables, and random processes; Mexico, Harper & Row Publishers, Newyork
Ross, S.M., 1996. Stochastic processes. John Wiley and Sons.

23ARE373	STOCHASTIC DYNAMICS	L-T-P-C: 3-0-0-3

Course Objectives

- To introduce the statistics of random process and probability functions.
- To impart the knowledge of analysing structures under random excitations.

Course Outcomes

At the end of the course the student will be able to
CO1: Understand the concepts of probability, random variables, and random processes
CO2: Analyse the response of single degree of freedom vibration system to random excitation.
CO3: Analyse the response of multi degree of freedom and continuous systems to random excitation
CO4: Define the failure criteria under random loading

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	1	1							1	2		
CO2	3	3	1	1	1							1	2		
CO3	3	3	1	1	1							1	2		
CO4	3	3	1	1	1							1	2		

Syllabus

Unit 1
Definition of probability-basic concepts of set theory and set operators – Axioms of probability theory. Random variable, Probability distribution, density functions. Expected values of functions of random variables. Moment of a random variable and log characteristic function. Functions of random variable. Extreme value statistics.
Statistics of random process. Stationary and non-stationary random process. Auto correlation, auto covariance, cross correlation, and cross variance functions. Modes of convergence of a sequence of random variables. Mean square convergence criteria. Spectral decomposition of random process, power spectral density functions, Wiener Khinchine relations.

Unit 2
Response of a single degree of freedom system to random excitation. Input output relationships in time and frequency domain. Response of multi degree of freedom system to random excitation. Normal mode method, state space method, 2n method. Response of continuous systems to random excitation.

Unit 3
Failure criteria in random vibrations. First passage or first excursion failure. Fractional occupation time, fatigue failure. Level crossing statistics, peak and envelope distributions.

Text / Reference Books
Probabilistic theory of structural dynamics, Y.K. Lin, McGraw Hill, 1967
Introduction to random vibrations, N.C.Nigam, MIT Press, 1983
Random Vibrations, Analysis of structural and Mechanical Systems, L.D Lutes and S. Sarkani, Elsevier Publications, 2004.
Random Vibration in Mechanical systems, S.H. Crandall and W.D Mark, Academic press, 1963.

23ARE374	NONLINEAR CONTROL SYSTEMS	L-T-P-C: 3-0-0-3

Course Objectives

- Familiarize with the principles of nonlinear systems
- Apply the nonlinear system theory to design control systems

Course Outcomes

At the end of the course the student will be able to
CO1: Analyse nonlinear systems using analytical techniques
CO2: Estimate the stability of nonlinear systems
CO3: Apply the centre manifold theorem to control systems
CO4: Apply the principles of nonlinear system theory to design feedback control systems

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	2	1								2	2	1
CO2	3	3	3	2	1								2	2	1
CO3	3	3	3	2	1								2	2	1
CO4	3	3	3	2	2								2	2	1

Syllabus
Introduction - Characteristics of nonlinear systems - Classification of equilibrium points- analysis of systems with piecewise constant inputs using phase plane analysis.
Periodic orbits - limit cycles-Poincare-Bendixson criterion Bendixson criterion. Existence and uniqueness of solutions, Lipschitz condition.

Stability of Nonlinear Systems - Lyapunov stability - local stability - local linearization and stability in the small- Direct method of Lyapunov - generation of Lyapunov function for linear and nonlinear systems – variable gradient method.

Centre manifold theorem - region of attraction - Feedback Control and Feedback Stabilisation-Analysis of feedback systems- Circle Criterion – Popov Criterion.

Feedback linearization- Design via linearization- stabilization - regulation via integral control- gain scheduling.
Exact Feedback Linearization - Input state linearization - input output linearization - state feedback control - stabilization - tracking - integral control.

Text / Reference Books
Alberto Isidori, "Nonlinear Control Systems: An Introduction", Springer-Verlag, 1985
Hassan K Khalil, Nonlinear Systems, Prentice - Hall International (UK), 2002.
Jean-Jacques E. Slotine and Weiping Li, "Applied Nonlinear Control", Prentice-Hall, NJ, 1991.

23ARE375	ENTREPRENEURSHIP	L-T-P-C: 3-0-0-3

Course Objectives

- Familiarize with innovation and intellectual property.
- Comprehend intellectual property, IP Strategies.
- Familiarize with the concepts of industrial design, and strategies for start-ups.
- Impart knowledge on Capital budgeting and financial statements.

Course Outcomes

At the end of the course, the student will be able to
CO1: Understand the concepts of innovation and intellectual property for an entrepreneur.
CO2: Apply various models for industrial design and planning for start-ups.
CO3: Analyze government and private initiatives and funding policies.
CO4: Develop market research strategies, capital budgeting and financial statements.

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1						2		1	2			2			2
CO2						2		2	2		2	2			2
CO3						2				2	3				
CO4						1		2		2	3	2			

Syllabus

Unit 1
In troduction to entrepreneurship and intellectual property: Definition, concepts, Introduction, Entrepreneurship and IP related, Role of IP strategy in entrepreneurship, Case studies.
Innovation and entrepreneurship: Ideation, Innovation, invention and creativity, Types of innovation, Market and IP, Open innovation, Case Studies.
IPR - Trademark, Patents and Copyrights: Definitions, Types, Registration, Infringements, Case studies.

Unit 2
Industrial design and entrepreneurship: Definition, concept, Key features, Raising financial resources, financial modeling and business planning, Start-ups - Pricing for start-ups, Lean start-ups, agility models, Case studies.
Government and Private initiatives: Venture capital, Incubators, research parks, Government policies, IP valuations, Bank loans, Insurance.

Unit 3
Venture planning and financials: Market Research - Purpose, potential market and competition, customer profiling, segmentation, targeting, differentiation and positioning, marketing strategy. Financial statements - balance sheet, income statement and cash flow statement, capital budgeting and management.

Project: Prepare a project report detailing a potential entrepreneurial venture, technical, financial and market feasibility, similar products/services in the market, capital budgeting.

Text Book / Reference Books
Rao, C. B. (2018). India as Global Start-up Hub: Mission with Passion. Notion Press.
Ries, E. (2011). The lean startup: How today's entrepreneurs use continuous innovation to create radically successful businesses. Currency.
Drucker, P. (2014). Innovation and entrepreneurship. Routledge.
Christensen, C., and Raynor, M. (2013). The innovator's solution: Creating and sustaining successful growth. Harvard Business Review Press.
Narayanan, V. K., (2006) Managing technology and innovation for competitive advantage, first edition, Pearson education, New Delhi.
Masters, B., and Thiel, P. (2014). Zero to one: notes on start ups, or how to build the future. Random House.

23MEE334	THEORY OF VIBRATIONS	L-T-P-C: 3-0-0-3

Course Objectives

- To familiarize students with the mathematical modelling and analysis of mechanical vibration systems
- To impart the knowledge of vibration analysis in the design of dynamical systems

Course Outcomes

At the end of the course the student will be able to
CO1: Classify different types of vibrations and develop mathematical models of vibratory systems.
CO2: Analyse free and forced vibrations of single degree of freedom systems.
CO3: Analyse the free and forced vibration of multi degree of freedom systems.
CO4: Analyse free vibration of continuous systems

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	1	1							1	2		
CO2	3	3	1	1	1							1	2		
CO3	3	3	1	1	1							1	2		
CO4	3	3	1	1	1							1	2		

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 dof systems-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.

Text / Reference Books
Theory of vibrations, W T Thomson, M D Dahleh and C Padmanabhan, Pearson Education,2018.
Fundamentals of vibrations, Leonard Meirovitch, McGraw Hill International edition,2010
Elements of vibration analysis, Leonard Meirovitch, Tata McGraw Hill, 2010.
Mechanical vibrations, S.S Rao.Pearson Education, 2018.
Engineering Vibrations, D.J Inman, Pearson International Education, 2011.

23ARE376	ELECTRIC DRIVES	L-T-P-C: 3-0-0-3

Course Objectives

- To equip the student with basic principles of operation of motors
- To equip the student with basic principles of operation of DC motors and drives
- To equip the student with basic principles of operation of induction motors and drives

Course Outcomes

At the end of the course, the student will be able to
CO1: Explain the basic principles of operation of motors
CO2: Explain the basic principles of operation of drives
CO3: Describe the construction of various motors and drives
CO4: Describe the working of various motors and drives

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3			1										
CO2	3	3			1										
CO3	3	3	1	1	1										
CO4	3	3	1	1	1										

Syllabus

Unit 1
Introduction to Electric Motors - Review of mathematical tools - phasor diagrams - solving ODEs - Z- transforms - Producing Rotation - Magnetic Circuits - Torque Production - Specific Loadings And Specific Output - Energy Conversion–Motional Emf - Equivalent Circuit - General Properties Of Electric Motors - Power Electronic Converters For Motor Drives - Introduction Voltage Control - Controlled Rectification - Single Phase Inversion - Inverter Switching Devices - Conventional D.C. Motors - Introduction - Torque Production - Motional E.M.F, D.C. Motor–Steady-State Characteristics - Transient Behavior – Shunt - Series and Compound Motors - Four-Quadrant Operation and Regenerative Braking.

Unit 2
D.C. Motor Drives - Thyristor D.C. Drives - Control Arrangements for D.C. Drives - Chopper-Fed D.C. Motor Drives - D.C. Servo Drives - Digitally Controlled Drives - Induction Motors - The Rotating Magnetic Field - Torque Production - Influence Of Rotor Current On Flux - Stator Current-Speed Characteristics - Methods Of Starting Cage Motors - Run-Up And Stable Operating Regions - Torque–Speed Curves–Influence Of Rotor Parameters - Influence Of Supply Voltage - Generating And Braking - Speed Control - Power Factor Control and Energy Optimization - Single-Phase Induction Motors.

Unit 3
Inverter-Fed Induction Motor Drives - Torque–Speed Characteristics–Constant V/F Operation, Control Arrangements For Inverter-Fed Drives - Vector (Field-Oriented) Control, D-Q model of induction motor - Cyclo-Converter Drives - Stepper motors – Synchronous - Brushless D.C. and Switched Reluctance Drives.

Text / Reference Books
Austin Hughes, "Electric Motors and Drives Fundamentals, Types and Applications, Newnes press", Elsevier Ltd. 3rd edition, 2006.
David Polka, "Motors and Drives: A Practical Technology Guide, The Instrumentation, Systems, and Automation Society", 2003.
Nagrath I J and Kothari D P, "Electrical Machines", Tata McGraw-Hill, Second Edition, 2000.
Gopal K. Dubey, "Fundamentals of Electrical Drives", Narosa Publishing House, 2001.
Pillay. S.K, A "First Course on Electric Drives", Wiley Eastern Limited, Bombay, 1987.

23ARE377	ENGINEERING ECONOMIC ANALYSIS	L-T-P-C: 3-0-0-3

Course Objective

- Familiarize business impact of economic environment on business decisions

Course Outcomes

At the end of the course the student will be able to
CO1: Understand and evaluate the economic theories, cost concepts and pricing policies and draw inferences for the investment decisions for appraisal and profitability
CO2: Appraise the dynamics of the market, market structures, and portray implication for profit and revenue maximization
CO3: Employ operations research and allied techniques in managerial economics for an enhanced analysis and decision-making

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	2	2		2		2			3	2	1		
CO2	1	3	2	1		2		2			3	2	1		
CO3	2	3	2	2		2		2			3	2	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

Text Book
Webster, T.J., 'Managerial Economics- Theory and Practice', Elsevier 2004.

Reference Books
Panneerselvam, R., 'Engineering Economics' Second edition, PHI, 2013.
R L Varshney& K L. Maheshwari, 'Managerial Economics', S Chand & Sons, 22e, 2014.
Harrison.B, Smith.C., and Davis.B.,, 'Introductory Economics', 2e Pr Macmillan, 2013.

23MEE433	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

At the end of the course the student will be able to
CO1: Appraise the selection and initiation of individual projects and its portfolios in an enterprise.
CO2: analyse 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

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	2	2	1				2	2	3	1	2	3	2
CO2	2	3	3	2	2				3	2	3	2	2	3	3
CO3	1	2	3	2	2				2	2	3	2	1	2	3
CO4	1	1	2		1				2	2	3	1	1	1	2
CO5	2	3	2	2	1				2	2	3	1	2	3	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 Behavioural Issues: Organizational Structure, Selection-Project Manager, Leadership Motivation, Communication, Risk Management.
Project Termination: Extinction, Addition, Integration, Starvation.

Text Books
Jack R. Meredith and Samuel J. Mantel, Jr. - 'Project Management- A Managerial Approach' Eighth Edition - John Wiley & Sons Inc - 2012.
Arun Kanda – 'Project Management-A Life Cycle Approach' PHI Learning Private Limited - 2011
Reference Books
'A Guide to Project Management Body of Knowledge' PMBOK GUIDE, Sixth edition, Project management Institute – 2017
Ted Klastrorin - 'Project Management, Tools, and Trade-Offs' - John Wiley – 2011

23MNG371	OPERATIONS RESEARCH	L-T-P-C: 2-0-3-3

Course Objectives

- Familiarizing the students with quantitative tools and techniques, which are frequently applied in operational decisions

Course Outcomes

At the end of the course the student will be able to
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

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2		2				1	1	2	2	2		
CO2	3	2	2		2				1	1	2	2	2		
CO3	3	2	2		2				1	1	2	2	2		
CO4	3	2	2		2				1	1	2	2	2		
CO5	3	2	2		2				1	1	2	2	2		
CO6	3	2	2		2				1	1	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
Hillier, F .S. and Lieberman, G .J, 'Operations Research', 9e, McGraw Hill, 2010

Reference Books
Taha,H.A., 'Operations Research: an Introduction', 8e, Prentice HalI, New Delhi, 2008.
Ravindran, A., Phillips, D.J., and Solberg, J.J., 'Operations Research- Principles and Practice', John Wiley & Sons, 2005.
Wagner, H.M., 'Principles of Operations Research', Prentice Hall, New Delhi, 1998.
Hardley, G.,'Linear Programming', Narosa Book Distributors Private Ltd 2002.

23ARE379	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

At the end of the course the student will be able to
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

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2											2	2		
CO2	2	2	2	1					2	1		1	2		1
CO3	2	2	2	2	1				2	1		1	2	1	2
CO4	2	2	2	1	1	1	1			1		2	2	1	1
CO5	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 completed Future State Maps – Application to factory simulation
Implementation of lean practices - Best Practices in Lean Manufacturing.

Text Books
Womack, J.P., Jones, D.T., and Roos, D.,'The Machine that Changed the World', Simon & Schuster, New York, 2007.
Liker, J.K., 'Becoming Lean', Industrial Engineering and Management Press, 1997.

References Books
Womack, J.P. and Jones, D.T.,'Lean thinking', Simon & Schuster, USA, 2003.
Rother, M. and Shook, J., 'Learning to see', The Lean Enterprise Institute, Brookline, USA, 2003.

23ARE378	NONLINEAR DYNAMICS AND CHAOS	L-T-P-C: 3-0-0-3

Course Objectives

This course is expected to enable the student

- Familiarize with nonlinear dynamics concepts for better understanding of physical systems
- Demonstrate analytical and numerical tools to analyse systems with nonlinear effects

Course Outcomes

CO1: Apply the qualitative approach to the study of dynamical systems to analyse nonlinear systems.
CO2: Develop theoretical and computational tools for the analysis of one-dimensional, two-dimensional and multi-dimensional nonlinear systems
CO3: Analyse different bifurcations of practical nonlinear systems and to use them in design
CO4: Differentiate chaotic and non-chaotic systems and to analyse mechanical engineering systems exhibiting chaotic behaviour
CO5: Solve interdisciplinary problems in engineering, ecological, electronic, biological and financial systems using nonlinear dynamics tools

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	1	1							1	2		
CO2	3	3	1	1	1							1	2		
CO3	3	3	1	1	1							1	2		
CO4	3	3	1	1	1							1	2		

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 ofoscillations, bifurcations in one dimensional case, saddle-node, transcritical and pitchfork, flows on the circle, examples.

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.

Unit 3
Chaotic Dynamics - One dimensional maps, fixed points and cobwebs, logistic map, bifurcations in iterated maps and chaos, Feigenbaum universality. Three dimensional systems, Poincaresections, 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.

Text Books

Steven H. Strogatz, "Nonlinear Dynamics and Chaos", Reading, Addison-Wesley, 1994.
Robert C. Hilborn, "Chaos and Nonlinear Dynamics", Second Edition, Oxford University Press, 2000.

Reference Books

Ali Hasan Nayfeh, "Introduction to Perturbation Techniques", John Wiley, 1993.
Morris W. Hirsch, Stephen Smale, and Robert L. Devaney, "Differential Equations, Dynamical Systems and an Introduction to Chaos", Academic Press, Elsevier, 2004.
Lakshmanan M. and Rajashekhar S., "Nonlinear Dynamics", Springer Verlag, 2003.
Robert L. Devaney, "An Introduction to Chaotic Systems", Second Edition, West View Press, 2003.
Edward Ott, "Chaos in Dynamical Systems", Cambridge University Press, 1993.

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 involving iterative methods, matrix algebra, Curve fitting.
Molecular mechanics: Basic theory - Harmonic oscillator – Parameterization - Energy equations - Principle of coupling - 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 PROCESS	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) indicatorand ion selective electrodes - Nernst equation - irreversible processes - kinetic treatment - Butler- Volmer equation - Overpotential, activation, concentration and IR overpotential - its practical significance - Tafel equation and Tafelplots - 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, fractional distillation, 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 sustainable products
CO2: Appreciate the need for Renewable energy and Feed stock along with carbon sequestration through the fundamentals 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 of zero 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; BlakwellPublishing.*
2. *Anastas, P. T., Warner, J. C. Green Chemistry: Theory and Practice, Oxford University Press Inc., NewYork, 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 - acidbase, 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 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 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) indicatorand 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 Outcomes

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

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	1	2											3	1		
CO2		3	1	2								1	1	2		
CO3		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 - stray current 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.

PHYSICS

23CHY240	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 lawsand 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

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	1								1			
CO2	3	3	1	1								1			
CO3	3	3	3	1								1			
CO4	3	3	3	1								2			
CO5	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 lawof 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-spinspacecraft, satellite maneouvering and attitude control - coning maneuver - Yo-yo despin mechanism - gyroscopicattitude 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.

23CHY241	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 to understand 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 inSi and Ge, carrier density, energy band structure and conduction mechanism in intrinsic and extrinsic semiconductors.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1											1	
CO2	2	2	2										1	
CO3	2	2	2										2	
CO4	2	2	2										2	
CO5	2	2	2					2					1	

Syllabus

Unit 1

Conducting materials: The nature of chemical bond, crystal structure Ohm's law and the relaxation time, collision time, 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 in matter, 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.

23CHY242	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.

23CHY243	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

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2												
CO2	2	3												
CO3				3										
CO4						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 nano transition – 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 surface modes.

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.

23CHY244	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 of electronic 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 semiconductor parameters 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 carrier concentration. 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:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3											1		
CO2	2	2												
CO3	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 of relativity – 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 - plank length 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

(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.

(b) Interpolations:
Interpolation and Approximation: Lagrange, Newton's Divided Difference, Newton's Forward and Backward interpolations.

(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

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3					1	1		3	3	1			
CO2	3	3					2	1		3	3	1			
CO3	3	2					1	1		3	3	1			
CO4	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 the financial system.

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.

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 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, 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

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1									1	3		
CO2	2	2	3	1						1	1	2	2		
CO3	3	3	3	3	2				3	1	1	3	2		
CO4	2	2	1	1						1	1	2	2		
CO5	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 routingand 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 partylogistics-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 Improving Service', 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 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, 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

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 a specific 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

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1			3	1								1			
CO2		1	3	3		2	1			2	2	2			
CO3	1	1	1	3	2	2	2		2	2	2	3			
CO4			2	2		2	1	1		3	3	3			
CO5	1	1	3	2		1	1			1	2	3			
CO6	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 of purchase- unique selling proposition. Characteristics, wholesaling, retailing, channel design, logistics, and modern trends 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 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, 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

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	2	2	1				2		3	1	2	3	2
CO2	2	3	3	2	2				3		3	2	2	3	3
CO3	1	2	3	2	2				2		3	2	1	2	3
CO4	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 crashingResource 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' EighthEdition - 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 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, 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

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

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	1	1							2	2			
CO2	2	1								1		2	1		1
CO3	2	1										2	1		1
CO4	2	1	1	1						1		2	1		1
CO5	2	1		1								2			
CO6	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 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, 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

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2		2						2	2	2		
CO2	3	2	2		2						2	2	2		
CO3	3	2	2		2						2	2	2		
CO4	3	2	2		2						2	2	2		
CO5	3	2	2		2						2	2	2		
CO6	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 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, 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 and material handling.

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	1	1						1		3	2		
CO2	2	1	2	1	1					1		3	2		
CO3	1	2		1	1						1	3	2		
CO4	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 of work 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 of work 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 and incentives, 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 a work 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 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, 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 quantitativedata 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

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3		2	2						2	2	3		
CO2	3	3		2	2						2	2	3		
CO3	3	3		2	2						2	2	3		
CO4	3	3		2	2						2	2	3		

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

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 PublishingCompany - 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 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, 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

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	2										2	2		
CO2	1	2										2	2		
CO3	2	2	2									2	2		
CO4	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 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, 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

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2											2	2		
CO2	2	2	2	1					2	1		1	2		1
CO3	2	2	2	2	1				2	1		1	2	1	2
CO4	2	2	2	1	1	1	1			1		2	2	1	1
CO5	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, NewYork, 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 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignment, 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 managementfor 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

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	1								1		3	2
CO2	3	2	3						3	3		2	3	2
CO3	3	2	2	3	2	2	2	2	3	3	2	2	3	2
CO4	2	2	2	1	3	2	2	2	3	3		2	3	2
CO5	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 and AOA-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

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	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.

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 and derivatives
CO3: Analyse and design Portfolio selection methods
CO4: Understand capital market theory for stock performance evaluation

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1			2								3	2
CO2	2	3	1										3	2
CO3	1	3			2								3	2
CO4	2	1											3	2

Syllabus

Unit 1

Cash Flows and Fixed income securities: Investments and markets - Principal and interest - Present and future values of 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 structure of 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	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.

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 on business 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 revenue maximization
CO3: Employ operations research and allied techniques in managerial economics for an enhanced analysis and decision making

CO-PO Mapping

PO/ PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	2	2		2		2			3	2	3	2
CO2	1	3	2	1		2		2			3	2	3	2
CO3	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	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.

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 also understand 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

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3												3	2
CO2	2	2			2								3	2
CO3	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, value chain, reengineering, virtual organization, knowledge creation-Organizational Planning, The Scenario Approach, Planning for Competitive Advantage, SWOT Business Models and Planning, Business IT Planning, -Business/ IT Strategies and Business Application Planning- Developing and Implementing Business Systems - Implementation Challenges- 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	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 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 possibilities for manifesting excellence in life. This course presents to the students, an opportunity to study the Indian perspective of 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 Modernneeds) 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. The course 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 Western Psychology - 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 all Yoga-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 – Unfolded belief - 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 BiharSchool of Yoga, Munger, India.*
2. *"The message of Upanishads" written by Swami Ranganathananda. Published by Bharathiya VidyaBhavan.*
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 thecross-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 the business 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

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1										3		2
CO2									1		1	
CO3										3		
CO4						2						
CO5									2			

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, Group Dynamics, 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 / McGrawHill.*
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 2Prose

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 literary insights; 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, Book reviews, 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

Mapping of course outcomes with program outcomes:

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1										3				
CO2										3				
CO3				1										
CO4									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 TechnologyProfessionals". II Edition. New York: IEEE press, 2002*
2. *Anderson, Paul. V. "Technical Communication: A Reader-Centred Approach". V Edition. Harcourt BraceCollege 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 (IndianAdaptation). 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, choosea 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

E 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.
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23GER232	PROFICIENCY IN GERMAN LANGUAGE (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 tocarry 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:

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1									2	3				
CO2									2	3				
CO3									2	3				
CO4										3				
CO5									2					

Syllabus

Unit 1

Introduction to Hindi Language, National Language, Official Language, link Language etc. Introduction to Hindi language, 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 in different 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 publishingHouse, 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 as anthology.

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:

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1									1	2				
CO2									1	2				
CO3									1	2				
CO4										3				
CO5									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. News reading 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 PageIndia 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.

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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 a chronological 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 a chronological 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 ofHinduism" 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 ofIndian 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 – classical sanskrit literature – Harsavardhana; Trade and commerce in classical and medieval India and the story of Indian supremacy 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, Rabindranath Tagore; 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.*
4. *Rao, S. Balachandra. Indian Astronomy: An Introduction. Hyderabad: Universities Press, 2000.*
5. *Bose, D. M. et. al. A Concise History of Science in India. New Delhi: 1971.*
6. *Bajaj, Jitendra & M. D. Srinivas. Indian Economy and Polity. Chennai: Centre for Policy Studies.*
7. *Bajaj, Jitendra & M. D. Srinivas.Timeless India, Resurgent India. Chennai: Centre for Policy Studies.*
8. *Joshi, Murli Manohar. Science, Sustainability and Indian National Resurgence. Chennai: Centre forPolicy Studies, 2008.*
9. *The Cultural Heritage of India. Kolkata: Ramakrishna Mission Institute of Culture.*
10. *Vivekananda, Swami. Selections from the Complete Works of Swami Vivekananda. Kolkata: AdvaitaAshrama.*
11. *Mahadevan, T. M. P. Invitations to Indian Philosophy. Madras: University of Madras.*
12. *Hiriyanna, M. Outlines of Indian Philosophy. Motilal Banarsidass.*
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.NewDelhi: 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'strade 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 theIndo-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 productionand urban economy, currency system; Vijayanagara samrajya and maritime trade – the story of Indian supremacyin 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 ofscience and (new/ emerging) technology on Indian economy; Histories of select Indian business houses and business entrepreneurship.

Conclusion

REFERENCES:

1. *The Cultural Heritage of India. Kolkata: Ramakrishna Mission Institute ofCulture.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. NewDelhi: 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 forPolicy 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: OxfordUniversity 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 and postures, 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 Councilof 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 - 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 youthprogramme/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 Outcomes

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

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1						1						1
CO2						2	3		3	3		
CO3						3	3	2	1		3	2
CO4						2	2	3				1
CO5						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 and enhancement of self esteem.

Unit 2
The Nature and Coping of Stress
Conflict, Relationship issues, PTSD. Stress – stressors – eustress - distress, coping with stress, stress management techniques.

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 awhole
- 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 nurturehealthy relationships.

CO-PO Mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1						3	3		3	2		1
CO2						3	3	2	3	3	1	2
CO3										2	1	
CO4							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, Pvt 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.

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 andtechnology: 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 ofNew 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 thedetermination.

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 Growingand 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 BHAGWAT 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 Modern Science.

Unit 2

The challenge of human experience & problems discussed in the Upanishads – the True nature of Man – theMoving power of the Spirit – The Message of Fearlessness – Universal Man - The central problems of theUpanishads – 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 foodcombinations, 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 Outcome:

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:

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		1	1			1	2	1	1	1	1	3
CO2		1	1			1	1	1	1	1	1	3
CO3		1	1			1	1	1	1	1	1	3
CO4		1	1			1	1	1	1	1	1	3
CO5		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, advanced research.
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. Informal sessions will be conducted occasionally, in which students can sing Japanese songs, watch Japanese movies, do Origami – 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 towrite 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 Japaneselanguage 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 Japanese language 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 andreading 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. BendreSwathantryada 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 andreading 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 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 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:

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1									2	3		
CO2									2	3		
CO3									2	3		
CO4										3		
CO5									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 ourculture & values; to equip students read & write correct Malayalam; to correct the mistakes in pronunciation; tocreate 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:

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1									2	3		
CO2									2	3		
CO3									2	3		
CO4										3		
CO5									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 Sanskritverses 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-kartharipra yoga

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 - 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.

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 Sanskritverses 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 underSection 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 toguide" 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 theusefulness 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

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1									2	2		
CO2									2	2		
CO3									2	2		
CO4									2	2		
CO5									2	2		
CO6									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 kaṇiṇi payaṉpāṭu. - Karuttu parimāṟṟam - viḻampara 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.Varatarācaṉ “tamiḻ ilakkiya varalāṟu” cāhitya akaṭemi papḷikēṣaṉs, 2012
4. nā.Vāṉamāmalai “paḻaṅkataikaḷum, paḻamoḻikaḷum” niyū ceñcuri puttaka veḷiyīṭṭakam,1980,2008
5. nā.Vāṉamāmalai, “tamiḻar nāṭṭuppāṭalkaḷ” niyū ceñcuri puttaka veḷiyīṭṭakam 1964,2006
6. poṉ maṇimāṟaṉ “aṭōṉ tamiḻ ilakkaṇam “aṭōṉ papḷiṣiṅ kurūp, vañciyūr,
7. tiruvaṉantapuram, 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 TamilLanguage.

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

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1									2	2		
CO2									2	2		
CO3									2	2		
CO4									2	2		
CO5									2	2		
CO6									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. 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 - viḻampara 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.