AMRITA VISHWA VIDYAPEETHAM
DEEMED TO BE UNIVERSITY
School of Engineering

(AMRITAPURI, BANGALORE, COIMBATORE, CHENNAI)

DEPARTMENT OF MECHANICAL ENGINEERING

B.Tech. in MECHANICAL ENGINEERING (BTC-MEC)

CURRICULUM AND SYLLABI
(2019)

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 (includingLanguages and others)
SCI	-	Basic Sciences (includingMathematics)
PRJ	-	Project Work (includingSeminars)
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

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

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

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.

Program Educational Objectives :

- Apply their Knowledge in Science, Mathematics and Engineering to address Industrial and Societal problems with a strong emphasis on creativity, confidence, ethics, and responsibility.
- Apply latest computational, analytical, simulation tools and techniques to develop and improve products and processes.
- Solve multidisciplinary problems by working in cross functional teams.
- Develop and upgrade technical, intellectual and emotional skills for life-long learning to compete in a rapidly evolving world.
- Nurture entrepreneurial ventures and foster research activities that support sustainable economic development to enhance the quality of life.

Program Specific Outcomes:

- Apply knowledge acquired in the field of Design, Manufacturing, Thermal, and Fluid sciences to solve real-world engineering problems using emerging technologies.
- Extend and implement innovative thinking on product design and development with the aid of modern CAD/CAM/CAE tools.
- Apply the Science and Engineering knowledge for materials design and processing for development and improvement of products and processes

SEMESTER I

Cat.	Code	Title	Credit
SCI	19MAT101	Single Variable Calculus	1
SCI	19MAT111	Multivariable Calculus	2
SCI	19MAT104	Basic Linear Algebra	2
ENGG	19CSE100	Problem Solving and Algorithmic Thinking	4
SCI	19PHY102/ 19CHY101	Engineering Physics - B /Engineering Chemistry - A	3
SCI	19PHY182/ 19CHY181	Engineering Physics Lab - B / Engineering Chemistry Lab - A	1
ENGG	19EEE100	Basic Electrical and Electronics Engineering	3
ENGG	19EEE181	Basic Electrical and Electronics Engineering Lab	1
ENGG	19MEE101	Engineering Drawing	3
HUM	19CUL101	Cultural Education - I	2
		TOTAL	**22**

SEMESTER II

Cat.	Code	Title	Credit
HUM	19ENG111	Technical Communication	3
SCI	19MAT114	Differential Equation and Transforms	4
SCI	19BIO111	Biology for Engineers - B	2
SCI	19PHY102/ 19CHY101	Engineering Physics - B /Engineering Chemistry - A	3
SCI	19PHY182/ 19CHY181	Engineering Physics Lab - B / Engineering Chemistry Lab - A	1
ENGG	19CSE102	Computer Programming	4
ENGG	19MEE182	Computer Aided Drafting	1
ENGG	19MEE111	Engineering Mechanics	4
ENGG	19MEE181	Manufacturing Practice	1
HUM	19CUL111	Cultural Education - II	2
		TOTAL	**25**

SEMESTER III

Cat.	Code	Title	Credit
SCI	19MAT210/. 22MAT210^	Probability and Complex Variables	4
ENGG	19MEE201	Thermodynamics	4
ENGG	19MEE203	Mechanics of solids	4
ENGG	19MEE204	Metallurgy and Material science	3
ENGG	19MEE202	Manufacturing Process I	3
ENGG	19MEE281	Material Testing and Metallurgy Lab	1
ENGG	19CSE282	Python Programming	1
HUM		Free Elective I*	2
HUM	19AVP201	Amrita Values Program I	1
HUM	19ENV300	Environmental Science	P/F
		TOTAL	**23**

^Revision March 2022

SEMESTER IV

Cat.	Code	Title	Credit
ENGG	19MEE211	Computational Methods in Engineering	3
ENGG	19MEE212	Fluid Mechanics and Machinery	4
ENGG	19MEE213	Heat Power Engineering	4
ENGG	19MEE214	Kinematics of Machines	4
ENGG	19MEE215	Manufacturing Process II	3
ENGG	19MEE283	Fluid Mechanics and Machinery Laboratory	1
ENGG	19MEE284	Thermal Science Laboratory	1
HUM	19AVP211	Amrita Values Program II	1
HUM	19SSK211	Soft Skills I	2
		TOTAL	**23**

SEMESTER V

Cat.	Code	Title	Credit
ENGG	19MEE301	Design of Machine Elements - I	3
ENGG	19MEE302	Dynamics of Machines	3
ENGG	19MEE303	Heat Transfer	4
ENGG	19MEE306	Operations Research	3
HUM	19MNG300	Disaster Management	P/F
ENGG	19MEE304	Instrumentation and Control Systems	3
HUM		Free Elective II**	2
ENGG	19LIV390	[Live in Labs]***	[3]
ENGG	19MEE381	Heat Transfer Laboratory	1
ENGG	19MEE382	Instrumentation and Control Laboratory	1
ENGG	19MEE305	Machine Drawing	3
HUM	19SSK301	Soft Skills II	2
		TOTAL	**25+[3]**

SEMESTER VI

Cat.	Code	Title	Credit
ENGG	19MEE314	Introduction to Finite Element Method	4
ENGG	19MEE313	Design of Machine Elements - II	3
ENGG	19MEE312	Automation and IoT	4
ENGG		Professional Elective I*	3
ENGG		Professional Elective II*	3
ENGG	19MEE384	Metrology Laboratory	1
ENGG	19MEE383	Machine Dynamics Laboratory	1
ENGG	19LIV490	[Live in Labs]***	[3]
ENGG	19MEE311	Design Thinking	2
HUM	19SSK311	Soft Skills III	2
		TOTAL	**23+[3]**

SEMESTER VII

Cat.	Code	Title	Credit
ENGG	19MEE401	Industrial Engineering	3
ENGG		Professional Elective III*	3
HUM	19MEE402	Research Methodology	P/F
ENGG		Professional Elective IV*	3
ENGG		Professional Elective V*	3
ENGG	19MEE481	CNC and System simulation Laboratory	1
HUM	19LAW300	Indian Constitution	P/F
PRJ	19MEE490	Summer Internship	P/F
PRJ	19MEE495	Project Phase I	2
		TOTAL	**15**

SEMESTER VIII

Cat.	Code	Title	Credit
ENGG		Professional Elective VI*	3
PRJ	19MEE499	Project Phase II	10
		TOTAL	**13**

		TOTAL CREDIT		**169**

***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-Labs project, can be exempted from registering for an Elective course in the higher semester.

PROFESSIONAL ELECTIVES

DESIGN STREAM			
Cat.	**Code**	**Title**	**Credit**
ENGG	19MEE331	Machine Learning Based Condition Monitoring	3
ENGG	19MEE332	Failure Analysis and Design	3
ENGG	19MEE333	Optimization Techniques in Engineering	3
ENGG	19MEE334	Modeling and Simulation of Engineering Systems	3
ENGG	19MEE335	Tool Design	3
ENGG	19MEE336	NVH and Refinement	3
ENGG	19MEE337	Fundamentals of Fracture Mechanics	3
ENGG	19MEE338	Theory of Vibrations	3
	19MEE339	Theory of Elasticity	3
Professional Electives (Open to all)			
Cat.	**Code**	**Title**	**Credit**
ENGG	19MEE340	Introduction to Nonlinear Dynamics and Chaos	3
ENGG	19MEE311	Design Thinking	2
ENGG	19MEE333	Optimization Techniques in Engineering	3

MANUFACTURING STREAM			
Cat.	**Code**	**Title**	**Credit**
ENGG	19MEE431	CNC Machines	3
ENGG	19MEE432	Composite Materials and Design	3
ENGG	19MEE433	Fundamentals of Nanomaterials	3
ENGG	19MEE434	Industrial Robotics	3
ENGG	19MEE435	Additive Manufacturing	3
ENGG	19MEE436	Nano Technology and Surface Engineering	3
ENGG	19MEE437	Advanced Casting Technology	3
ENGG	19MEE438	Advanced Manufacturing Processes	3
ENGG	19MEE439	Advanced Materials and Processes	3
ENGG	19MEE440	Advanced Metrology and Sensing Systems	3
ENGG	19MEE441	Advanced Welding Technology	3
ENGG	19MEE442	Micro-Manufacturing	3

ENGG	19MEE443	Non-Destructive Testing	3
ENGG	19MEE444	Product Cost Estimation	3
ENGG	19MEE445	Quality Control and Reliability Engineering	3
ENGG	19MEE446	Simulation Modeling of Manufacturing Systems	3
Professional Electives (Open to all)			
Cat.	**Code**	**Title**	**Credit**
ENGG	19MEE434	Industrial Robotics	3
ENGG	19MEE443	Non-Destructive Testing	3
ENGG	19MEE445	Quality Control and Reliability Engineering	3

INDUSTRIAL ENGINEERING AND MANAGEMENT STREAM			
Cat.	**Code**	**Title**	**Credit**
ENGG	19MEE341	Engineering Economic Analysis	3
ENGG	19MEE342	Lean Manufacturing	3
ENGG	19MEE343	Manufacturing Planning and Control	3

THERMAL STREAM			
Professional Electives			
Cat.	**Code**	**Title**	**Credit**
ENGG	19MEE351	Computational Fluid Dynamics	3
ENGG	19MEE352	Gas Dynamics and Jet Propulsion	3
ENGG	19MEE353	HVAC Systems & Applications	3
ENGG	19MEE354	Power Plant Engineering	3
ENGG	19MEE355	Turbo Machinery	3
ENGG	19MEE356	Automotive Technology	3
ENGG	19MEE357	Solar and Wind Power Technologies	3
ENGG	19MEE358	IC Engines and Emission	3
ENGG	19MEE359	Advanced Fluid Mechanics	3
ENGG	19MEE360	Electric Vehicle Design	3
Professional Electives (Open to all)			
Cat.	**Code**	**Title**	**Credit**
ENGG	19MEE356	Automotive Technology	3
ENGG	19MEE357	Solar and Wind Power Technologies	3
ENGG	19MEE360	Electric Vehicle Design	3
Cat.	**Code**	**Title**	**Credit**
ENGG	19MEE344	Biomass Energy Conversion Techniques	3
ENGG	19MEE345	Sustainable Manufacturing	3

PROFESSIONAL ELECTIVES UNDER SCIENCE STREAM

CHEMISTRY			
Cat.	**Code**	**Title**	**Credit**
SCI	**19CHY243**	**Computational Chemistry and Molecular Modelling**	**3**
SCI	**19CHY236**	**Electrochemical Energy Systems and Processes**	**3**
SCI	**19CHY240**	**Fuels and Combustion**	**3**
SCI	**19CHY232**	**Green Chemistry and Technology**	**3**
SCI	**19CHY239**	**Instrumental Methods of Analysis**	**3**
SCI	**19CHY241**	**Batteries and Fuel Cells**	**3**
SCI	**19CHY242**	**Corrosion Science**	**3**
PHYSICS			
SCI	**19PHY340**	**Advanced Classical Dynamics**	**3**
SCI	**19PHY342**	**Electrical Engineering Materials**	**3**
SCI	**19PHY331**	**Physics of Lasers and Applications**	**3**
SCI	**19PHY341**	**Concepts of Nanophysics and Nanotechnology**	**3**
SCI	**19PHY343**	**Physics of Semiconductor Devices**	**3**
SCI	**19PHY339**	**Astrophysics**	**3**
Mathematics			
SCI	**19MAT341**	**Statistical Inference**	**3**
SCI	**19MAT342**	**Introduction to Game Theory**	**3**
SCI	**19MAT343**	**Numerical Methods and Optimization**	**3**

FREE ELECTIVES

FREE ELECTIVES OFFERED UNDER MANAGEMENT STREAM			
Cat.	**Code**	**Title**	**Credit**
HUM	**19MNG331**	**Financial Management**	**3**
HUM	**19MNG332**	**Supply Chain Management**	**3**
HUM	**19MNG333**	**Marketing Management**	**3**

HUM	19MNG334	Project Management	3
HUM	19MNG335	Enterprise Management	3
HUM	19MNG338	Operations Research	3
HUM	19MEE401	Industrial Engineering	3
HUM	19MEE346	Managerial Statistics	3
HUM	19MEE347	Total Quality Management	3
HUM	19MEE342	Lean Manufacturing	3
HUM	19CSE358	Software Project Management	3
HUM	19CSE359	Financial Engineering	3
HUM	19CSE360	Engineering Economic Analysis	3
HUM	19MNG331	Financial Management	3
HUM	19CSE362	Information Systems	3

FREE ELECTIVES OFFERED UNDER HUMANITIES / SOCIAL SCIENCE STREAMS

Cat.	Code	Title	Credit
HUM	19CUL230	Achieving Excellence in Life - An Indian Perspective	2
HUM	19CUL231	Excellence in Daily Life	2
HUM	19CUL232	Exploring Science and Technology in Ancient India	2
HUM	19CUL233	Yoga Psychology	2
HUM	19ENG230	Business Communication	2
HUM	19ENG231	Indian Thought through English	2
HUM	19ENG232	Insights into Life through English Literature	2
HUM	19ENG233	Technical Communication	2
HUM	19ENG234	Indian Short Stories in English	2
HUM	19FRE230	Proficiency in French Language (Lower)	2
HUM	19FRE231	Proficiency in French Language (Higher)	2
HUM	19GER230	German for Beginners I	2
HUM	19GER231	German for Beginners II	2
HUM	19GER232	Proficiency in German Language (Lower)	2
HUM	19GER233	Proficiency in German Language (Higher)	2

HUM	**19HIN101**	**Hindi I**	**2**
HUM	**19HIN111**	**Hindi II**	**2**
HUM	**19HUM230**	**Emotional Intelligence**	**2**
HUM	**19HUM231**	**Glimpses into the Indian Mind - the Growth of Modern India**	**2**
HUM	**19HUM232**	**Glimpses of Eternal India**	**2**
HUM	**19HUM233**	**Glimpses of Indian Economy and Polity**	**2**
HUM	**19HUM234**	**Health and Lifestyle**	**2**
HUM	**19HUM235**	**Indian Classics for the Twenty-first Century**	**2**
HUM	**19HUM236**	**Introduction to India Studies**	**2**
HUM	**19HUM237**	**Introduction to Sanskrit Language and Literature**	**2**
HUM	**19HUM238**	**National Service Scheme**	**2**
HUM	**19HUM239**	**Psychology for Effective Living**	**2**
HUM	**19HUM240**	**Psychology for Engineers**	**2**
HUM	**19HUM241**	**Science and Society - An Indian Perspective**	**2**
HUM	**19HUM242**	**The Message of Bhagwad Gita**	**2**
HUM	**19HUM243**	**The Message of the Upanishads**	**2**
HUM	**19HUM244**	**Understanding Science of Food and Nutrition**	**2**
HUM	**19JAP230**	**Proficiency in Japanese Language (Lower)**	**2**
HUM	**19JAP2313**	**Proficiency in Japanese Language (Higher)**	**2**
HUM	**19KAN101**	**Kannada I**	**2**
HUM	**19KAN111**	**Kannada II**	**2**
HUM	**19MAL101**	**Malayalam I**	**2**
HUM	**19MAL111**	**Malayalam II**	**2**
HUM	**19SAN101**	**Sanskrit I**	**2**
HUM	**19SAN111**	**Sanskrit II**	**2**
HUM	**19SWK230**	**Corporate Social Responsibility**	**2**
HUM	**19SWK231**	**Workplace Mental Health**	**2**
HUM	**19TAM101**	**Tamil I**	**2**
HUM	**19TAM111**	**Tamil II**	**2**

Value Added Courses

Value Added Courses are offered to students during the weekend / summer/ winter vacations by the experts. These courses are non-credit courses. Certificates will be issued to the students after successful completion of the course. Additional courses will be added in this list based on the demand from the students and as well as requirements from the industry.

1. CNC Programming and Simulation using CAM software
2. Geometric Dimensioning and Tolerancing
3. Tool Design
4. Design of Experiments
5. Simulation of Manufacturing Systems using Discrete event simulation software
6. Advanced CAD Modelling & Engineering Analysis
7. MATLAB programming
8. Advanced Python programming
9. Material Characterization

MOOC Courses

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

SYLLABUS

SEMESTER I

19MAT101	SINGLE VARIABLE CALCULUS	L-T-P-C: 1- 0 - 0 -1

Course Objectives

- Understand the various functions and their graphs.
- Understand the basic concept of continuous function and find the extreme values of the continuous functions.
- Understand the definite integral and various integration techniques.

Course Outcomes

CO1: To understand the concepts of single variable calculus.
CO2: To sketch graphs for functions using the concepts of single variable calculus and apply the fundamental theorem of calculus to evaluate integrals.

CO-PO Mapping

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

Syllabus
Unit 1
Calculus
Graphs: Functions and their Graphs. Shifting and Scaling of Graphs. (1.5)
Unit 2
Limit and Continuity**:** Limit (One Sided and Two Sided) of Functions. Continuous Functions, Discontinuities, Monotonic Functions, Infinite Limits and Limit at Infinity. (2.1, 2.6)
Unit 3
Graphing : Extreme Values of Functions, Concavity and Curve Sketching, (4.1, 4.4).
Unit 4
Integration: Definite Integrals, The Mean Value Theorem for definite integrals, Fundamental Theorem of Calculus, Integration Techniques. (5.2 - 5.3, 8.1 – 8.5)

Text Book
Calculus', G.B. Thomas Pearson Education, 2009, Eleventh Edition.

Reference
'Calculus', Monty J. Strauss, Gerald J. Bradley and Karl J. Smith, 3rd Edition, 2002

Evaluation pattern
At the end of the course, a two-hour test will be conducted for 50 marks. The marks will be converted to 100 for grading.

19MAT111	MULTI VARIABLE CALCULUS	L-T-P-C: 2-0-0-2

Course Objective

- 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

CO1: Select suitable parameterization of curves and to find their arc lengths
CO2: Find partial derivatives of multivariable functions and to use the Jacobian in practical problems.
CO3: Apply Fundamental Theorem of Line Integrals, Green's Theorem, Stokes' Theorem, or Divergence Theorem to evaluate integrals.

CO-PO Mapping

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

Syllabus

Unit 1
Functions of severable variables
Functions, limit and continuity. Partial differentiations, total derivatives, differentiation of implicit functions and transformation of coordinates by Jacobian.Taylor's series for two variables.

Unit 2
Vector Differentiation
Vector and Scalar Functions, Derivatives, Curves, Tangents, Arc Length, Curves in Mechanics, Velocity and Acceleration, Gradient of a Scalar Field, Directional Derivative, Divergence of a Vector Field, Curl of a Vector Field.

Unit 3
Vector Integration
Line Integral, Line Integrals Independent of Path.
Green's Theorem in the Plane, Surfaces for Surface Integrals, Surface Integrals, Triple Integrals – Gauss Divergence Theorem, Stoke's Theorem.

Unit 4
Lab Practice Problems:
Graph of functions of two variables, shifting and scaling of graphs. Vector products. Visualizing different surfaces.

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

Reference Book(s)

Advanced Engineering Mathematics by 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.
'Calculus', G.B. Thomas Pearson Education, 2009, Eleventh Edition.

Evaluation pattern

Assessment	Weightage
Test 1 (after 8th Lecture hr)	25
*Continuous Assessment (CA)	25
Test 2 (after 15th Lecture hr)	50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MAT104	BASIC LINEAR ALGEBRA	L-T-P-C: 2-0-0-2

Course Objectives

- To solve simultaneous algebraic equations using methods of matrix algebra
- To understand basics of matrix algebra and determinants
- To use vector space methods and diagonalization in practical problems

Course Outcomes

CO1: Apply concepts of matrix algebra for solving simultaneous linear algebraic equations
CO2: Understand the power of mathematical abstraction through introduction and application of concepts like vector spaces inner product spaces and linear transformations

CO-PO Mapping

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

Syllabus

Unit 1
Vectors in Rn, notion of linear independence and dependence, linear span of a set of vectors, vector subspaces of Rn, basis of a vector subspace.

Unit 2
Linear system of equations, Gauss elimination, Linear independence, Rank of a matrix, row space and column space, existence and uniqueness of system of linear equations, Determinants, Cramer's' rule, Inverse of a matrix, Gauss-Jordan elimination.

Unit 3
Vector spaces, subspaces, linear independence, basis, dimension, change of basis, row, column and null spaces, linear transformation, eigen values and eigen vectors, diagonalization, inner product spaces, Gram-Schmidt orthogonalisation.

Text Book
Elementary Linear Algebra, Howard Anton and Chris Rorres, 11th Edition, Wiley, 2015.
Linear algebra: A modern introduction, D Poole. Cengage Learning,4thEdition 2015.
Engineering Mathematics, Srimanta Pal and Subodh C Bhunia, , John Wiley and Sons, 2012, Ninth Edition.

Evaluation pattern

Assessment	Weightage
Test 1 (after 8th Lecture hr)	25
*Continuous Assessment (CA)	25
Test 2 (after 15th Lecture hr)	50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19CSE100.	PROBLEM SOLVING AND ALGORITHMIC THINKING	L-T-P-C: 2-1-3-4

Course Objectives

- To provide the foundations of algorithmic thinking and problem solving
- To focus on principles and methods rather than on systems and tools thus providing transferable skills to any other domain
- To provide foundations for developing computational perspective of one's own discipline

Course Outcomes

CO 1: To apply algorithmic thinking to understand, define and solve problems
CO 2: To Design and implement algorithm(s) for a given problem
CO 3: To apply the basic programming constructs for problem solving
CO 4: To understand an algorithm by tracing its computational states, identifying bugs and correcting them

CO-PO Mapping

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

Syllabus

Unit 1
Problem Solving and Algorithmic Thinking Overview – problem definition, logical reasoning; Algorithm – definition, practical examples, properties, representation, algorithms vs programs.

Unit 2
Algorithmic thinking – Constituents of algorithms – Sequence, Selection and Repetition, input-output; Computation – expressions, logic; algorithms vs programs, Problem Understanding and Analysis – problem definition, input-output, variables, name binding, data organization: lists, arrays etc. algorithms to programs.

Unit 3
Problem solving with algorithms – Searching and Sorting, Evaluating algorithms, modularization, recursion. C for problem solving – Introduction, structure of C programs, data types, data input, output statements, control structures.

Text Book
Riley DD, Hunt KA. Computational Thinking for the Modern Problem Solver.CRC press; 2014 Mar 27.

References
Ferragina P, Luccio F. Computational Thinking: First Algorithms, Then Code. Springer; 2018.
Beecher K. Computational Thinking: A beginner's guide to Problem-solving and Programming.BCS Learning & Development Limited; 2017.
Curzon P, McOwan PW. The Power of Computational Thinking: Games, Magic and Puzzles to help you become a computational thinker. World Scientific Publishing Company; 2017.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment (Theory) (CAT)	15	
*Continuous Assessment (Lab) (CAL)	30	
End Semester		35

*CA – Can be Quizzes, Assignments, Projects, and Reports

19PHY102	ENGINEERING PHYSICS - B	L-T-P-C: 2- 1-0- 3

Course Objectives

- To get deeper knowledge and ability to apply concepts of Newtonian mechanics including conservation theorems to engineering applications.
- To familiarize the principles of interference, diffraction and polarization and apply in engineering context.
- To gain knowledge of basic quantum mechanics, crystal structure and classification of solids based on their properties and applications.

Course outcomes

CO1: Be able to apply the concepts of Newtonian mechanics including conservation theorems to engineering Applications and problem solving.
CO2: Understand the principles of interference, diffraction and polarization and apply it in engineering context and to solve numerical problems
CO3: Understand the principles and applications of solid state and gas lasers
CO4: Be exposed to the basic principles of Quantum mechanics with elementary applications in one dimensional potential well
CO5: Be familiar with crystals structure, free electron theory and basic semiconductor theory.

CO-PO Mapping

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

Syllabus

Unit 1
Mechanics
Newton's laws of motion – forces, frictional forces, dynamics of uniform circular motion, work, kinetic energy, work-energy theorem, potential energy, conservation of energy, Newton's law of gravitation, motion in uniform gravitational field, centre of mass, conservation of linear and angular momentum.

Unit 2
Waves and Optics
Huygens' Principle, superposition of waves and interference of light by wave front splitting and amplitude splitting, Young's double slit experiment, Newton's Rings, Michelson interferometer.
Fraunhofer diffraction from single slit and circular aperture, Rayleigh criterion for limit of resolution and its application to vision, diffraction gratings and their resolving power.

Polarization: Unpolarized, polarized and partially polarized lights, polarization by reflection, double refraction by uniaxial crystals, Polaroid, half wave and quarter wave plates.

Unit 3

Lasers

Einstein's theory of matter radiation interaction and A and B coefficients; amplification of light by population inversion, different types of lasers: gas lasers (He-Ne, CO2), solid-state lasers (Ruby, Neodymium), dye lasers.

Unit 4

Quantum Mechanics

De Broglie waves, wave functions, wave equation, Schrodinger wave equation: time dependent and time independent form, operators – Eigen functions and Eigen values, uncertainty principle, particle in a finite potential one -dimensional box, tunnelling effect (Qualitative).

Unit 5

Introduction to Solids

Crystal systems – Miller indices, crystal planes and directions, packing fraction, Classification of solids: Metals, semiconductors and insulators (qualitative), free electron theory of metals, Fermi level, Density of states, Kronig-Penney model and origin of energy bands.

Text Books

Halliday, Resnick, Jearl Walker, "Principles of Physics", 10th Edition, Wiley,2015.
Ajay Ghatak, "Optics", 6th Edition, McGraw Hill Education India Private Limited, 2017.
Eugene Hecht, A R Ganesan, "Optics", 4th Edition, Pearson Education, 2008.
Arthur Beiser, ShobhitMahajan, S RaiChoudhury"Concepts of Modern Physics" McGraw Hill Education India Private Limited, 2017.
Charles Kittel, "Introduction to Solid State Physics" 8th Edition, Wiley, 2012.

Reference Books

David Kleppner, Robert Kolenkow, "An Introduction to Mechanics", 1st Edition, McGraw Hill Education, 2017.
F A Jenkins, H E White, "Fundamental of Optics", 4thEdition,McGraw Hill Education India Private Limited, 2017.
David J Griffiths, "Introduction to Quantum Mechanics",2ndEdition, Pearson Education,2015
M A Wahab, "Solid State Physics", 3rd Edition, Narosa Publishing House Pvt. Ltd., 2015.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19PHY182	ENGINEERING PHYSICS LABORATORY - B	L-T-P-C: 0- 0-3-

Course Objective

- To gain practical knowledge by applying experimental methods to correlate with the theory.
- Apply the analytical techniques and graphical analysis to the experimental data.
- To develop intellectual communication skills and discuss the basic understanding of various experimental principles involved.

Course Outcomes

CO1: Prepare and perform individually a wide spectrum of experiments.
CO2: Present experimental data in various appropriate forms like tabulation and plots.
CO3: Analyse, interpret and summarize the experimental results.
CO4: Communicate clearly the understanding of various experimental principles, instruments/setup, and Procedure.

CO-PO Mapping

PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1		2		2									
	1		2						1				
	2		2				1						
		1								3	1		

List of Experiments:

1. To determine the Young's modulus of the given material using non-uniform bending.
2. Determination of Rigidity modulus of the given wire using torsional oscillation method.
3. To find the dispersive power of the material of the prism.
4. Determination of the wavelength of diode laser using diffraction grating and to find the mean size of Lycopodium particles
5. To find the radius of curvature of given convex lens by Newton's rings method.
6. Determination of Planck's constant and work function of the given metal using photoelectric effect.
7. To determine the efficiency and fill factor of the given solar cell and to study its characteristics.
8. Determination of band gap of a semiconductor.
9. Experiment to verify the quantum nature of the hydrogen atom by measuring the wavelengths of spectral lines in the Balmer series.

Evaluation Pattern

Assessment	Internal	End Semester
*Continuous Assessment (CA)	80	
End Semester		20

*CA – basic principles of experiment, skill, result analysis and viva

19EEE100	BASIC ELECTRICAL AND ELECTRONICS ENGINEERING	L-T-P-C: 3-0-0-3

Course Objectives

- To impart basic knowledge of electrical quantities and provide working knowledge for the analysis of DC and AC circuits.
- To understand the construction and working principle of DC and AC machines.
- To facilitate understanding of basic electronics and operational amplifier circuits.

Course Outcomes

CO 1: Understand the basic electric and magnetic circuits
CO 2: Analyse DC and AC circuits
CO 3: Interpret the construction and working of different types of electrical machines
CO 4: Analysebasic electronic components and circuits.

CO-PO Mapping

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

Syllabus

Unit 1
Introduction to Electrical Engineering, Current and Voltage sources, Resistance, Inductance and Capacitance; Ohm's law, Kirchhoff's law, Energy and Power – Series parallel combination of R, L, C components, Voltage Divider and Current Divider Rules – Super position Theorem, Network Analysis – Mesh and Node methods- Faraday's Laws of Electro-magnetic Induction, Magnetic Circuits, Self and Mutual Inductance, Generation of sinusoidal voltage, Instantaneous, Average and effective values of periodic functions, Phasor representation. Introduction to 3-phase systems, Introduction to electric grids.

Unit 2
Electrical Machines: DC Motor: Construction, principle of operation, Different types of DC motors, Voltage equation of a motor, significance of back EMF, Speed, Torque, 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, principle and mode of operation.

Unit 3
PN Junction diodes, VI Characteristics, Rectifiers: Half wave, Full wave, Bridge. Zener Diode- characteristics, Optoelectronic devices. BJT – characteristics and configurations, Transistor as a Switch. Junction Field Effect Transistors - operation and characteristics, Thyristor – Operation and characteristics. Fundamentals of DIAC and TRIAC.555 Timer, Integrated circuits.Operational Amplifiers – Inverting and Non-inverting amplifier – Instrumentation amplifiers.

Text Books

Edward Hughes. "Electrical and Electronic Technology", 10th Edition, Pearson Education Asia, 2019.
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.
Vincent Del Toro, "Electrical Engineering Fundamentals", Prentice Hall of India Private Limited, 2nd Edition, 2003.
David A. Bell, "Electronic Devices and Circuits", 5th Edition, Oxford University Press, 2008.
Michael Tooley B. A., "Electronic circuits: Fundamentals and Applications", 3rd Edition, Elsevier Limited, 2006.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19EEE181 BASIC ELECTRICAL AND ELECTRONICS ENGINEERING LABORATORY L-T-P-C: 0-0-3-1

Course Objective

- To understand the basics of electrical connections and analyse the performance of electrical machines and electronic circuits.

Course Outcomes

CO1: Construct basic electrical connections for domestic applications
CO2: Measure the various electrical parameters in the circuit
CO3: Analyse the performance of electrical machines.
CO4: Analyse basic electronic circuits.

CO-PO Mapping

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

LIST OF EXPERIMENTS:
Electrical
1. a) Wiring practices
   b) Study of Electrical protection systems.
2. Verification of circuit theorem
3. Experiment on DC machine
4. Experiment on single phase Transformer
5. Experiment on induction motor
6. VI characteristics of PN junction and Zener diode
7. Implementation of Half wave and Full wave rectifier using PN junction diode
8. Transistor as a switch
9. Experiment on Thyristor
10. Implementation of inverting and non-inverting amplifier using Op-amp

REFERENCES / MANUALS / SOFTWARE:
Lab Manuals

Evaluation Pattern

Assessment	Internal	End Semester
*Continuous Assessment (CA)	80	
End Semester		20

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE101	ENGINEERING DRAWING	L-T-P-C: 2-0-3-3

Course Objectives

- Familiarize with Bureau of Indian Standards (BIS) for creating engineering drawings
- Familiarize with the use of drawing instruments
- Train the students on proper dimensioning and construction of simple geometries
- Inculcate with the concept of developing orthographic projections and isometric views

Note:
1. Manual practice of drawing to be followed
2. First angle projection to be followed

Course Outcomes

CO1: Understand the engineering drawing standards and their usage
CO2: Interpret engineering drawings
CO3: Construct and dimension geometric entities and simple machine parts
CO4: Demonstrate coherent visualization skills
CO5: Apply the concepts of orthographic projections and isometric projection

CO-PO Mapping

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

Syllabus

Unit 1
Basic principles of engineering drawing, Standards and conventions, Drawing instruments and their uses, Lettering and types of lines.Concept of scale in drawings, Dimensioning of drawings.Construction of conic sections, involutes and cycloids.

Unit 2
Orthographic projections of points, lines, planes and solids.Sections of regular solids, Development of lateral surface of regular solids, frustum and truncations.

Unit 3
Introduction to isometric views and projections, Orthographic projections of isometric drawings. Floor plans of simple buildings.

Text Book
Basant Agarwal and C M Agarwal., "Engineering Drawing", 2e, McGraw Hill Education, 2015

References

Bhat N.D. and Panchal V.M. , " Engineering Drawing Plane and Solid Geometry , 42e, Charoatar Publishing House , 2010
James D. Bethune, "Engineering Graphics with AutoCAD", Pearson Education, 2014
K.R. Gopalakrishna, "Engineering Drawing", 2014, Subhas Publications
Narayan K.L. and Kannaiah P, Engineering Drawing, SciTech Publications, 2003
John K.C., "Engineering Graphics for Degree", 1e, Prentice Hall India, 2009

Evaluation Pattern

Assessment	Internal	End Semester
*Continuous Assessment (CA)	80	
End Semester		20

*CA – Can be Quizzes, Assignments, Projects, and Reports

19CUL101	CULTURAL EDUCATION I	L-T-P-C: 2-0-0-2

Course Objective

- 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

CO1: Be introduced to the foundational concepts of Indian culture and heritage, the cultural ethos of Amrita Vishwa Vidyapeetham, and Amma's life and vision of holistic education
CO2: To Understand the foundational concepts of Indian civilization like purusharthas, karma-siddhanta, Indian Society and Varna-ashrama-dharma which contributes towards personality growth.
CO3: To Gain a positive appreciation of symbols of Indian culture, itihasas, festivals, traditions and the spirit of living in harmony with nature
CO4: To Imbibe the principles and practices of Yoga.
CO5: Get guidelines for healthy and happy living from the great spiritual masters.

CO-PO Mapping

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

Syllabus

Unit 1
Introduction to Indian culture; Understanding the cultural ethos of Amrita Vishwa Vidyapeetham; Amma's life and vision of holistic education.

Unit 2
Goals of Life – Purusharthas; Introduction to Varnasrama Dharma; Law of Karma; Practices for Happiness.

Unit 3
Symbols of Indian Culture; Festivals of India; Living in Harmony with Nature; Relevance of Epics in Modern Era; Lessons from Ramayana; Life and Work of Great Seers of India.

Text Book
Cultural Education Resource Material Semester-1

Reference Book(s)
The Eternal Truth (A compilation of Amma's teachings on Indian Culture)
Eternal Values for a Changing Society. Swami Ranganathananda. BharatiyaVidyaBhavan.
Awaken Children (Dialogues with Mata Amritanandamayi) Volumes 1 to 9

My India, India Eternal. Swami Vivekananda. Ramakrishna Mission.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

SEMESTER II

19ENG111	TECHNICAL COMMUNICATION	L-T-P-C: 2-0-3-3

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

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

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

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:Writingformal 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

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment (Theory) (CAT)	10	
*Continuous Assessment (Lab) (CAL)	40	
End Semester		30

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MAT114	DIFFERENTIAL EQUATIONS AND TRANSFORMS	L-T-P-C: 3-1-0-4

Course objectives

The course is expected to enable the students

- To model mechanical systems using differential equations
- To analyse and solve ordinary differential equations
- 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 techniques

Course Outcomes

CO1: To model and solve homogeneous and non-homogeneous first order ordinary differential equations corresponding to different practical scenarios.
CO2: To solve homogeneous linear second order ordinary differential equations corresponding to different practical Scenarios
CO3: To solve system of order ordinary differential equations corresponding to different practical scenarios
CO4: To learn modeling the wave equation, heat equation as partial differential equations and to use Fourier series to obtain solutions to them.

CO-PO Mapping

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

Syllabus

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

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

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, solution by Fourier transforms, Laplace's equation and its solution.

Text Book

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

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Evaluation Pattern

Assessment	Weightage
Test 1	15
*Continuous Assessment (CA)	20
Test 2	15
End Semester	50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19BIO111	BIOLOGY FOR ENGINEERS - B	L-T-P-C: 2-0-0-2

Course objectives

- Inculcate the principles of cellular and molecular biology at an engineering point of view
- Familiarize with the functioning of physiological systems in human body
- Familiarize with the engineering applications in biological systems

Course Outcomes

CO1: Illustrate the basic biological concepts from an engineering perspective
CO2: Interpret the functioning of physiological systems in the human body
CO3: Understand and apply engineering principles in human physiological systems
CO4: Apply the knowledge of mechanics, instrumentation, materials and image processing in bio-engineering

CO-PO Mapping

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

Syllabus

Unit 1
Principles of Biology: Biomolecules, Cell Structure and Function, Membranes and Cell Transport, Principles of Cell Metabolism and communication, DNA Structure and Chromosomes

Unit 2
Physiological principles: Cardiovascular systems, respiratory systems and central nervous systems

Unit 3
Engineering Principles: Introduction to Biomechanics, Bioinstrumentation, Bioimaging, Biomaterials and artificial organs, Biomolecular engineering, Emerging Areas in Bioengineering

Text books
Gabi Nindl Waite, Lee R.Waite, Applied Cell and Molecular Biology for Engineers, McGraw-Hill Education, 2007.
W. Mark Saltzman, Biomedical Engineering: Bridging Medicine and Technology, Cambridge University Press,2009

Reference Books
S. A. Berger, W. Goldsmith, E. R. Lewis, Introduction to Bioengineering, Oxford University Press, 2000.
Michael Chappell, Stephen Payne, Physiology for Engineers - Applying Engineering Methods to Physiological Systems, Springer International Publishing, 2016

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19CHY101	ENGINEERING CHEMISTRY - A	L-T-P-C: 2-1-0-3

Course Objectives

- The main objective of the course is to impart knowledge on the fundamentals concepts of chemistry involved in application of several important engineering materials that are used in the industry/day-to day life

Course Outcomes

CO1: Understand the fundamental concepts of chemistry to predict the structure, properties and bonding of engineering materials
CO2: Understand the principle of electrochemistry/photochemistry and applications of various energy storage systems
CO3: Identify the correct materials, design and operation conditions to reduce the likelihood of corrosion in new Equipment and engineering operations
CO4: Understand the fundamental problems and explain operation maintenance procedures of equipment used in water treatment

CO-PO Mapping

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

Syllabus

Unit 1: Atomic Structure and Chemical Bonding
Fundamental particles of atom – their mass, charge and location – atomic number and mass number – Schrondinger equation.Significance of ψ and ψ^2 – orbital concept – quantum numbers - electronic configuration.Periodic properties.Formation of cation and anion by electronic concept of oxidation and reduction – theories on bonding-octet, Sidgwick and Powell, VSEPR and VBT-MOT.Formation of electrovalent, covalent and coordination compounds.Chemistry of weak interactions – van der Waals force and hydrogen bonding.

Unit II: Electrochemical energy system
Faradays laws, origin of potential, electrochemical series, reference electrodes, Nernst equation, introduction to batteries – classification – primary, secondary and reserve (thermal) batteries. Characteristics – cell potential, current, capacity and storage density, energy efficiency. Construction, working and application of Leclanche cell-Duracell, Li-MnO_2 cell, lead acid batteries. Ni-Cd battery, Lithium ion batteries.Fuel cell - construction and working of PEMFC.

Unit III: Photochemistry and solar energy
Electromagnetic radiation.Photochemical and thermal reactions. Laws of photochemistry, quantum yield, high and low quantum yield reactions. Jablonski diagram - photophysical and photochemical processes, photosensitization, photo-polymerization and commercial application of photochemistry.
Solar energy - introduction, utilization and conversion, photovoltaic cells – design, construction and working, panels and arrays.Advantages and disadvantages of PV cells.DSSC (elementary treatment).

Unit IV: Corrosion control and metal finishing

Introduction, causes and different types of corrosion and effects of corrosion, theories of corrosion – chemical corrosion, Pilling Bed-worth ratio, electrochemical corrosion and its mechanism, factors affecting corrosion –galvanic series. Corrosion control methods – cathodic protection, sacrificial anode, impressed current cathode. Surface coatings - galvanizing, tinning, electroplating of Ni and Cr, organic surface coatings – paints, constituents and functions. Anodising and electroplating of aluminium.

UNIT V: Water Technology

Hardness of water – types – expression of hardness – units – estimation of hardness of water by EDTA. Numerical problems – boiler troubles (scale and sludge). Treatment of boiler feed water – Internal treatment (phosphate, colloidal, sodium aluminate and calgon conditioning).External treatment – Reverse Osmosis, ion exchange process.
(Note - 36 Hours contact theory and 9 hours for tutorials – total 45 hours)

Text Books

Vairam and Ramesh "Engineering Chemistry", Wiley, 2012
Amrita Vishwa Vidyapeetham, Department of sciences, "Chemistry Fundamentals for Engineers", McGraw Hill Education, 2015

Reference Books

Jain and Jain, "Engineering Chemistry", Dhanpat Rai Publishing company, 2015
Puri, Sharma and Patania, "Principles of Physical chemistry", Vishal Publishing Co., 2017.
Atkins, "Physical Chemistry", OUP, Oxford, 2009

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19CHY181	ENGINEERING CHEMISTRY LABORATORY - A	L-T-P-C: 0-0-3-1

Course Objectives

- The objective of the laboratory sessions is to enable the learners to get hands-on experience on the principles discussed in theory sessions and to understand the applications of these concepts in engineering.

Course Outcomes

CO1: Learn and apply basic techniques used in chemistry laboratory for small/large scale water analyses/purification.
CO2: Estimate the ions/metal ions present in domestic/industry waste water.
CO3: Utilize the fundamental laboratory techniques for analyses such as titrations, separation/purification and spectroscopy.
CO4: Analyze and gain experimental skill.

CO-PO Mapping

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

List of Experiments

1. Estimation of alkalinity in given water samples
2. Adsorption of acetic acid by charcoal
3. Potentiometric titration – acid-base/redox
4. Conductometric titration
5. Estimation of hardness by ion-exchange method
6. Determination of kinematic viscosity by Redwood Viscometer
7. Anodisation of aluminium – Relation between current and thickness
8. Determination of acid value of an oil
9. Separation techniques – TLC, Column chromatography
10. Verification of B-L law by UV-spectrophotometer

Evaluation Pattern

Assessment	Internal	End Semester
*Continuous Assessment (CA)	80	
End Semester		20

*CA – Can be Quizzes, Assignments, Projects, and Reports

19CSE102	COMPUTER PROGRAMMING	L-T-P-C: 3-0-3-4

Prerequisite(s): 19CSE100 Problem Solving and Algorithmic Thinking

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

CO1: Understand the typical programming constructs: data (primitive and compound), control, modularity, recursion etc. thereby to understand a given program
CO2: Understand and analyze 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

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

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

TextBook
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, McGrawHill,; 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.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment (Theory) (CAT)	15	
*Continuous Assessment (Lab) (CAL)	30	
End Semester		35

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE182	COMPUTER AIDED DRAFTING	L-T-P-C: 0-0-3-1

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

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

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

Project: Students have to complete a project involving creating orthographic 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 SudheerGopalakrishna "Computer Aided Engineering Drawing", Subhas Publications, 2015.
AUTO-CAD manual (In-House)

Evaluation Pattern

Assessment	Internal	End Semester
*Continuous Assessment (CA)	80	
End Semester		20

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE111	ENGINEERING MECHANICS	L-T-P-C: 3-1-

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

CO1: Determine rectangular components of a force
CO2: Derive the equivalent force - couple system
CO3: Analyze 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

PO/PSO / CO	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", 11/e, 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

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE181	MANUFACTURING PRACTICE	L-T-P-C: 0-0-3-1

Course Objectives

- Introduce basic concepts pertaining to product dismantling and assembly
- Familiarize with basic pneumatic components and design & validate simple circuits
- Familiarize with sheet metal tools and operations
- Provide hands-on training on welding and soldering
- Familiarize with plumbing tools and processes
- Inculcate and apply the principles of 3D printing to build simple geometries

Course Outcomes

CO1: Interpret the functionality of various components in a product through dismantling and assembly
CO2:I dentify various pneumatic and electro-pneumatic components
CO3: Fabricate simple sheet metal objects using concepts of surface development
CO4: Perform metal joining operations using soldering and arc welding
CO5: Make simple plumbing joints for domestic applications
CO6: Build simple geometries using 3D printing tools

CO-PO Mapping

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

Syllabus

1. **Product Workshop**
   Disassemble the product of sub assembly-Measure various dimensions using measuring instruments-Free hand rough sketch of the assembly and components-Name of the components and indicate the various materials used-Study the functioning of the assembly and parts-Study the assembly and components design for compactness, processing, ease of assembly and disassembly-Assemble the product or subassembly.

2. **Pneumatic and PLC Workshop**
   Study of pneumatic elements-Study of PLC and programming.Design and simulation of simple circuits using basic pneumatic elements-Design and simulation of simple circuits using electro-pneumatics.

3. **Sheet Metal Workshop**
   Study of tools and equipment - Draw development drawing of simple objects on sheet metal (cone, cylinder, pyramid, prism, tray etc.)-Fabrication of components using small shearing and bending machines-Riveting practice.

4. **Welding, Soldering and Plumbing Workshops**
   Study of tools and equipment - Study of various welding & soldering methods-
   Arc welding practice - fitting, square butt joint and lap joint - Soldering practice. Plumbing tools – Make a piping joint to a simple piping layout (should include cutting, threading and pipe fixing)

5. **3D-Printing Workshop**
   Introduction to Additive Manufacturing process, Fused Filament Fabrication, Materials for 3D printing, Process parameters, CAD for 3D printing, G code generation, 3D printing of simple geometries, Applications of 3D printing.
   (Note: Classes will be conducted in sequence. End-Semester exam will be conducted in the last class of the semester)

REFERENCE:

Concerned Workshop Manuals

Evaluation Pattern

Assessment	Internal	End Semester
*Continuous Assessment (CA)	80	
End Semester		20

*CA – Can be Quizzes, Assignments, Projects, and Reports

19CUL111	CULTURAL EDUCATION - II	L-T-P-C: 2-0-0-2

Course Objective

- To deepen students' understanding and further their knowledge about the different aspects of Indian culture and heritage.
- To in still into students a dynamic awareness and understanding of their country's achievements and civilizing influences in various fields and at various epochs.

Course Outcome

CO1: Get an overview of Indian contribution to the world in the field of science and literature.
CO2: Understand the foundational concepts of ancient Indian education system.
CO3: Learn the important concepts of Vedas and *Yogasutra*-s and their relevance to daily life.
CO4: Familiarize themselves with the inspirational characters and anecdotes from the *Mahābhārata* and *Bhagavad-Gītā* and Indian history.
CO5: Gain an understanding of Amma's role in the empowerment of women

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						1		3				2		
CO3						3	3	3				2		
CO4						3	3	3				2		
CO5						1		1						

Syllabus

Unit 1
To the World from India; Education System in India; Insights from Mahabharata; Human Personality. India's Scientific System for Personality Refinement.

Unit 2
The Vedas: An Overview; One God, Many Forms; Bhagavad Gita – The Handbook for Human Life; Examples of Karma Yoga in Modern India.

Unit 3
Chanakya's Guidelines for Successful Life; Role of Women; Conservations with Amma.

Text Book
Cultural Education Resource Material Semester-2

Reference Book(s)
Cultural Heritage of India. R.C.Majumdar. Ramakrishna Mission Institute of Culture.
The Vedas. Swami ChandrashekharaBharati. BharatiyaVidyaBhavan.
Indian Culture and India's Future. Michel Danino. DK Publications.
The Beautiful Tree. Dharmapal. DK Publications.
India's Rebirth. Sri Aurobindo. Auroville Publications.

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.

SEMESTER III

19MAT210/ 22MAT210* PROBABILITY AND COMPLEX VARIABLES L-T-P-C: 4-0-0-4

***Revised with effect from 7th March 2022**

Course objectives:

The course is expected to enable the students to

- Understand discrete and continuous random variables and to compute important measures.
- Perform statistical tests using experimental data and arrive practical inferences.
- Compute calculus for complex variables.
- Apply complex analysis to integrals and series.

Course outcomes:

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

- CO1:Formulate and solve problems involving random variables
- CO2:Apply statistical methods for analysing experimental data and draw statistical inference
- CO3:Analyse the complex function with reference to their analyticity and perform differentiation of complex functions
- CO4:Apply Cauchy residue theorem to integrate Complex functions

CO-PO Mapping

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

Syllabus

Probability:

Probability – Probability models and axioms, conditioning, and Bayes' rule.

Discrete random variables; probability mass functions; expectations, examples, two dimensional discrete random variables: Joint PMFs and expectations.

Continuous random variables, probability density functions, expectations, examples, two dimensional continuous random variables: Joint PDFs.

Statistics:

Statistics – Bayesian statistical inference, point estimators, parameter estimators, test of hypotheses, tests of significance.

Complex Variables:

Complex numbers, complex plane, polar form of complex numbers. Powers and roots, derivative. Analytic functions, Cauchy Riemann equations Conformal mapping (definition andexamples only).

Exponential function, trigonometric functions, hyperbolic functions, logarithms.

Complex line integral, Cauchy integral theorem, Cauchy integral formula, derivatives of analytical functions. Power series, Taylor series and McLaurin series.

Laurent series, zeroes and singularities, residues, Cauchy residue theorem, evaluation of real integrals using residue theorem (simple examples)

Textbook:

1. Introduction to Probability, D. Bertsekas and J. Tsitsiklis, 2nd Edition, Athena Scientific,2008.
2. Advanced Engineering Mathematics, Erwin Kreyszig, 10th Edition, Wiley, 2011.

Evaluation Pattern

Assessment	Weightage
Periodical Test 1	15
Periodical Test 2	15
Continuous Assessment (CA)	20
End Semester	50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE201	THERMODYNAMICS	L-T-P-C: 3-1-0-4

Course Objectives

- To introduce the thermodynamic laws and their application to open and closed systems
- To familiarize the variation of thermodynamic properties of pure substances and compare the ideal and real gas behavior
- To explain the concept of entropy and isentropic efficiency
- To derive fundamental relations between thermodynamic properties

Course Outcomes

CO1: Evaluate the deviation of a real gas from ideal gas behavior based on compressibility chart and best equations of state
CO2: Solve energy balance problems for closed and open systems for pure substances, ideal gases, liquids and solids
CO3: Examine the possibility of a thermodynamic process based on first and second laws of thermodynamics and increase of entropy principle
CO4: Determine the expressions for the thermal efficiencies and coefficients of performance for reversible heat engines, heat pumps, and refrigerators by modelling thermodynamic cycles
CO5: Evaluate the performance of power plants, automobiles, refrigeration and air-conditioning units
CO6: Establish relationship between measurable and derivable properties

CO-PO Mapping

PO/PSO / CO	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								1	3		
CO3	3	3	2	2		1	1					1	3		
CO4	3	3	2	2		1	1					1	3		
CO5	3	3	2	2		1	1					1	3		
CO6	3	3	2	2								1	3		

Syllabus

Unit 1

Introduction and Basic Concepts: Importance of Dimensions and Units, definitions: system, surroundings, boundary, types of systems, properties, thermodynamic equilibrium, quasi static process, cyclic process.
Concept of Zeroth Law, thermometry, temperature scales, Pressure measurement, Manometers.
Energy and its interactions –forms of energy, Heat, Work, I law of thermodynamics
Ideal-Gas Equation of State, specific heats, characterization of thermodynamic processes. Compressibility Factor and other Equations of State.
Thermodynamic properties of Pure Substances: Phase-Change processes of pure substances, property diagrams for Phase change processes, property tables.

Unit 2

Energy analysis: closed and open systems, Steady Flow Engineering Devices.

Second Law of Thermodynamics: statement of Kelvin-Planck and Clausius, Heat Engines, Heat Pump and Refrigerators, Reversible and Irreversible processes, the Carnot Cycle and Principles, Carnot engine, Carnot Refrigerator and Heat pump. The inequality of Clausius and thermodynamic Temperature scale, concept of entropy, principle of increase in entropy for closed and open systems, Entropy change in different processes involving solids, liquids and gases.

Unit 3

Thermodynamic property relations: Introduction, important mathematical relations, cyclic rule, Maxwell relations, Clausius-Clapeyron equation, Joule Thomson coefficient and inversion line.

Gaspower cycles: Otto, Diesel, Dualand Brayton cycle.

Vapor power cycles: The Carnot vapor cycle and the Rankine cycle.

Refrigeration cycles: The reversed Carnot cycle and the ideal vapor compression Refrigeration cycle.

Text Book

Cengel Y. A. & Boles M. A.,"Thermodynamics - an Engineering Approach", 8/e, Tata McGraw hill, 2016

Reference Books

Sonntag R. E.,Borgnakke C. and Van Wylen, G., "Fundamentals of Thermodynamics", 7/e, John Wiley and Sons, 2008

Saad M. A.,"Thermodynamics: Principles and Practice",2/e, Prentice Hall, 1998

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE203	MECHANICS OF SOLIDS	L-T-P-C: 3-1-0-4

Course Objectives

The course is expected to

- 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

Course Outcomes

CO1: Apply the principles of equilibrium, superposition, and compatibility to estimate the stress-strain behavior of linear elastic solids under axial and torsional loading

CO2: Construct shear force and bending moment diagrams, to estimate the deflection and stress distribution in beams of various cross sections

CO3: Analyze stresses at inclined planes and construct Mohr's circle to predict the principal and maximum shear planes and apply the theories of failure

CO4: Determine longitudinal and circumferential stresses in thin and thick cylinders subjected to internal and external pressures

CO5: Apply Euler's and Rankine's formulae to determine the buckling load of columns under different end conditions

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2								1	3	1	1
CO2	3	3	1	0								1	3	1	1
CO3	3	3	2	1								1	3	1	1
CO4	3	3	2	1								1	3	1	1
CO5	2	3	2	1								1	3	1	1

Syllabus

Unit 1

Simple Stress and Strain: Introduction, Properties of Materials, Stress, Strain, Hook's law, Poisson's Ratio, Stress – Strain Diagram for structural steel and nonferrous materials, Principles of superposition, Total elongation of tapering bars of circular and rectangular cross sections. Elongation due to self – weight, Thermal stresses. Composite section, Volumetric strain, expression for volumetric strain, Elastic constants, relationship among elastic constants, Thermal stresses (including thermal stresses in compound bars). Strain Energy & Impact loading.

Torsion of circular shafts: Introduction – Pure torsion - torsion equation of circular shafts, Strength and stiffness, Torsional rigidity and polar modulus, Power transmitted by shaft of solid and hollow circular sections.

Unit 2

Bending moment and shear force in beams: Introduction, Types of beams loadings and supports, Shearing force in beam, Bending moment, Sign convention, Relationship between loading, shear force and bending moment, Shear force and bending moment equations, SFD and BMD with salient values for cantilever beams, simply supported beams and overhanging beams considering point loads, UDL, UVL and Couple. Bending and shear stresses in beams.

Deflection of beams: Introduction – Definitions of slope, deflection, elastic curve, deflection using Macaulay's method, Moment Area method for prismatic beams and overhanging beams subjected to point loads, UDL and Couple.

Unit 3

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

Thick and Thin Cylinders and shells: Analysis of thin cylindrical shells and analysis of thick cylindrical shells using Lame's equation.

Elastic stability of columns: Introduction – Short and long columns, Euler's theory on columns, Effective length slenderness ration, radius of gyration, buckling load, Assumptions, derivations of Euler's Buckling load for different end conditions, Limitations of Euler's theory, Rankine's formula and problems.

Text Book

Ferdinand Beer & Russell Johnston - 'Mechanics of Materials' - Tata Mc Graw Hill – 2016, 7th Edition.

Reference Books

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,

W. A. Nash, Schaum's Outline Series - 'Strength of Materials' - 2007 - 4th Edition

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE204	METALLURGY AND MATERIALS SCIENCE	L-T-P-C: 3-0-0-3

Course Objectives

- To impart knowledge on fundamental concepts of crystalline materials, structure and mechanical behaviour of materials
- To familiarize various phases and phase diagrams of metal and alloys and crystalline defects.
- To facilitate an understanding of various strengthening mechanisms, heat treatment, for specific materials and requirements
- To familiarize with the properties and applications of non-ferrous materials, light materials and advanced materials

Course Outcomes

CO1: Understand the structure and properties of various materials
CO2: Analyze the various modes of imperfections and failure in solids and methods to strengthen it.
CO3: Understand the phase diagrams of metallic materials
CO4: Comprehend the effect of mechanical properties by heat treatment processes.
CO5: Select ferrous, non-ferrous, and advanced materials for various applications.

CO/PO Mapping

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

Syllabus

Unit 1
Basic principles of crystalline materials, classification of metallic materials, Structure of Crystalline Solids - Crystal Systems - unit cells - Metallic Crystal Structures - Miller indices - Crystallographic planes and directions - Linear and Planar Atomic Densities - Imperfections in Solids: Point – Linear - Interfacial defects.
Elastic, Anelastic and Plastic behaviour. Mechanical properties - stress-strain curves for ductile and brittle alloys. Ductility – Resilience -toughness. Hardnesstesting. Dislocations and plastic deformation. Slip phenomenon. Slip in single crystals.

Unit 2
Constitution of alloys-solid solutions, intermetallic compound, Hume-Rothery rule. Phase diagram-phase rule, lever principle, isomorphous, eutectic, peritectic and eutectoid reactions. Iron-Carbon phase diagram, equilibrium and non-equilibrium cooling in solid state, isothermal transformation, martensite and bainite reactions
Strengthening mechanisms - grain boundary hardening, solution hardening, work hardening, Ductile and Brittle Fracture - fracture mechanics. Impact testing. Ductile - brittle transition. Fatigue and creep properties.

Unit 3

Heat treatment of steels: annealing, normalizing, hardening and tempering. Heat treatment of tool and die steels. Hardenability, its testing and simple problems related to materials selection. Surface hardening of steels - carburizing, nitriding, carbo-nitriding, induction method.

Classification of cast iron and steels - properties, microstructures and uses of cast irons, plain carbon, alloy, stainless, heat resistant, tool and die steels. Composition, properties, microstructures and uses of non-ferrous alloys - brass, bronze, aluminium, magnesium, nickel and zinc alloys. Introduction to light alloys, ceramicsand electronic materials. Introduction to materials design-material selection –processing concept, case study

Text Book

Callister W. D. - 'Materials Science and Engineering' - John Wiley & Sons – 2010 - 8th Edition

Reference Books

Avner S. H. - 'Physical Metallurgy' – McGraw Hill Education – 2000 - 2nd Edition

Shackelford J. F. - 'Introduction to Materials Science for Engineers' - Prentice Hall 2014 - 8th Edition

JavedHashemi, Smith F. W. - 'Foundations of Materials Science and Engineering' – McGraw Hill Education - 2010 - 5th Edition.

Dieter G. E. - 'Mechanical Metallurgy'- Tata McGraw Hill - 2013 - 3rd Edition.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19CSE282	PYTHON PROGRAMMING	L-T-P-C:0-0-3 1

Course Objective

This course provides the foundations of programming using Python programming language

Course Outcomes

CO1: Understand the given programming language constructs and solve and implement known problems using the same
CO2: Understand and apply advanced libraries in this programming language for real-time applications.

CO-PO Mapping

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

Syllabus:

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

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.

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.

Use of libraries like *gpiozero, mraa, paho-mqtt, and requests* for IoT applications and hands-on exercises.

Text Book(s)

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 (27 October 2017), Shroff/O'Reilly, ISBN-10: 9789352136414, ISBN-13: 978-9352136414

Hans Fangohr, Faculty of Engineering and the Environment, University of Southampton, *Introduction to Python for Computational Science and Engineering (A beginner's guide),* September 7, 2015. Online version available at: *https://www.southampton.ac.uk/~fangohr/training/python/pdfs/Python-for-Computational-Science-and-Engineering.pdf*

Reference(s)

Al Sweigart, Automate the Boring Stuff with Python, April 2015, ISBN-13: 978-1-59327-599-0, also available for free at https://automatetheboringstuff.com

gpiozero – A simple interface to GPIO devices with Raspberry Pi https://gpiozero.readthedocs.io

Evaluation Pattern

Assessment	Internal	End Semester
*Continuous Assessment (CA)	80	
End Semester		20

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE202	MANUFACTURING PROCESS I	L-T-P-C: 2-0-3-3

Course Objectives

- To elucidate the fundamentals of metal casting, metal forming and joining process.
- Prepare mould with proper gating and riser system.
- Understand the working of TIG / MIG welding process and prepare weld joints, perform welding operation.
- Understand the press working processes such as blanking, bending and forming operation and compute load calculation

Course Outcomes

CO1: Design and develop pattern and sand mould with gating and riser system for a given component with simple geometries / features
CO2: Prepare sheet metal layout and compute load calculations for metal forming process.
CO3: Select and perform a suitable welding process with optimum parameters.
CO4: Identify various defects in casting, welding and forming
CO5: Follow safety rules and good practices in casting, welding and metals forming operations

CO-PO Mapping

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

Syllabus

Unit 1
Casting and Moulding: Metal casting processes and equipment, shrinkage, principles of gating and riser design, Casting processes - sand, die, gravity, centrifugal, shell mould and Investment casting. Fettling and cleaning of casting. casting defects.

Unit 2
Introduction to bulk and sheet metal forming: Plastic deformation and yield criteria; fundamentals of hot and cold working processes, bulk forming processes - forging, rolling, extrusion, drawing and sheet forming processes - shearing, deep drawing, bending.

Unit 3
Metal Joining Processes: Principles of welding, brazing and soldering; Solid and liquid state joining processes - arc welding, gas welding, resistance welding, soldering, brazing and adhesive bonding. weld defects and inspection.

Lab Sessions
Metal Casting
Design pattern/core for a given component drawing and develop a sand mould with optimum gating and riser system for ferrous and non-ferrous materials.Melting and casting, inspection for macroscopic casting defects.

Welding
TIG and MIG welding processes - design weld joints – welding practice –weld quality inspection.

Metal Forming
Press working operation - hydraulic and mechanical press -load calculation: blanking, bending and drawing operations – sheet metal layout design.

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

Text Book
SeropeKalpakjian and Steven R. Schmid – 'Manufacturing Engineering and Technology' - Prentice Hall - 2013 - 7th Edition

Reference Books
Roy A. Lindberg - 'Processes and Materials for Manufacture' - Prentice Hall of India Private limited – 2000

Amitabh A. Ghosh and Asok Kumar Mallik - 'Manufacturing Science' - Affiliated East-West, Press Private Limited – 2010

Lab Manuals

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment (Theory) (CAT)	10	
*Continuous Assessment (Lab) (CAL)	40	
End Semester		30

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE281 MATERIALS TESTING AND METALLURGY LABORATORY L-T-P-C: 0-0-3-1

19MEE281 (a) Materials Testing Laboratory

Course Objectives:

- To inculcate knowledge on mechanical behaviour of engineering materials
- To equip students with the skills to determine the mechanical properties of engineering materials

Course Outcomes:

CO1: determine tensile elastic properties of mild steel and compressive strength of wood
CO2: determine the shear strength, impact properties of mild steel and compare hardness of ferrous and nonferrous materials
CO3: evaluate modulus of rigidity of materials and analyze beams subjected to lateral loading

CO-PO Mapping

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

List of Exercises

Tension test on metals - Impact tests (Charpy and Izod) - Test on springs (closed coil and open coil) – Torsion test on mild steel rods - Static bending test on wooden beams - Hardness tests (Brinell and Rockwell tests) - Tensile test on thin wires - Double shear test on mild steel rods - Compression test on wood (parallel and perpendicular to the grains) - Verification of Maxwell's theorem of reciprocal deflection

19MEE281 (b) Metallurgy Laboratory

Course Objectives

The purpose of this course is to

- Study the microstructures of metals and alloys
- Understand the type, and effect of heat treatment on properties and hardness of materials.

Course outcomes

CO1: Prepare the specimens and characterize the microstructures of different ferrous and non-ferrous metals.
CO2: Evaluate the effect of heat treatment on properties of steel.
CO3: Measure the hardness of ferrous and non-ferrous materials
CO4: Conduct hardenability studies on steel

CO-PO Mapping

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

List of Exercises

1. Study of metallurgical microscope and sample preparation.
2. Preparation and study of the micro structure of low carbon steel, mild steel, high speed steel and stainless steel.
3. Preparation and study of microstructure of cast Irons
4. Preparation and study of the microstructure of copper and its alloys
5. Preparation and study of microstructure of aluminum and its alloys
6. Study of microstructure of heat treated steels.
7. To Measure the hardness of various heat treated and untreated plain carbon steels.
8. Hardenability of steels by Jominy end quench test.
9. Introduction to Non destructive testing.

Evaluation Pattern

Assessment	Internal	End Semester
*Continuous Assessment (CA)	80	
End Semester		20

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE282	PYTHON PROGRAMMING	L-T-P-C: 0-0-3-1

Course Objectives

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

Course Outcomes

CO1: Understand the given programming language constructs and solve and implement known problems using the same.
CO2: Understand and apply advanced libraries in this programming language for real-time applications.

CO-PO Mapping

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

Syllabus

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

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.

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.

Use of libraries like *gpiozero, mraa, paho-mqtt, and requests* for IoT applications and hands-on exercises.

Text Books

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 (27 October 2017), Shroff/O'Reilly, ISBN-10: 9789352136414, ISBN-13: 978-9352136414

Hans Fangohr, Faculty of Engineering and the Environment, University of Southampton, Introduction to Python for Computational Science and Engineering (A beginner's guide),September 7, 2015. Online version available at:*https://www.southampton.ac.uk/~fangohr/training/python/pdfs/Python-for-Computational-Science-and-Engineering.pdf*

Reference Books

Al Sweigart, Automate the Boring Stuff with Python, April 2015, ISBN-13: 978-1-59327-599-0, also available for free at https://automatetheboringstuff.com
gpiozero – A simple interface to GPIO devices with Raspberry Pi https://gpiozero.readthedocs.io

Evaluation Pattern

Assessment	Internal	End Semester
*Continuous Assessment (CA)	80	
End Semester		20

*CA – Can be Quizzes, Assignments, Projects, and Report

19AVP201	AMRITA VALUES PROGRAM I	L-T-P-C: 1-0-0-1

Amrita University's Amrita Values Programme (AVP) is a new initiative to give exposure to students about richness and beauty of Indian way of life. India is a country where history, culture, art, aesthetics, cuisine and nature exhibit more diversity than nearly anywhere else in the world.

Amrita Values Programmes emphasize on making students familiar with the rich tapestry of Indian life, culture, arts, science and heritage which has historically drawn people from all over the world.

Students shall have to register for any two of the following courses, one each in the third and the fourth semesters, which may be offered by the respective school during the concerned semester.

Course Outcome

CO1: Understanding the impact of *itihasas* on Indian civilization with a special reference to the *Adiparva* of Mahabharata

CO2: Enabling students to importance offighting*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 Bhishmaparvas.

CO4: Getting the deeper understanding of the Yuddha Dharma through the subsequent Parvas viz., Drona, Karna, Shalya, SauptikaParvas.

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 SwargarohanaParvas.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
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	-	-

Courses offered under the framework of Amrita Values Programmes I and II

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.

Lessons 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.

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.

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.

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.

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.

Life and Teachings of Spiritual Masters India
Sri Rama, Sri Krishna, Sri Buddha, AdiShankaracharya, Sri Ramakrishna Paramahamsa, Swami Vivekananda, Sri RamanaMaharshi, Mata Amritanandamayi Devi.

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.

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.

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.

Course on Organic Farming and Sustainability
Organic farming is emerging as an important segment of human sustainability and healthy life. Haritamritam' is an attempt to empower the youth with basic skills in tradition of organic farming and to revive the culture of growing vegetables that one consumes, without using chemicals and pesticides. Growth of Agriculture through such positive initiatives will go a long way in nation development. In Amma'swords "it is a big step in restoring the lost harmony of nature".

Benefits of Indian Medicinal Systems
Indian medicinal systems are one of the most ancient in the world. Even today society continues to derive enormous benefits from the wealth of knowledge in Ayurveda of which is recognised as a viable and sustainable medicinal

tradition. This course will expose students to the fundamental principles and philosophy of Ayurveda and other Indian medicinal traditions.

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.

Science of Worship in India

Indian mode of worship is unique among the world civilisations. 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 realisation 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.

TEXT BOOKS/REFERENCES:

1. Rajagopalachari. C, *The Ramayana*
2. Valmiki, *The Ramayana*, Gita Press

19ENV300	ENVIRONMENTAL SCIENCE	L-T-P-C: P/F

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

CO1: Ability to understand aspects of nature and environment
CO2: Ability to analyse impact of environment on human world
CO3: Ability to comprehend pollution control and waste management

CO – PO Mapping

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

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 Book(s)

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

Reference(s)

G.T.Miller Jr., "Environmental Science", 11th Edition, Cenage Learning Pvt. Ltd., 2008.
Benny Joseph, "Environmental Studies", Tata McGraw-Hill Publishing company Limited, 2008.

Evaluation Pattern

Assessment	Internal	External
Online Test	-	100
		P/F

SEMESTER IV

19MEE211	COMPUTATIONAL METHODS IN ENGINEERING	L-T-P-C: 2-0-3-3

Course objectives

The course is expected to enable the students

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

Course outcomes

CO1: Solve linear and nonlinear algebraic equations and systems of nonlinear equations using numerical techniques
CO2: Use regression and interpolation methods for curve fitting.
CO3: Select and apply numerical schemes for differentiating and integrating complicated functions.
CO4: Apply computational schemes for solving systems of ordinary differential equations.
CO5: Solve PDEs by numerical methods

CO-PO Mapping

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

Syllabus

Introduction to programming in MATLAB, examples. Error definitions, Taylor series and error propagation.
Roots of equations – Bisection method, fixed point iteration, Newton-Raphson method, secant method, systems of nonlinear equations. Numerical linear algebra – Gauss elimination, LU decomposition, matric inversion, power method for finding eigen values, QR factorisation.
Curve Fitting – Linear regression, polynomial regression, nonlinear regression, Newton's divided difference interpolation, Lagrange interpolation.
Numerical Integration and Differentiation – Trapezoidal rules, Simpson's rules, Newton-Cotes algorithm, Gauss quadrature, high accuracy differentiation formulas, Richardson extrapolation, partial derivatives.
Differential Equations – Euler's method, improved Euler's methods, 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 Books

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

Reference Books

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

C. F Gerald and P. O Wheatley, Applied Numerical Analysis, 7th edition, Addison Wesley, 2009.

Rizwan Butt, Introduction to Numerical Analysis Using MATLAB, Jones and Bartlett Publisher, 2010.

AbdelwahabKharab, Ronald B, An Introduction to Numerical Methods: A MATLAB Approach, Third Edition, CRC Press, 2012.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment(Theory) (CAT)	10	
*Continuous Assessment(Lab) (CAL)	40	
End Semester		30

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE212	FLUID MECHANICS AND MACHINERY	L-T-P-C: 3-1-0-4

Course Objectives

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

Course Outcomes

CO1: Solve practical problems involving fluid properties and hydrostatic pressure, and predict the stability of floating bodies
CO2: Evaluate fluid kinematic properties to classify types of fluid flow using flow visualization techniques
CO3: Apply the governing equations for mass, momentum and energy based on Reynolds Transport Theorem and utilize them in practical problems
CO4: Estimate the pumping power by considering major and minor losses in flow through pipes
CO5: Apply dimensional analysis for fluid problems based on Buckingham-Pi Theorem and utilize it for model testing of fluid machineries
CO6: Analyze the performance characteristics of centrifugal pumps and hydraulic turbines

CO-PO Mapping

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

Syllabus

Unit 1

Introduction and Basic concepts of Fluid Mechanics: Definition and applications, fluid properties: density, specific volume, specific weight, specific gravity, pressure, vapor pressure and cavitation, viscosity, surface tension and capillarity, coefficient of compressibility, isothermal compressibility and coefficient of volume expansion. (8 hours)
Hydrostatics: Pressure distribution in a static fluid - Pascal's law and hydrostatic law, absolute, gauge and vacuum pressures, static pressure measurement, manometry, hydrostatic force on plane surfaces and curved surfaces, buoyancy, Archimedes principle, Stability of floating bodies, Meta centric height
Fluid: Eulerian and Lagrangian description of fluid flow - material derivative, system and control volume approach for fluid flow analysis - Reynolds Transport Theorem. Flow visualization – streamlines, streak lines, path lines, Flow kinematic properties– velocity, acceleration, linear strain rate, shear strain rate, vorticity and rationality, strain rate tensor

Unit 2

Governing Equations for flow analysis: Mass, linear momentum, angular momentum, energy and Bernoulli's equation– its applications. Flow rate measurement -Venturimeter, Orifice meter and Pitot tube. Hydraulic and energy grade lines

Flow in Pipes: Flow in pipes-laminar and turbulent flow. Boundary layer development--entry length, developing and developed flows. Average and maximum velocities, shear stress distribution, pressure drop, Major and minor energy losses in pipes. Moody's chart. Piping systems- series and parallel connections, Equivalent pipe

Dimensional Analysis and modeling: Significance, Buckingham's Pi Theorem, Similitude, types of similitude. Model and prototype testing

Unit 3

Introduction to fluid machines:

Centrifugal Pump: working principle, terminologies and classification. Velocity triangles. Pump performance parameters, performance curves. Introduction to cavitation, NPSH and specific speed

Hydraulic turbines: Classification. Impulse and reaction machines-Pelton and Francis Turbines.Velocity Triangles. Performance characteristics

Text Book

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

Reference Books

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

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE213	HEAT POWER ENGINEERING	L-T-P-C: 3-1-

Course Objectives

- To inculcate concept of second law of thermodynamics applied to engineering devices
- To familiarize the working principle of two stroke and four stroke engines and their performance, combustion analysis
- To discuss types of air compressors and their working principle
- To discuss the principles of refrigeration, air- conditioning, steam nozzle and turbines.

Course Outcomes

After completion of this course, students will be able to
CO1: Apply energy, entropy and exergy balance for a system
CO2: Evaluate the combustion properties of reacting mixtures
CO3: Compute the efficiency of gas and vapor power cycles
CO4: Analyze the performance of engineering devices such as compressor, IC engines, refrigeration and air-conditioning system
CO5: Examine the operation of a steam nozzle and work output of the steam turbine using velocity triangles

CO-PO Mapping

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

Syllabus

Unit 1
Exergy: reversible work and irreversibility, second law efficiency, Exergy change of a system, Exergy transfer by heat, work and mass, Exergy balance for closed and open systems.
Fuels and Combustion: Types of fuel and its properties, Stoichiometry, enthalpy of formation and enthalpy of combustion, adiabatic flame temperature.
Internal combustion engines: Working principles of Spark ignition engines and compression ignition engines. Combustion phenomenon in S.I & C.I. engines. Diesel knock. Octane and Cetane number, Supercharging, Testing and performance of IC engines.

Unit 2
Refrigeration systems: Refrigerants- types and desirable properties, vapor compression and vapor absorption systems.
Air conditioning systems: Psychrometry, Air-conditioning Processes, cooling load calculations.
Air compressors: Working of reciprocating compressors, effect of clearance and volumetric efficiency, adiabatic, isothermal and mechanical efficiencies, multistage compressor, intercooling and its effects.

Unit 3

Steam nozzles: Convergent and convergent-divergent nozzles, Supersaturated or metastable expansion of steam in a nozzle.

Steam turbines: Impulse and Reactions turbine, compounding principles.

Gas turbines: Gas turbine cycles, methods to improve efficiency of gas turbines

Text Books

Cengel Y. A. & Boles M. A. "Thermodynamics - an Engineering Approach", 8/e, Tata McGraw Hill, 2016

Ganesan.V. "Internal Combustion Engines", 4/e, Tata McGraw Hill, 2012

Reference Books

Sonntag R. E., Borgnakke C. & Van Wylen, G. - 'Fundamentals of Thermodynamics', John Wiley and Sons , 2004

Rajput R. K., "Thermal Engineering",9/e,Laxmi Publications (P) Ltd., New Delhi , 2013

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE214	KINEMATICS OF MACHINES	L-T-P-C: 3-0-

Course Objectives

This course is expected to enable the students to

- Familiarize with fundamental definitions and classification of mechanisms
- Perform kinematic synthesis and analysis of planar mechanisms with lower and higher pairs
- Perform kinematic analysis using software package

Course Outcomes

CO1: Classify and solve for mobility of planar mechanisms
CO2: Perform kinematic synthesis and analysis of planar mechanisms
CO3: Construct and analyze cam profiles for a specified motion of the follower
CO4: Analyze different types of gear trains
CO5: Model and analyze planar mechanisms using software package

CO-PO Mapping

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

Syllabus

Unit 1

Review of kinematics of planar rigid bodies

Definitions- link, kinematic pair, kinematic chain, mechanism and machines. Degrees of freedom - mobility – Kutzbach criterion - Grashoff's law. Kinematic inversions - four bar chain and slider crank - mechanical advantage - transmission angle.

Mechanisms - quick return mechanism- pantograph - straight line mechanisms - steering gear for automobiles- Hookes joint - Toggle Analysis of slider crank and four bar mechanisms - Graphical method for position,velocity and acceleration. Instantaneous center - velocity analysis - Kennedy's theorem.

Shaping machine mechanism - coincident points - Corioli's component of acceleration – graphical approach for quick return mechanism. Analysis of complex mechanisms

Unit 2

Loop closure method for slider crank, four bar and quick return mechanism –computer programs for analysis of mechanisms – numerical solution of loop closure equations.

Synthesis of mechanisms – dimensional and three position synthesis

Unit 3

Cams – classification of cams and followers, nomenclature, description and analysis of follower motion, pressure angle - Determine of basic dimensions and synthesis of cam profiles, graphical and analytical methods, cams with specified contours.

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 gear trains.

Lab session (ADAMS software/ MAKEIT Tool kit)

- Modelling and analysis of slider crank mechanism and its inversions
- Modelling and analysis of four bar mechanism and its inversions
- Modelling and analysis of 6 bar chains
- Modelling and analysis of crank and slotted lever and Whitworth quick return mechanism
- Modelling and analysis of Cam mechanism
- Modelling and analysis of gear drives
- Modelling and analysis of practical mechanisms (mini project)
- Demonstration of mechanism using the Tool kit

Text Books

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. AffiliatedEast-West Press Private Limited, 2002.
Rattan, Sarjit S. Theory of machines.Tata McGraw-Hill Education, 2014.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment(Theory) (CAT)	15	
*Continuous Assessment(Lab) (CAL)	30	
End Semester		35

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE215	MANUFACTURING PROCESS II	L-T-P-C: 2-0-3-3

Course Objectives

- To impart knowledge on theory of metal cutting, its mechanics, and the influence of its parameters on machining processes.
- Understand the working principles of lathe, milling and grinding and independently operate these machines by selecting optimum machining parameters.
- Measure cutting forces in turning, milling and drilling processes using cutting tool dynamometers.

Course Outcomes

CO1: Interpret the machining characteristics using theory of metal cutting
CO2: Understand the construction and mechanisms of machine tools
CO3: Select and perform machining operations with optimum machining parameters, cutting tools and accessories for a machining process.
CO4: Measure cutting forces using tool dynamometers
CO5: Follow safety rules and good practices in machining operations.

CO-PO Mapping

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

Syllabus

Unit 1
Theory of metal cutting: 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.

Cylindrical Surface Machining: Basics of turning process, lathe and its accessories, operations, process parameters. Machining time calculations. Drilling Machines: Types, operations, process parameters. Design considerations for drilling operations. Machining time calculations.
Unit 2
Flat and Profile Machining: Milling operations - Milling machines: types, operations, process parameters.

Unit 3
Finishing Processes: Theory of grinding process - Fundamentals of abrasives – Grinding wheels- Grinding operations and machines. Super finishing processes.

Lab Session
Process Planning: Selection of tooling and optimum process parameters and preparation of process plan for machining a given component.

Machining practice: Study and practice various metal cutting operations in lathe, milling, drilling and grinding machines.

Cutting force measurement: Measurement of cutting forces in turning, milling and drilling processes using tool dynamometers.

Group Project: Process planning, Tool life studies, selection of optimum machining conditions for MRR and Surface finish criterions in lathe, drilling, grinding and milling operations and perform machining operation as per the given drawing using the machines available in the workshop.

Text Book

SeropeKalpakjian and Steven R. Schmid - ''Manufacturing Engineering and Technology' - Prentice Hall - 2013 - 7th 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
Ghosh A. and Mallik A. S. - 'Manufacturing Science' - Affiliated East West Press Private Limited - 2010
'H.M.T. Production Technology: Hand book` - Tata McGraw-Hill Publishing Company Limited - 1990

Lab Manuals

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment (Theory) (CAT)	10	
*Continuous Assessment (Lab) (CAL)	40	
End Semester		30

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE283	FLUID MECHANICS AND MACHINERY LABORATORY	L-T-P-C: 0-0-3-1

Course Objectives

- To inculcate practical knowledge in characterizing fluid properties, hydrostatic force on submerged bodies, and stability of floating bodies
- To visualize flow patterns over a bank of cylinders, measurement of flow rate, pumping power of fluid flow through duct and reaction force of jet impact
- To demonstrate performance characteristics of pumps and turbines

Course Outcomes

CO1: characterize fluid properties, estimate hydrostatic force on submerged bodies and assess the stability of the floating body
CO2: evaluate stream lines, streak lines, flow rate, pumping power and reaction force using conservation laws
CO3: estimate head and pump efficiency under various operating conditions
CO4: calculate output power and turbine efficiency under various operating conditions

CO-PO Mapping

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

Syllabus

Fluid Mechanics:
Fluid properties: vapor pressure and viscosity.**Hydrostatics:** hydrostatic force on plane surfaces and curved surfaces.**Stability of floating bodies:** Meta centric height.**Fluid Kinematics:** f low visualization – streamlines and streak lines.**Flow analysis:** momentum – Impact of jet, Bernoulli's equation – Venturimeter, energy equation - losses in pipes.
Fluid machines: Pumps: centrifugal pump, submersible pump and gear pump.**Hydraulic turbines:** Pelton and Francis Turbines.

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

Evaluation Pattern

Assessment	Internal	End Semester
*Continuous Assessment (CA)	80	
End Semester		20

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE284	THERMAL SCIENCE LABORATORY	L-T-P-C: 0-0-3-1

Course Objectives

- To conduct performance and emission tests on CI and SI engines
- To demonstrate the working of blower / air compressor, refrigeration, air-conditioning systems, and mini thermal power plant

Course Outcomes

CO1: Compute the property of fuels and lubricating oils using suitable tests
CO2: Analyze the performance of internal combustion engines under various operating conditions
CO3: Analyze the performance of blower / air compressor
CO4: Measure the COP of refrigerator and air conditioning units
CO5: Understand the working of a thermal power plant

CO-PO Mapping

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

Syllabus

Determination of flash and fire point, viscosity and calorific value of fuels.Study of I.C engines, components and loading devices, Valve timing and port timing diagrams. Performance test on Petrol/LPG and Diesel/Biodiesel engines, Testing of I.C. Engines: Heat Balance test, Morse test and retardation test. Performance test on centrifugal blower.Performance test on refrigeration and air-conditioning system.Performance test on Boiler, Turbine and Condenser.Bomb calorimeter.

Evaluation Pattern

Assessment	Internal	End Semester
*Continuous Assessment (CA)	80	
End Semester		20

*CA – Can be Quizzes, Assignments, Projects, and Reports

19AVP211	AMRITA VALUES PROGRAM II	L-T-P-C: 1-0-0-1

Amrita University's Amrita Values Programme (AVP) is a new initiative to give exposure to students about richness and beauty of Indian way of life. India is a country where history, culture, art, aesthetics, cuisine and nature exhibit more diversity than nearly anywhere else in the world.

Amrita Values Programmes emphasize on making students familiar with the rich tapestry of Indian life, culture, arts, science and heritage which has historically drawn people from all over the world.

Students shall have to register for any two of the following courses, one each in the third and the fourth semesters, which may be offered by the respective school during the concerned semester.

Course Outcome

CO1: Understanding the impact of *itihasas* on Indian civilization with a special reference to the *Adiparva* of Mahabharata

CO2: Enabling students to importance offighting*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 Bhishmaparvas.

CO4: Getting the deeper understanding of the Yuddha Dharma through the subsequent Parvas viz., Drona, Karna, Shalya, SauptikaParvas.

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 SwargarohanaParvas.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
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	-	-

Courses offered under the framework of Amrita Values Programmes I and II

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.

Lessons 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.

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.

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.

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.

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.

Life and Teachings of Spiritual Masters India
Sri Rama, Sri Krishna, Sri Buddha, AdiShankaracharya, Sri Ramakrishna Paramahamsa, Swami Vivekananda, Sri RamanaMaharshi, Mata Amritanandamayi Devi.

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.

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.

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.

Course on Organic Farming and Sustainability
Organic farming is emerging as an important segment of human sustainability and healthy life. Haritamritam' is an attempt to empower the youth with basic skills in tradition of organic farming and to revive the culture of growing vegetables that one consumes, without using chemicals and pesticides. Growth of Agriculture through such positive initiatives will go a long way in nation development. In Amma'swords "it is a big step in restoring the lost harmony of nature".

Benefits of Indian Medicinal Systems
Indian medicinal systems are one of the most ancient in the world. Even today society continues to derive enormous benefits from the wealth of knowledge in Ayurveda of which is recognised as a viable and sustainable medicinal

tradition. This course will expose students to the fundamental principles and philosophy of Ayurveda and other Indian medicinal traditions.

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.

Science of Worship in India

Indian mode of worship is unique among the world civilisations. 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 realisation 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.

TEXT BOOKS/REFERENCES:

1. Rajagopalachari. C, *The Ramayana*

2. Valmiki, *The Ramayana*, Gita Press

19SSK211	SOFT SKILLS I	L-T-P-C: 1-0-

Course Outcome

CO 1 - Soft Skills: At the end of the course, the students would have developed self-confidence and positive attitude necessary to compete and challenge themselves. They would also be able to analyse and manage their emotions to face real life situations.

CO 2 - Soft Skills: Soft Skills: At the end of the course, the students would hone their presentation skills by understanding the nuances of content creation, effective delivery, use of appropriate body language and the art of overcoming nervousness to create an impact in the minds of a target audience.

CO 3 - Aptitude: At the end of the course, the student will have acquired the ability to analyze, understand and classify questions under arithmetic, algebra and logical reasoning and solve them employing the most suitable methods. They will be able to analyze, compare and arrive at conclusions for data analysis questions.

CO 4 – Verbal: At the end of the course, the students will have the ability to dissect polysyllabic words, infer the meaning, inspect, classify, contextualise and use them effectively.

CO 5 - Verbal: At the end of the course, the students will have the ability to understand the nuances of English grammar and apply them effectively.

CO 6 – Verbal: At the end of the course, the students will have the ability to identify, analyse and interpret relationship between words and use the process of elimination to arrive at the answer. They will also have the ability to judge, evaluate, summarise, criticise, present and defend their perceptions convincingly.

CO-PO Mapping:

CO/PO	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		3
CO5										3		3
CO6									3	3		3

Soft skills and its importance: Pleasure and pains of transition from an academic environment to work - environment. Need for change. Fears, stress and competition in the professional world. Importance of positive attitude, Self motivation and continuous knowledge upgradation.

Self-confidence: Characteristics of the person perceived, characteristics of the situation, characteristics of the perceiver. Attitude, values, motivation, emotion management, steps to like yourself, positive mental attitude, assertiveness.

Presentations: Preparations, outlining, hints for efficient practice, last minute tasks, means of effective presentation, language, gestures, posture, facial expressions, professional attire.

Vocabulary building: A brief introduction into the methods and practices of learning vocabulary. Learning how to face questions on antonyms, synonyms, spelling error, analogy, etc. Faulty comparison, wrong form of words and confused words like understanding the nuances of spelling changes and wrong use of words. Listening skills: The importance of listening in communication and how to listen actively.

Prepositions, articles and punctuation: A experiential method of learning the uses of articles and prepositions in sentences is provided.

Problem solving level I: Number system; LCM &HCF; Divisibility test; Surds and indices; Logarithms; Ratio, proportions and variations; Partnership;

Problem solving level II: Time speed and distance; work time problems;

Data interpretation: Numerical data tables; Line graphs; Bar charts and Pie charts; Caselet forms; Mix diagrams; Geometrical diagrams and other forms of data representation.

Logical reasoning: Family tree; Deductions; Logical connectives; Binary logic; Linear arrangements; Circular and complex arrangement; Conditionalities and grouping; Sequencing and scheduling; Selections; Networks; Codes; Cubes; Venn diagram in logical reasoning; Quant based reasoning; Flaw detection; Puzzles; Cryptogrithms.

TEXTBOOKS

A Communicative Grammar of English: Geoffrey Leech and Jan Svartvik. Longman, London.
Adair. J., (1986), "Effective Team Building: How to make a winning team", London, U.K: Pan Books.
Gulati. S., (2006) "Corporate Soft Skills", New Delhi, India: Rupa& Co.
The Hard Truth about Soft Skills, by Amazone Publication.
Quantitative Aptitude by R. S. Aggarwal,S. Chand
Quantitative Aptitude – AbijithGuha, TMH.
Quantitative Aptitude for Cat - Arun Sharma. TMH.

REFERENCES:

Books on GRE by publishers like R. S. Aggrawal, Barrons, Kaplan, The Big Book, and Nova.
More Games Teams Play, by Leslie Bendaly, McGraw Hill Ryerson.
The BBC and British Council online resources
Owl Purdue University online teaching resources
www.the grammarbook.com - online teaching resources www.englishpage.com- online teaching resources and other useful websites.

SEMESTER V

19MEE301	DESIGN OF MACHINE ELEMENTS - I	L-T-P-C: 3-0-0-3

Course Objectives

- Introduce basic concepts of design process
- Impart design principles involved in evaluating the critical design parameters of machine elements to satisfy functional and strength requirements
- Familiarize standard codes and practices to select materials and geometric parameters

Course Outcomes

CO1: Select suitable materials for various machine elements
CO2: Estimate allowable loads in machine elements using failure theories
CO3: Analyze steady and variable stresses induced in machine elements for different applications
CO4: Design shaft, keys, keyway, coupling, helical and leaf spring for specific applications
CO5: Design friction drives for specific applications

CO-PO Mapping

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

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 – Impact and shock loading – calculation of principle stresses for various load combinations, eccentric loading Factor of Safety, Factor influencing the selection of Factor of Safety, Working stress, 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, Modifying factors: Size, surface finish, Stress concentration factors, Goodman and Soderberg relationship, Stress due to combined loading

Unit 2

Design of Shaft, Coupling and Spring

Design of shaft based on strength, rigidity. Shaft subjected to combined twisting and bending moment, Shaft under fluctuating and combined loading, Design of Key and keyways

Rigid and flexible couplings

Springs: Design of springs for static and varying loads, Helical and leaf springs

Unit 3

Friction Drives

Clutches: types -single plate, multi plate, centrifugal and cone clutches.

Brakes-types, design of shoe (single and double), band, block, differential band brakes and internally expanding brakes, self energizing and self locking in brakes

Text Book

V.B. Bhandari, "Design of Machine Elements", 4e, TMH, 2016

Reference Books

Richard G.Budynas, J.KeithNisbett, " Shigley's Mechanical Engineering Design", 10e, TMH, 2015

Hall, Holowenko, Laughlin, "Machine Design", Special Indian Edition, TMH, 2008.

Robert L.Norton, "Machine Design- An integrated Approach", 5e., Pearson Education, New Delhi 2014.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE302	DYNAMICS OF MACHINES	L-T-P-C: 3-0-0-3

Course Objectives

This course is expected to enable the student to:

- Impart knowledge on dynamic analysis and balancing of mechanisms
- Familiarize with gyroscopes and flywheels
- Familiarize with mathematical modelling and analysis of mechanical vibration systems

Course Outcomes

CO1: Apply the principles of statics and dynamics to analyze mechanisms to determine joint forces and torques.
CO2: Estimate the magnitude and position of balancing masses for unbalanced rotating and reciprocating parts.
CO3: Construct turning moment diagrams for two and four stroke engines to evaluate the flywheel mass.
CO 4: Formulate the dynamic equilibrium equations of single and two degrees of freedom vibration systems and solve for the response under free and forced conditions.
CO5: Analyze the effect of gyroscopic couple on automobiles, ships, and airplanes.

CO-PO Mapping

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

Syllabus

Unit 1

Force analysis - Applied and Constraint Forces - Free body diagrams - Static Equilibrium conditions - two, three and four force members - Static force analysis

Inertia force and Inertia torque – D' Alembert's principle - principle of superposition. Dynamic Analysis in Reciprocating Engines – Gas Forces - Equivalent masses - Bearing loads - Crank shaft Torque. Turning moment diagrams - Fly wheels.

Unit 2

Balancing-Static and dynamic balancing - Balancing of rotating masses - Balancing a single cylinder Engine Balancing-Multi-cylinder Engines - Partial balancing in locomotive Engines –Balancing machines

Vibrations-single degree of freedom system- equations of motion-undamped and damped free vibration of single degree of freedom system- logarithmic decrement

Unit 3

Forced vibration of single degree of freedom system-magnification factor- rotating unbalance-support harmonic excitation- critical speed of shafts-vibration measuring instruments.Vibration of two degree of freedom system-formulation and solution of matrix eigen value problem- natural frequencies and normal modes

Gyroscope- gyroscopic couple- gyroscopic stabilization- gyroscopic effects in automobiles, airplanes and ships

Text Book

Shigley J E and Uicker J J, 'Theory of Machines and Mechanisms', Oxford University Press, 2015.

Reference Books

Rattan S S, 'Theory of Machines', Tata McGraw-Hill PublishingCompany Limited,1994.
Ghosh A and Mallick A K, 'Theory of Mechanisms and Machines',Affiliated East-West,1998
Rao SS., and FookFah Yap, 'Mechanical vibrations', Upper Saddle River:Prentice Hall 2011.
L Meirovitch, 'Elements of Vibration Analysis', McGraw-Hill, New York, 1985
Norton, R.L., 'Design of Machinery ', Tata McGraw-Hill Publishing Company Limited, 2009.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE303	HEAT TRANSFER	L-T-P-C: 3-1-0-4

Course Objectives

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

Course Outcomes

CO1: Solve steady and unsteady heat conduction problems with different boundary conditions, and assess the performance of fins
CO2: Estimate the pumping power of the fluid and convective heat transfer rate by using semi-empirical correlation associated with different types of flows and geometries
CO3: Evaluate emissive and spectral emissive power for a black and grey surface, and determine radiation heat transfer between enclosures
CO4: Solve sizing and rating problems associated with different types of heat exchanger

CO-PO Mapping

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

Syllabus

Unit 1
Introduction and Basic Concepts: Thermodynamics and Heat Transfer, heat and other forms of energy, Heat Transfer Mechanism: Conduction, Convection and Radiation –fundamental equations, Simultaneous heat transfer mechanisms

Heat conduction equation: General heat conduction equation – One dimensional steady state equation -boundary and initial conditions- Heat generation in solids- generalized thermal resistance network – critical radius of insulation, Variable thermal conductivity, thermal contact resistance
Extended surface heat transfer: Governing equation, boundary conditions, Performance of fins – efficiency and effectiveness, proper length of the fin, Types of fins: Pin fin, rectangular, Parabolic and annular fins
Unsteady heat conduction analysis: Lumped mass analysis with temporal effects – Governing equations - Biot number significance. Heat Conduction in Large Plane Walls, Long Cylinders, and Spheres with both Spatialand temporal Effects –Governing equations - Graphical Solution - Fourier number significance.

Unit 2
Convective heat transfer: Boundary layer theory – physical mechanism of convection – Governing equation, Analogy between momentum and heat transfer: Reynolds analogy and Chilton Colburn analogy.Dimensionless numbers – Nusselt number, skin friction coefficient, Stanton number, Prandtl number, Reynolds number, Grashoff Number – Significance

Forced Convection: External flows - Flow over flat plates, cylinders and spheres. Flow over tubes and bank of tubes, Internal Flows – flow through circular and non-circular
Natural convection: External surface
Combined natural and forced convection
Phase change heat transfer: Condensation and boiling

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

Text Book
Yunus A Cengel&Afshin J. Ghajar, "Heat Transfer and Mass Transfer – Fundamentals & Applications", 5/e, McGraw-Hill., 2015

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

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MAT219	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

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

PO/PSO / CO	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
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.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment (Theory) (CAT)	10	
*Continuous Assessment (Lab) (CAL)	40	
End Semester		30

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MNG300	DISASTER MANAGEMENT	L-T-P-C: P/F

Course Objectives

- To provide basic conceptual understanding of the disaster phenomenon, its different contextual aspects, impacts and public health consequences.
- To gain understand approaches of Disaster Risk Reduction (DRR) and the relationship between vulnerability, disasters, disaster prevention and risk reduction.
- To ensure skills and abilities to analyse potential effects of disasters and of the strategies and methods to deliver public health response to avert these effects.
- To enhance awareness of Disaster Risk Management institutional processes in India and to build skills to respond to disasters for sustainable development

Course Outcomes

The student will develop competencies in
CO1: Application of Disaster Concepts to Management
CO2: Ability to understand Categories of Disasters
CO3: Analyzing Relationship between Development and Disasters
CO4: Realization of the responsibilities to society

CO/PO Mapping

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

Syllabus

Unit 1
Introduction - Concepts and definitions: disaster, hazard, vulnerability, risks- severity, frequency and details, capacity, impact, prevention, mitigation. Disasters - Disasters classification; natural disasters (floods, draught, cyclones, volcanoes, earthquakes, tsunami, landslides, coastal erosion, soil erosion, forest fires etc.); manmade disasters (industrial pollution, artificial flooding in urban areas, nuclear radiation, chemical spills, transportation accidents, terrorist strikes, etc.); hazard and vulnerability profile of India, mountain and coastal areas, ecological fragility.

Unit 2
Disaster Impacts - Disaster impacts (environmental, physical, social, ecological, economic, political, etc.); health, psycho-social issues; demographic aspects (gender, age, special needs); hazard locations; global and national disaster trends; climate change and urban disasters.
Disaster Risk Reduction (DRR) - Disaster management cycle – its phases; prevention, mitigation, preparedness, relief and recovery; structural and non-structural measures; risk analysis, vulnerability and capacity assessment; early warning systems,

Unit 3
Post-disaster environmental response (water, sanitation, food safety, waste management, disease control, security, communications); Roles and responsibilities of government, community, local institutions, NGOs and other

stakeholders; Policies and legislation for disaster risk reduction, DRR programmes in India and the activities of National Disaster Management Authority.
Disaster Development - Sustainable and environmental friendly recovery; reconstruction and development methods.

Text/*Reference Books*

http://ndma.gov.in/ (Home page of National Disaster Management Authority)
http://www.ndmindia.nic.in/ (National Disaster management in India, Ministry of Home Affairs).
Pradeep Sahni, 2004, Disaster Risk Reduction in South Asia, Prentice Hall.
Singh B.K., 2008, Handbook of Disaster Management: Techniques & Guidelines, Rajat Publication.
Ghosh G.K., 2006, Disaster Management, APH Publishing Corporation
Disaster Medical Systems Guidelines. Emergency Medical Services Authority, State of California, EMSA no.214, June 2003
Inter Agency Standing Committee (IASC) (Feb. 2007). IASC Guidelines on Mental Health and Psychosocial Support in Emergency Settings. Geneva: IASC

Evaluation Pattern

Assessment	Internal
*Continuous Assessment (CA)	100

*CA – Can be Quizzes, Assignments, Projects, Presentations, and Reports

19MEE304	INSTRUMENTATION AND CONTROL SYSTEMS	L-T-P-C: 3-0-0-3

Course Objectives

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

Course Outcomes

CO1: Analyze static and dynamic characteristics of measuring instruments and identify the errors involved
CO2: Apply signal conditioning techniques and analyze the signal
CO3: Select and use various measuring instruments for a practical application
CO4: Derive the transfer function toobtain steady state response
CO5: Analyze dynamic systems for their stability and performance
CO6: Design controllers based on stability and performance requirements

CO/PO Mapping

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

Syllabus

Unit 1
Fundamentals of Measurement Systems, Instrument Types and Performance Characteristics, sources of error, classification and elimination of error, uncertainty analysis- statistical analysis of experimental data, curve fitting.

Signal conditioning, amplifiers, and filter, Wheatstone bridge, Analog to Digital and Digital to Analog Circuits.

Unit 2
Pressure Measurement: Elastic transducers, Bourdon gauge, Bellows, Diaphragm. Flow measurement: Turbine meter, hot-wire anemometer and Laser Doppler Anemometer. Level Measurement: Float gauge, Capacitive and ultrasonic level sensors.

Introduction to control systems – open and closed loop control systems – Modeling of simple mechanical and electrical systems – transfer functions – block diagrams and its reduction techniques, signal flow graphs.

Unit 3
Time response characteristics of control systems – Time response of first order systems – response to step, ramp and impulse – Time response of second order system to step input – time domain specifications and steady state error

Stability analysis of control systems- concept of poles and zeros- Routh Hurwitz criterion- simple examples- root locus technique

Frequency Response- Frequency Response specifications, Bode diagram, Polar Plot and Nyquist Plot, Stability analysis using Nyquist Stability Criterion, Relative stability, Gain and Phase Margin. Lag-Lead Compensation, Control systems analysis and design in state space

Basic control actions: Introduction to PI, PD and PID controllers, Design of a PID controller with Ziegler-Nichols rule

Text Book

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

Reference Books

John P. Bentley, "Principles of Measurement Systems", 4th Edition, Pearson Education, New Delhi, 2005
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

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19LIV390	LIVE IN LABS	L-T-P-C: 0-0-0-3

Course Objectives

- Identify and analyse the various challenge indicators present in the village by applying concepts of Human Centered Design and Participatory Rural Appraisal.
- User Need Assessment through Quantitative and Qualitative Measurements
- Designing a solution by integrating Human Centered Design concepts
- Devising proposed intervention strategies for Sustainable Social Change Management

Course Outcome

CO1: Learn ethnographic research and utilise the methodologies to enhance participatory engagement.
CO2: Prioritize challenges and derive constraints using Participatory Rural Appraisal.
CO3: Identify and formulate the research challenges in rural communities.
CO4: Design solutions using human centered approach.

CO-PO Mapping

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

Syllabus

This initiative is to provide opportunities for students to get involved in coming up with technology solutions for societal problems. The students shall visit villages or rural sites during the vacations (after 4th semester) and if they identify a worthwhile project, they shall register for a 3-credit Live-in-Lab project, in the fifth semester.
Thematic Areas

- Agriculture & Risk Management
- Education & Gender Equality
- Energy & Environment
- Livelihood & Skill Development
- Water & Sanitation
- Health & Hygiene
- Waste Management & Infrastructure

The objectives and the projected outcome of the project will be reviewed and approved by the department chairperson and a faculty assigned as the project guide.

Evaluation Pattern

Assessment	**Marks**
Internal (Continuous Evaluation) [75 marks]	
Workshop (Group Participation)	15
Village Visit Assignments & Reports	15
Problem Identification and Assessment	15
Ideation: Defining the Needs, Proposed Designs & Review	20
Poster Presentation	10
External [25 marks]	
Research Paper Submission	25
Total	**100**
Attendance (To be added separately)	5
Grand Total	**105**

19MEE381	HEAT TRANSFER LABORATORY	L-T-P-C: 0-0-3-1

Course Objectives

- To familiarize the concepts of conduction, convection and radiation heat transfer by conducting experiments
- To conduct experiments to compute the effectiveness of heat exchangers
- To demonstrate the phase change heat transfer-condensation and boiling

Course Outcomes

CO1: Determine the thermal conductivity of insulating materials
CO2: Determine the convective heat transfer coefficient in free and forced convective conditions
CO3: Estimate the rating of a heat exchanger
CO4: Estimate the emissivity of real surfaces
CO5: Compute the rate of evaporation in boiling heat transfer

CO-PO Mapping

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

Syllabus

To determine of thermal conductivity of metal rod and composite wall, heat transfer coefficient in free and forced convection, emissivity of a test plate. Verification of Stefan-Boltzmann constant. Performance test on extended surfaces. Performance test on heat exchangers-double pipe, shell-tube and single effect evaporator. Determination of heat transfer coefficient in condensation heat transfer using drop wise and film wise condensation apparatus.

Evaluation Pattern

Assessment	Internal	End Semester
*Continuous Assessment (CA)	80	
End Semester		20

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE382	INSTRUMENTATION AND CONTROL LABORATORY	L-T-P-C: 0-0-3-1

Course Objectives

This course is expected to:

- Impart the principles of measurement using various sensors and transducers
- Familiarize with the static characteristics of measuring instruments
- Familiarize with the frequency and time domain analyses to determine stability

Course Outcomes

CO1: Select suitable sensors and transducers to measure response parameters
CO2: Determine the static performance of measuring instruments
CO3: Analyze the time and frequency response of the control systems
CO4: Compare the performances of various control strategies

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

a) Instrumentation Lab

1. Linear and Angular displacement measurement using inductive (LVDT) and resistive (Potentiometer) transducer with DAQ system.
2. Determination of modulus of elasticity, measurement of Force and Torque using Load cell
3. Rotational Speed measurement using Photo electric, Capacitive, Inductive, stroboscope and optical encoder
4. Temperature Measurement using RTD, TC sensors, thermistor, thermocouple, bimetallic thermometer and monitoring DAQ system.
5. Calibration of Pressure Gauge using dead weight tester.
6. Study of stress concentration using photo-elasticity for simple machine components. (Plate with hole under tension or bending, circular disk with circular hole under compression).
7. Measurement of vibration in motor assembly using accelerometer and find the frequency components (using LabVIEW)

b) Control Lab

1. Time domain and frequency domain Response plots of systems for test signals (using Matlab Program, Time domain specifications, Bode plot)
2. PID control of level and flow control systems.
3. Determine System Stability using Root Locus plot (using Matlab Program)

Evaluation Pattern

Assessment	Internal	End Semester
*Continuous Assessment (CA)	80	
End Semester		20

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE305	MACHINE DRAWING	L-T-P-C: 2-0-3-3

Course Objectives:

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

Course Outcomes:

CO1: Follow the standards to create machine drawings.
CO2: Apply limits and tolerances to assemblies and choose appropriate fit.
CO3: Develop solid models of machine components and assembly, and Construct sectional and orthographic views of components.
CO4: Make use of CAD packages for solid modeling of machine parts and Create bill of materials.

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		1	1		1
CO2	2				1				1	3		1	1		
CO3	1		1		3				1	2		1	1		2
CO4	1				2				1	2		1	1		2

Syllabus

Unit1
Fundamentals of Machine Drawing: Standardization,Inter-changeability, Selective Assembly,Limits, Fits, Tolerance, Tolerance of form and position,Grades of tolerance, Standard tolerances
Machining symbols, Welding symbols, Surface finish indication, Functional and manufacturing datum, Riveted and butt Joints,Fasteners and keys

Unit 2
Drawing of Machine Elements (Manual & Using Application Packages):
Application package Introduction: Drawing, Editing, Dimensioning, Assembly, basic principles of GD&T (geometric dimensioning & tolerance)
Shaft joints:Cotter joint and Knuckle joint. Shaft coupling: Muff, Flanged, Flexible, Universal and Oldham's coupling. Shaft bearing: Solid and bush bearing, Plummer block, Footstep bearing. Pipe joint: Flanged joint, Socket and Spigot joint, Hydraulic joint, Union joint, Gland & Stuffing Boxand Expansion joint.
Pulley: Belt pulley, V belt pulley, Fast and loose pulley, Speed cone pulley and built up pulley

Unit 3
Assembly Drawings (Manual & Using Application Packages): Valves: Stop valve, relief valve, safety valve and non- return valve
Machine tool components: Drill Jig, Tail Stock, Tool post, machine vice and screw jack.Engine: Piston and connecting rod. Preparation of bill of materials and tolerance data
Project: Students will be assigned to take up an assembly and create three dimensional and part drawings by following standard drawing practices

Text Book
Gopalakrishna K. R., "Machine Drawing", 16th Edition, Subhas publishing House, 2002

Reference Books

Narayana K.L., "Machine Drawing", 4th Edition, New Age International publishers, 2010
Gill P.S. "A Textbook of Machine Drawing", 18th Edition, S. K. Kataria& Sons, 2013
Bhat N.D., and Panchal, V.M., "Machine Drawing" 48th Edition, Charotar Publication House, 2013

Evaluation Pattern

Assessment	Internal	End Semester
*Continuous Assessment (CA)	80	
End Semester		20

*CA – Can be Quizzes, Assignments, Projects, and Reports

19SSK301	SOFT SKILLS II	L-T-P-C: 1-0-3-2

Course Outcomes

CO # 1 - Soft Skills: At the end of the course, the students will have the ability to communicate convincingly and negotiate diplomatically while working in a team to arrive at a win-win situation. They would further develop their inter-personal and leadership skills.

CO # 2 - Soft Skills: At the end of the course, the students shall learn to examine the context of a Group Discussion topic and develop new perspectives and ideas through brainstorming and arrive at a consensus.

CO # 3 - Aptitude: At the end of the course, students will be able to identify, recall and arrive at appropriate strategies to solve questions on geometry. They will be able to investigate, interpret and select suitable methods to solve questions on arithmetic, probability and combinatorics.

CO # 4 – Verbal: At the end of the course, the students will have the ability to relate, choose, conclude and determine the usage of right vocabulary.

CO # 5 - Verbal: At the end of the course, the students will have the ability to utilise prior knowledge of grammar to recognise structural instabilities and modify them.

CO # 6 – Verbal At the end of the course, the students will have the ability to comprehend, interpret, deduce and logically categorise words, phrases and sentences. They will also have the ability to theorise, discuss, elaborate, criticise and defend their ideas.

Syllabus

Professional grooming and practices: Basics of corporate culture, key pillars of business etiquette. Basics of etiquette: Etiquette – socially acceptable ways of behaviour, personal hygiene, professional attire, cultural adaptability. Introductions and greetings: Rules of the handshake, earning respect, business manners. Telephone etiquette: activities during the conversation, conclude the call, to take a message. Body Language: Components, undesirable body language, desirable body language. Adapting to corporate life: Dealing with people.

Group discussions: Advantages of group discussions, structured GD – roles, negative roles to be avoided, personality traits to do well in a GD, initiation techniques, how to perform in a group discussion, summarization techniques.

Listening comprehension advanced: Exercise on improving listening skills, grammar basics: Topics like clauses, punctuation, capitalization, number agreement, pronouns, tenses etc.

Reading comprehension advanced: A course on how to approach middle level reading comprehension passages.

Problem solving level III: Money related problems; Mixtures; Symbol based problems; Clocks and calendars; Simple, linear, quadratic and polynomial equations; special equations; Inequalities; Functions and graphs; Sequence and series; Set theory; Permutations and combinations; Probability; Statistics.

Data sufficiency: Concepts and problem solving.

Non-verbal reasoning and simple engineering aptitude: Mirror image; Water image; Paper folding; Paper cutting; Grouping of figures; Figure formation and analysis; Completion of incomplete pattern; Figure matrix; Miscellaneous.

Spacial aptitude: Cloth, leather, 2D and 3D objects, coin, match sticks, stubs, chalk, chess board, land and geodesic problems etc., related problems.

TEXTBOOK(S)

A Communicative Grammar of English: Geoffrey Leech and Jan Svartvik. Longman, London.
Adair. J., (1986), "Effective Team Building: How to make a winning team", London, U.K: Pan Books.
Gulati. S., (2006) "Corporate Soft Skills", New Delhi, India: Rupa& Co.
The Hard Truth about Soft Skills, by Amazone Publication.
Quick Maths – Tyra.
Quicker Arithmetic – Ashish Aggarwal

Test of reasoning for competitive examinations by Thorpe.E. TMH
Non-verbal reasoning by R. S. Aggarwal, S. Chand

REFERENCE(S)

Books on GRE by publishers like R. S. Aggrawal, Barrons, Kaplan, The Big Book, and Nova
More Games Teams Play, by Leslie Bendaly, McGraw Hill Ryerson.
The BBC and British Council online resources
Owl Purdue University online teaching resources
www.the grammarbook.com - online teaching resources www.englishpage.com- online teaching resources and other useful websites.

SEMESTER VI

19MEE314 INTRODUCTION TO FINITE ELEMENT METHOD L-T-P-C: 3-0-3-4

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

CO1: Understand the fundamental concepts of finite element method 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 structural, thermal, and dynamic problems using the developed finite element formulations
CO4: Demonstrate the ability to create models for structural, thermal, and fluid flow applications using commercial finite element packages
CO5: Interpret the analysis results to improve product and system design

CO-PO Mapping

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

Syllabus

Unit 1

Basic Concepts, applicability and applications, basic equations of solid mechanics, boundary and initial conditions, Euler Lagrange equation, Generalization of finite element concepts.
Discretization, Interpolation models, weighted residual and variational approaches, Principle of minimum potential energy, principle of virtual work.

Unit 2

Element types– Line element (bar, truss, beam and frame element), Plane elements- Triangular, rectangular, quadrilateral, sector, Solid elements – tetrahedron and hexahedron.
Curved andiso-parametric elements, coordinate systems and numerical integration, Mesh generation.

Unit 3

Structural applications -line elements, two-dimensional stress analysis (Plane stress, plane strain and axisymmetric analysis),three dimensional stress analyses.
Application to field Problems - heat transfer, dynamics and fluid flow problems.

Laboratory Sessions: Introduction to Finite Element packages and its application to solid mechanics, fluid and heat transfer problems.

Text 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
Moaveni, Saeed. "Finite element analysis theory and application with ANSYS", 3/e. Pearson Education India, 2011.

References Books

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
Cook, R.D., Malkus, D.S., and Plesha, M.E., "Concepts and Application of Finite Element Analysis", 4/e, John Wiley & Sons, 2007
Reddy J.N, "An Introduction to Finite Element Method", McGraw-Hill International Education, 3/e., 2005

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment(Theory) (CAT)	15	
*Continuous Assessment(Lab) (CAL)	30	
End Semester		35

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE313	DESIGN OF MACHINE ELEMENTS - II	L-T-P-C: 2-1-0-3

Course Objectives

- Impart knowledge in fundamental concepts and apply engineering principles for the design of machine elements in mechanical systems.
- Introduce standards and codes for design of machine elements
- Inculcate design principles for designing power transmission system

Course Outcomes

CO1: Select the type of bearing and Estimate the size based on load carrying capacity in rotating machines
CO2: Select and Design suitable power transmission systems for specific applications
CO3: Design multi stage gear boxes for machine tool applications
CO4: Validate the design of machine elements using numerical analysis

CO-PO Mapping

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

Syllabus

Unit 1
Bearings: Theories of lubrication, types of lubrication: thin and thick film, boundary lubrication, Hydrodynamic and hydrostatic lubrication, Types of bearings, bearing materials, Stribeck curve, Design of hydrodynamic bearings, bearing characteristics number, Petroff's equation, Sommerfeld number, Mckee's equation.
Rolling element bearings: types, static and dynamic load carrying capacity, reliability, selection of rolling element bearings for constant and varying loads.

Unit 2
Flexible Transmission System
Belt drives: Types and configuration of belt drive, slip, initial tension, centrifugal tension, selection of flat belt drive, Selection of V-belt drives, problems-based on basic equations and manufacturer's catalogue, Selection of pulley.

Chain drives: Types of chain, factor of safety, selection of chain drives.
Gears: Gear nomenclature, Spur gears: Stresses induced in gears, gear tooth failure, Lewis bending equations, Calculation of appropriate safety factors and power rating, force analysis, Design of spur gears, helical, bevel and worm gears

Unit 3
Gear Box
Types of gear box, standard speed ratio, speed diagram, kinematic arrangement of gear box, design of multi stage, multi speed gear boxes.

Unit 4

Mechanical System Design

Case studies for the design of mechanical systems involving identification of mechanical system, material selection, detailed design and validation using numerical analysis.

Project Component:

At the end of the courses, student should complete a design project based on knowledge gained in the design and drawing related courses. The students should design a mechanical system and prepare a report and present the details of the project. The design project has 40% weightage. The evaluation components include periodic review, project report and presentation.

Text Book

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

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.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment (CA, Theory)	10	
Project component	40	
End Semester		30

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE312	AUTOMATION AND IoT	L-T-P-C: 3-0-3-4

Course Objectives

- To provide the student with basic skills useful in identifying the concepts of automation using hydraulics, pneumatic and PLC.
- To impart knowledge on robot kinematics and programming for a given application.
- To provide an introduction to Industry 4.0 its applications in industry.

Course Outcomes

CO1: design pneumatic and hydraulic circuits
CO2: program PLC for a given application
CO3: choose appropriate materials handling devices and perform robot programming for a given application
CO4: solve direct and inverse kinematics and choose appropriate Robot for given application
CO5: apply IOT to different applications

CO-PO Mapping

PO/PSO / CO	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	1		1							1	1		
CO3	3	1			1							1	1		
CO4	3	2			1							1	1		
CO5	3	1	1		1							1	1		

Syllabus

Unit 1
Introduction to Automation - Automated manufacturing systems. Sensors and Actuators in Automation - Digital and analog sensors; Fluid power actuators; Control valves; Electrical system elements; Motors drives; Mechanical devices. Pneumatic and Hydraulic Systems - Pneumatic fundamentals - control elements, position and pressure sensing - logic circuits - switching circuits - sequential circuits - cascade method. Control Using PLCs - Relay logic; Combinational and sequential control, Sequential flow chart**,** Minimization of logic equations; Ladder logic diagrams; Programmable logic controllers (PLCs); PLC components; Programming; I/O addresses; Timer and counters; A/D conversion and sampling; PLC applications. Introduction to SCADA

Experiments: Logical Circuits - Pneumatic and Electro-Pneumatic Circuits, Study of PLC and PLC based Electro-Pneumatic Sequencing Circuits.

Unit 2
Detroit Automation, Material Handling –Mechanization devices and material handling systems; Mechanization of parts handling; Parts feeding; Parts sensing; Automated Guided Vehicle.
Industrial Robotics -Robot anatomy - Work volume - Drive systems - Sensors in robotics - Robot reference frames and coordinates and robot kinematics. End effectors: Mechanical and other types of grippers - Tools as end effectors - Robot end effectors interface. Robot kinematics. Typical applications of robots: material transfer, machine loading/unloading; processing operations; assembly and inspection.

Experiments: Visual Inspection of Objects by Computer Vision Technology.
Robot Programming using Teach Pendent and Offline Programming to Perform Pick and Place, Stacking of Objects.

Unit 3

Industry 4.0 &IoT: Introduction. Digitization, Drivers of Industry 4.0, End-to-end digital integration within a smart factory, IOT Swarm Sensors, RF and wireless sensors module, power management module; Challenges. **Internet of Things (IoT):** Introduction, Physical system, Cyber-Physical Systems, IoT Architectures. **Applications:** Smart cities & smart homes, connected vehicles, Healthcare, Machine condition monitoring, Process monitoring and control.

Experiments : Implementation of IoT for temperature dependent cooling system, engine management system, machine condition monitoring and health care monitoring.

Text Books

Robert J. Schilling, "Fundamentals of Robotics, Analysis & Control", Prentice Hall, 2009.
Antony Espossito, "Fluid power with Applications ", Pearson, Sixth Edition., 2003.
Raj, Pethuru, and Anupama C. Raman.The Internet of things: Enabling technologies, platforms, and use cases. Auerbach Publications, 2017.

Reference Books

Mikell P. Groover, "Automation, Production Systems and Computer Integrated Manufacturing", Third Edition, Pearson Education, 2009.
Nanua Singh, Tatla Dar Singh., "Systems Approach to Computer-Integrated Design and Manufacturing", John Wiley & Sons, 1995.
Bahga, Arshdeep, and Vijay Madisetti.Internet of Things: A hands-on approach. Vpt, 2014.
Buyya, Rajkumar, and Amir VahidDastjerdi, eds. Internet of Things: Principles and paradigms. Elsevier, 2016.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment(Theory) (CAT)	15	
*Continuous Assessment(Lab) (CAL)	30	
End Semester		35

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE384	METROLOGY LABORATORY	L-T-P-C: 0-0-3-1

Course Objectives

- To expose the students in the measurement of linear, angular, surface roughness, threads and gears
- To calibrate the various instruments and measure the features of the components
- To measure bore, taper, angle and intricate profiles

Course Outcomes

CO1: Calibrate the basic instruments and analyze the measurements using process control charts
CO2: Measure surface roughness, tool nomenclature, threads and gear tooth thickness using appropriate instruments
CO3: Measure bore, taper, angle and intricate profiles using appropriate instruments
CO4: Measure various features of machined components using appropriate instruments

CO-PO Mapping

PO/PSO / CO	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			
CO3	1				1					1		1			
CO4	1				1					1		1			

List of Experiments

Calibration of Instruments: Micrometer, Vernier Caliper, Dial Indicator using precision Gauge blocks.
Statistical Quality Control chart: Plotting of $\bar{x}$ and R chart for a given sample after measuring the dimensions of the specific features.
Comparative measurements: calibration of Plug gauge using Electronic Comparator. Measurement using Pneumatic Comparator. Angle measurements using Sine bar with reference to the Gauge block.
Optical Projector measurements: Linear, angle and radius measurements using Profile Projector and Tool Maker's Microscope. Measurement of Straightness and flatness using Autocollimator.
Gear Metrology: Measurement of chordal tooth thickness of spur gear using gear tooth Vernier.Gear nomenclature measurements using Gear Rolling Tester.
Hole and shaft diameter measurements: Cylinder liner Inner diameter and taper measurement using Bore Gauge. Measurement of Run out of a shaft using Bench center and dial gauge.
Screw thread metrology: Measurement of Major, Minor and Mean Effective Diameter of various threads using Floating Carriage Micrometer.
Surface Roughness Measurement: Demonstration of Surface Roughness measurement using Mechanical stylus instrument.
Measurement of form features using Optical autocollimater.
Measurement of machined components using coordinate measuring machine (CMM)

Evaluation Pattern

Assessment	Internal	End Semester
*Continuous Assessment (CA)	80	
End Semester		20

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE383	MACHINE DYNAMICS LABORATORY	L-T-P-C: 0-0-3-1

Course Objectives:

This course is expected to:

- Demonstrate experiments on single and two degrees of freedom translational and rotational vibration systems
- Familiarize students with measurement of moment of inertia and center of gravity of complex objects
- Provide an exposure to governors and gyroscope
- Demonstrate balancing of rotating and reciprocating masses

Course Outcomes

CO1: Interpret the concepts of natural frequency, damping, critical speeds in translational and rotating vibrational systems
CO2: Determine moment of inertia and center of gravity of complex objects
CO3: Construct the characteristic plots for different types of governors
CO4: Evaluate the working of a gyroscope and measure the gyroscopic couple
CO5: Analyze and implement the balancing of rotating and reciprocating masses

CO-PO Mapping

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

List of Experiments

Free vibration of undamped and damped systems – critical speed of shafts – balancing in single plane and different planes for rotating masses – balancing of reciprocating masses– gyroscope – study of governors – Bifilar, trifilar and compound pendulums – forced vibrations.

Evaluation Pattern

Assessment	Internal	End Semester
*Continuous Assessment (CA)	80	
End Semester		20

*CA – Can be Quizzes, Assignments, Projects, and Reports

19LIV490	LIVE IN LABS II	L-T-P-C: 0-0-0-3

Course Objectives

- Proposal writing in order to bring in a detailed project planning, enlist the materials required and propose budget requirement.
- Use the concept of CoDesign to ensure User Participation in the Design Process in order to rightly capture user needs/requirements.
- Building and testing a prototype to ensure that the final design implementation is satisfies the user needs, feasible, affordable, sustainable and efficient.
- Real time project implementation in the village followed by awareness generation and skill training of the users (villagers)

Course Outcome

CO1: Learn co-design methodologies and engage participatorily to finalise a solution
CO2: Understand sustainable social change models and identify change agents in a community.
CO3: Learn Project Management to effectively manage the resources
CO4: Lab scale implementation and validation
CO5. Prototype implementation of the solution

CO-PO Mapping

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

Syllabus

The students shall visit villages or rural sites during the vacations (after 6th semester) and if they identify a worthwhile project, they shall register for a 3-credit Live-in-Lab project, in the fifth semester.
Thematic Areas

- Agriculture & Risk Management
- Education & Gender Equality
- Energy & Environment
- Livelihood & Skill Development
- Water & Sanitation
- Health & Hygiene
- Waste Management & Infrastructure

Evaluation Pattern

Assessment	Marks
Internal (Continuous Evaluation) [63 marks]	
1. Proposed Implementation	**2**
Presentation Round 1	
2. Proposal Submission + Review	**6**
3. Co-design	**6**
i. Village Visit I (Co-Design Field Work Assignments)	4
ii. Presentation of Co-design Assessment	2
4. Prototype Design	**14**
i. Prototype Design	4
ii. Prototype Submission	8
iii. Sustenance Plan	2
5. Implementation	**35**
i. Implementation Plan Review	3
ii. Implementation	24
iii. Testing & Evaluation	4
iv. Sustenance Model Implementation	4
External [37 marks]	
6. Research Paper	**18**
7. Final Report	**15**
8. Poster Presentation	**4**
Total	**100**
Attendance	5
Grand Total	**10**

19MEE311	DESIGN THINKING	L-T-P-C: 1-0-3-2

Course Objectives

- Inculcate the fundamental concepts of design thinking
- Develop the students as a good designer by imparting creativity and problem solving ability
- Conceive, conceptualize, design and demonstrate innovative ideas using prototypes

Course Outcomes

CO1: Demonstrate the 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

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

Syllabus

Unit 1
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

Unit 2
Design team-Team formation, Conceptualization: Visual thinking, Drawing/sketching, New concept thinking, Patents and Intellectual Property, Concept Generation Methodologies, Concept Selection, Concept Testing, Opportunity identification
Prototyping: Principles of prototyping, Prototyping technologies, Prototype using simple things, Wooden model, Clay model, 3D printing; Experimenting/testing.

Unit 3
Sustainable product design, Ergonomics, Semantics, Entrepreneurship/business ideas,
Product Data Specification, Establishing target specifications, Setting the final specifications. Design projects for teams.

Text Books
Tim Brown, Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation, HarperCollins Publishers Ltd.
IdrisMootee, Design Thinking for Strategic Innovation,2013, John Wiley & Sons Inc

Reference Books

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,
BjarkiHallgrimsson, Prototyping and model making for product design, 2012, Laurence King Publishing Ltd
Kevin Henry, Drawing for Product designers, 2012, Laurence King Publishing Ltd

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment (Theory) (CAT)	10	
*Continuous Assessment(Lab) (CAL)	40	
End Semester		30

*CA – Can be Quizzes, Assignments, Projects, and Reports

19SSK311	SOFT SKILLS III	L-T-P-C: 1-0-3-2

Course Outcomes:

CO # 1 - Soft Skills: At the end of the course, the students will have the ability to prepare a suitable resume (including video resume). They would also have acquired the necessary skills, abilities and knowledge to present themselves confidently. They would be sure-footed in introducing themselves and facing interviews.

CO # 2 - Soft Skills: At the end of the course, the students will have the ability to analyse every question asked by the interviewer, compose correct responses and respond in the right manner to justify and convince the interviewer of one's right candidature through displaying etiquette, positive attitude and courteous communication.

CO # 3 - Aptitude: At the end of the course, students will be able to interpret, critically analyze and solve logical reasoning questions. They will have acquired the skills to manage time while applying methods to solve questions on arithmetic, algebra, logical reasoning, and statistics and data analysis and arrive at appropriate conclusions.

CO # 4 – Verbal: At the end of the course, the students will have the ability to understand and use words, idioms and phrases, interpret the meaning of standard expressions and compose sentences using the same.

CO # 5 - Verbal: At the end of the course, the students will have the ability to decide, conclude, identify and choose the right grammatical construction.

CO # 6 – Verbal: At the end of the course, the students will have the ability to examine, interpret and investigate arguments, use inductive and deductive reasoning to support, defend, prove or disprove them. They will also have the ability to create, generate and relate facts / ideas / opinions and share / express the same convincingly to the audience / recipient using their communication skills in English.

Team work: Value of team work in organisations, definition of a team, why team, elements of leadership, disadvantages of a team, stages of team formation. Group development activities: Orientation, internal problem solving, growth and productivity, evaluation and control. Effective team building: Basics of team building, teamwork parameters, roles, empowerment, communication, effective team working, team effectiveness criteria, common characteristics of effective teams, factors affecting team effectiveness, personal characteristics of members, team structure, team process, team outcomes.

Facing an interview: Foundation in core subject, industry orientation / knowledge about the company, professional personality, communication skills, activities before interview, upon entering interview room, during the interview and at the end. Mock interviews.

Advanced grammar: Topics like parallel construction, dangling modifiers, active and passive voices, etc.

Syllogisms, critical reasoning: A course on verbal reasoning. Listening comprehension advanced: An exercise on improving listening skills.

Reading comprehension advanced: A course on how to approach advanced level of reading, comprehension passages. Exercises on competitive exam questions.

Problem solving level IV: Geometry; Trigonometry; Heights and distances; Co-ordinate geometry; Mensuration.

Specific training: Solving campus recruitment papers, national level and state level competitive examination papers;

Speed mathematics; Tackling aptitude problems asked in interview; Techniques to remember (In mathematics). Lateral thinking problems. Quick checking of answers techniques; Techniques on elimination of options, estimating and predicting correct answer; Time management in aptitude tests; Test taking strategies.

TEXTBOOK(S)

A Communicative Grammar of English: Geoffrey Leech and Jan Svartvik. Longman, London.
Adair. J., (1986), "Effective Team Building: How to make a winning team", London, U.K: Pan Books.
Gulati. S., (2006) "Corporate Soft Skills", New Delhi, India: Rupa& Co.
The Hard Truth about Soft Skills, by Amazone Publication.
Data Interpretation by R. S. Aggarwal, S. Chand
Logical Reasoning and Data Interpretation – Niskit K Sinkha
Puzzles – Shakuntala Devi
Puzzles – George J. Summers.

REFERENCE(S)

Books on GRE by publishers like R. S. Aggrawal, Barrons, Kaplan, The Big Book, and Nova.
More Games Teams Play, by Leslie Bendaly, McGraw-Hill Ryerson.
The BBC and British Council online resources
Owl Purdue University online teaching resources

www.the grammarbook.com - online teaching resources www.englishpage.com- online teaching resources and other useful websites

SEMESTER VII

19MEE401	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

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

PO/PSO / CO	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

Barnes, R, "Motion and Time Study" - Design and Measurement of Work . NY: John Wiley and Sons, 8th Edition, 1985.

"Introduction to Work Study", 4ed, International Labor Office, Geneva, 2006.

Reference Books

Martand T. Telsang, 'Industrial Engineering and Production Management' S Chand; 2nd Rev Edn 2006.

Mahajan M., "Industrial Engineering and Production Management" Dhanpat rai and Sons Publishers, 2005.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continues Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE402	RESEARCH METHODOLOGY	L-T-P-C: P/F

Course Objectives

The objective of the course is to make the student:

- 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

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

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

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

Evaluation Pattern

Assessment	Internal
*Continuous Assessment (CA)	100

*CA – Can be Quizzes, Assignments, Projects, Presentations, and Reports

19MEE481	CNC AND SYSTEM SIMULATION LABORATORY	L-T-P-C: 0-0-3-1

19MEE481 (a) CNC Laboratory

Course Objectives

The course will expose the students to

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

Course Outcomes

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

PO/PSO / CO	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	

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

19MEE481 (b) Simulation of Manufacturing Systems

Course Objectives

The course will expose the students

- 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

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

PO/PSO / CO	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.

Evaluation Pattern

Assessment	Internal	End Semester
*Continuous Assessment (CA)	80	
End Semester		20

*CA – Can be Quizzes, Assignments, Projects, and Reports

19LAW300	INDIAN CONSTITUTION	L-T-P-C: P/F

Course Objective

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

Course Outcomes

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

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
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 Book(s)
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.

Reference(s)
Sharma, Brij Kishore, "Introduction to the Constitution of India", Prentice Hall of India, New Delhi.

Evaluation Pattern

Assessment	Internal	External
Online Test	-	100
		P/F

PROFESSIONAL ELECTIVES

DESIGN STREAM

19MEE331 MACHINE LEARNING BASED CONDITION MONITORING L-T-P-C: 3-0-0-3

Course Objectives

This course is expected to enable the student to:

- Familiarize with the concept of condition-based maintenance for effective utilization of machines
- Impart knowledge of artificial intelligence for machinery fault diagnosis

Course Outcomes

CO1: Select the proper maintenance strategies and condition monitoring techniques for identification of failure in a machine.
CO2: Acquire and Process sound and vibration signals in a dynamic mechanical system
CO3: Predict the faulty component in a machine by analyzing the acquired vibration signals
CO4: Build a classifier model for machine learning based fault diagnosis of rotating machines

CO/PO Mapping

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

Syllabus

Unit 1
Basic Concepts: Machinery failures, basic maintenance strategies, factors influencing maintenance strategies, machine condition monitoring, transducer selection and location, PC interfacing and virtual instrumentation. Vibration signatures of faults in rotating machines; detection and diagnosis of faults.

Unit 2
Instrumentation and Signal Processing: Types of sensors in condition monitoring: vibration, sound, acoustic emission, temperature, ultrasonic and infra-red sensors - Signal processing: basic signal and systems concepts, time domain analysis, frequency domain analysis, time-frequency analysis and wavelets.

Unit 3
Machine Learning: Feature extraction and feature selection methods, feature reduction using PCA - discriminate functions and decision boundaries, decision trees, maximum likelihood and nearest neighbor classification - Bayesian theory, neural networks and support vector machines in classification
Application and case studies of condition monitoring: Bearings, gear boxes, centrifugal pumps, turbines and tool wear monitoring.

Text Books

Clarence W.de Silva "Vibration Monitoring, Testing and Instrumentation (Mechanical and Aeropace Engineering Series)", CRC Press, Taylor & Francis, 2007.

A. R. Mohanty, "Machinery Condition Monitoring: Principles and Practices" , CRC Press, Taylor & Francis, 2015

Reference Books

Collacot, "Mechanical Fault Diagnosis and Condition Monitoring", Chapman- Hall, 1987.

Davies, "Handbook of Condition Monitoring - Techniques and Methodology", Springer, 1998.

Cornelius SchefferandPareshGirdhar, "Practical Machinery Vibration Analysis and Predictive Maintenance", Elsevier, 2004.

K.P.Soman, ShyamDiwakar and V.Ajay, "Data Mining: Theory and Practice" PHI Learning Pvt. Ltd., 2006.

Duda, R.O., Peter, Hart, E., and Stork, D.E., "Pattern Classification", 2e, Wiley India, 2007.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE332	FAILURE ANALYSIS AND DESIGN	L-T-P-C: 3-0-0-3

Course objectives

- Familiarize with various failure modes and examine the failed components
- Impart knowledge of vibration analysis for early fault detection

Course outcomes

CO1: Recognize and describe common engineering failure mechanisms
CO2: Detect and diagnose the machine faults from the vibration signals
CO3: Predict the remaining useful life of the components using fatigue, fracture and creep
CO4: Analyse the failed engineering components

CO-PO Mapping

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

Syllabus

Unit 1
Introduction, causes of failures, classification, steps in failure analysis, tools, sample selection and treatment, materials analysis, equipments,
Metallography, commonly used NDT methods. Machine condition monitoring techniques and condition monitoring of gearboxes.
Unit 2
Failure mechanisms, overload failure, ductile and brittle fracture, ductile to brittle transition, stress concentration approach. Fracture mechanics approach, Fatigue mechanisms, classical fatigue prevention and prediction, fractography, damage tolerant fatigue approach. Wear failures, adhesive, abrasive, erosive, corrosive wear. Elevated temperature failures, creep, creep crack branching. Corrosion failures, types and their identification.
Unit 3
Application and case studies on Failure analysis: Failures of cast and welded components, failures of rotating components-shaft, bearing and gears.

Text Books
Jones D. R. H., "Engineering Materials 3–Materials Failure Analysis: Case Studiesand Design Implications", Pergamon Press, 1993.
ASM Handbook, Vol. 11, "Failure Analysis and Prevention" Edited by, ASM Publications, 2002.

Reference Books
ASM Handbook, Vol. 11, "Failure Analysis and Prevention" Edited by, ASM Publications, 2002.
Colangelo Vito J. and Heiser F., "Analysis of Metallurgical Failures", Second Edition, John Wiley & Sons, Inc., 1987.
Jones D. R. H.,"Failure Analysis and Case Studies", Elsevier Publications, 1998.
Robert Bond Randall, "Vibration-Based Condition Monitoring: Industrial, Aerospaceand Automotive Applications", John Wiley & Sons, 2011.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE333	OPTIMIZATION TECHNIQUES IN ENGINEERING	L-T-P-C: 2-0-3-3

Course Objectives

- Impart knowledge on theory of optimization and conditions for optimality for unconstraint and constraint optimization problems
- Inculcate modeling skills necessary to describe and formulate optimization problems in design and manufacturing
- Familiarize with the working principle of optimization algorithms used to solve linear and non-linear problems
- Train the students to solve optimization problems using software tools

Course Outcomes

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 and 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

PO/PSO / CO	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		
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: Problems involving design and manufacturing - Optimality criteria - Classical optimization techniques - Kuhn-Tucker (KT) optimality conditions.

Unit 2
Non-linear programming: One dimensional minimization methods - Unconstrained optimization techniques - Constrained optimization techniques - Transformation methods - Interior and exterior penalty function method - Convergence and divergence of optimization algorithms - Complexity of algorithms.

Unit 3
Modern Methods in Optimization: Genetic Algorithm - Simulated Annealing - Particle Swarm Optimization - Neural Network based optimization - Optimization of Fuzzy systems - Multi-Objective optimization - Data Analytics and optimization using Machine learning approach.

Unit 4

Implementing optimization algorithmsinMatlab / R / Python environment and solving linear, non-linear, multi-objective un constrained and constrained optimization problems.

Text Books

S.S. Rao, Engineering optimization: Theory and Practice, New age international, 3rd edition, 2013.
K. Deb., Optimization for Engineering Design: Algorithms and Examples, PHI, 2nd Edition, 2012.
J. S. Arora, Introduction to Optimum Design, Academic press, 4th Edition, 2017.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment (Theory) (CAT)	10	
*Continuous Assessment(Lab) (CAL)	40	
End Semester		30

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE334 MODELING AND SIMULATION OF ENGINEERING SYSTEMS L-T-P-C: 3-0-0-3

Course Objectives

- Provide a generalized framework on modelling of engineering system through lumped parameter elements
- Introduce and apply different mathematical tools to analyse models of engineering systems
- Familiarize the use of software tools for solving engineering problems.

Course Outcomes

CO1: Develop mathematical models for engineering systems in different domains and derive analogies
CO2: Analyze first and second order linear and nonlinear systems in time and frequency domain
CO3: Perform system identification for linear time invariant systems
CO4: Simulate mathematical models of engineering systems using simulation software.

CO-PO Mapping

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

Syllabus

Unit 1
Fundamental concepts in mathematical modeling: Abstraction-linearity and superposition-balance and conservation laws and the system boundary approach.
Lumped element modeling: Mechanical systems- Translational, rotational. Hydraulic systems. Thermal systems.RLC electrical systems. Modeling analogies.

Unit 2
Modeling of first order and second order systems: Governing equations for free and forced responses - transient response specifications - experimental determination of time constant and damping coefficient. Laplace Transforms. State space formulation.
Frequency response of Linear Time Invariant (LTI) systems: Frequency response of first order and second order systems - Transfer function - mathematical features - Bode plots-Relating time domain, frequency domain and state space.
Introduction to modeling and analysis of nonlinear engineering systems.

Unit 3
Introduction to linear system identification – time and frequency domain identification – discrete time input output models for LTI systems – linear least square parameter estimation.

Text Books
Cha P.D, Rosenberg J.J and Dym C.L, Fundamentals of Modeling and Anlayzing Engineering Systems, Cambridge University 2000
Keesman, Karel J. System identification: an introduction. Springer Science & Business Media, 2011.

Reference Books

Katsuhiko Ogata, System Dynamics, 4th Edition, Pearson Prentice Hall, 2004.
Karnopp D C, Margolis D L and Rosenberg R C,Modeling and Analysis of Mechatronic Systems, Wiley Interscience, 3rd Ed, 1999.
Doebelin E O, System Dynamics: Modeling, Analysis, Simulation and Design, Marcel Dekker 1998.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE335	TOOL DESIGN	L-T-P-C: 3-0-0-3

Course objectives

- Familiarize with location and clamping principles for design of a jig or a fixture
- Elucidate design of jigs and fixtures for any given component
- Elucidate design of a die-set for a given sheet metal component

Course outcomes

CO1: Select standard components, clamping and locating devices using basic principles of jigs and fixtures
CO2: Formulate the design procedure and select the materials used for manufacture
CO3: Design jigs and fixtures for a given component
CO4: Identify and choose the types of presses for a given sheet metal component
CO5: Design a die-set for a given sheet metal component using the design procedure for various sheet metal working processes.

CO-PO Mapping

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

Syllabus

Unit 1
Design of Jigs: Introduction - Location Principles – Six Point Location Principle – Locators – Clamping Principles – Clamping Devices – Drill Jigs – Drill Bushes – Drill Jig Types – Design and Development of Jigs for given components.

Unit 2
Design of Fixtures: Milling Fixtures – Milling Methods – Milling Fixture Types – Turning fixtures – Broaching Fixtures – Grinding Fixtures – Assembly, Inspection and Welding Fixtures – Modular Fixtures – Design and Development of Fixtures for given components.

Unit 3
Design of Dies: Power presses types and construction details, die cutting operation, cutting action in die and punch, center of pressure, clearance and its significance, cutting forces, methods of reducing cutting forces, methods of punch support, strippers, stock stops, guide pilots, knockout, design of blanking and piercing dies. Design Concepts and description of the components of progressive dies. Design of progressive dies. Design of compound dies. Design of combination dies.

Unit 4
Drawing Dies: Metal flow and factors affecting drawing, blank size calculations, drawing force, single and double acting drawing dies, design and development of drawing dies for different components.

Unit 5

Bending and Forming Dies: Spring back, bend allowance; calculation of development length, bending force calculations types of bending dies. Curling dies.
Forging process and forging dies. (Introductory Treatment)

Text Books

P. H. Joshi – 'Jigs and Fixtures Design Manual' - McGraw Hill - 2002
Kempster M. H. A. - 'An Introduction to Jig and Tool Design' - Viva Books Pvt. Ltd. - 2002
P. H. Joshi – 'Press Tools Design and Construction' – S. Chand and Company Ltd. – Revised edition, 2008

Reference Books

John G. Nee - 'Fundamentals of Tool Design' - Society of Manufacturing - 1998 - 4th Edition
E. K. Henriksen – 'Jig and Fixture Design Manual' - Industrial Press, New York - 1973
Paquin and Crowley – 'Die Design Fundamentals' - Industrial Press, New York – 1979
Donaldson, Lecain and Goold – 'Tool Design' - McGraw Hill, New York - 1976

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE336	NVH AND REFINEMENT	L-T-P-C: 3-0-0-3

Course Objectives

- Familiarize the fundamentals of Vibration and Acoustics.
- Inculcate various methods of sound signal processing
- Demonstrate various test methods to increase the NVH refinement levels

Course Outcomes

CO1: Understand fundamentals of Vibration and Acoustics
CO2: Model and analyze SDOF, MDOF and Continuous System
CO3: Comprehend vehicle noise and vibration measurement, data acquisition, signal processing and analysis, Fourier Series and their applications
CO4: Simulate and validate techniques in NVH & Refinement, Sound quality and their Metrics
CO5: Identify various sources of NVH in a vehicle, their control techniques
CO6: Analyze and identify measures for active Noise and Vibration Control

CO-PO Mapping

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

Syllabus

Unit 1
Introduction to Automotive NVH– Fundamentals of vibrations –Vibrations of Single degree of freedom , Multi degree of freedom and Continuous Systems - Vehicle vibration measurement and analysis –Vibration endurance test - Fundamentals of acoustics, Vehicle noise measurement, Data Acquisition Systems, Noise Standards, Types of Signals, Signal conditioning and processing, Analysis and presentation of data Ride Comfort – Sound Quality and psychoacoustics –Sound Quality Metrics Subjective–objective correlation –Squeak and rattle.

Unit 2
Fourier series – Fourier Integrals –- Discrete Fourier Transforms – Fourier and Laplace Transforms - Filters - Windowing - Uncertainty principle – Time Sampling and Aliasing - Random signal processing and analysis -Theory of modal analysis - Methods for performing modal analysis.

Unit 3
Vehicle NVH refinement –Vehicle Development process - target setting and Benchmarking– Simulation and Experimental techniques in NVH refinement - Refinement of Power train systems – Aerodynamic noise and its refinement - Mid– and high-frequency problems – Statistical Energy Analysis-Acoustic shielding and sound packages-Active noise control and their applications.

Text Books / Reference Books

Xu Wang, "Vehicle Noise and Vibration Refinement", CRC Press Publication, 2010.
J.M. KrodkiewskI, "Mechanical Vibration" Univ of Melbourne, 2008
Kihong Shin and Joseph K. Hammond "Fundamentals of Signal Processing for Sound andVibration Engineers", John Wiley, 2008.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE337	FUNDAMENTALS OF FRACTURE MECHANICS	L-T-P-C: 3-0-0-3

Course Objectives

- Familiarize with the basics of fracture mechanics
- Impart knowledge on strain energy release rate, stress intensity factor and J-integral and crack growth
- Expose students to various type of fracture and fracture parameters

Course Outcomes

CO1: Apply principles of linear elastic fracture mechanics to solve for stress intensity factor and energy release rate of structures with cracks.
CO2: Formulate J-integral and analyze stress-strain fields around a crack tip for non-linear material behavior.
CO3: Classify the type of fracture and predict ductile to brittle transition.
CO4: Estimate fatigue crack growth using principles of fracture mechanics.
CO5: Predict stress intensity factor, energy release rate and J-integral, computationally, as per ASTM standards.

CO-PO Mapping

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

Syllabus

Unit 1
Introduction to Fracture Mechanics: Fundamentals of elasticity and plasticity theory, types of Failure, historical perspective, ductile, brittle fracture, Stress concentration effect of flaws, Griffith energy balance, the energy release rate (G), instability and resistance curve.
Stress analysis of cracks, Linear Elastic Fracture Mechanics (LFEM), modes of fracture, stress intensity factor, prediction, fracture toughness, crack tip plasticity, plastic zone, Dugdaleapproach

Unit 2
Elastic Plastic Fracture Mechanics (EPFM): Crack-Tip-Opening Displacement (CTOD), the J contour integral and its determination, relationships between J and CTOD, crack-growth resistance curves, J-controlled fracture.

Fracture mechanism in metals and non-metals: Ductile fracture, cleavage, the ductile-brittle transition, intergranular fracture, fracture in polymeric materials, and fracture in ceramic and ceramic composites.

Unit 3
Applications: Introduction to fracture toughness testing of metals and non-metals for determination of fracture parameters, Application of fracture mechanics concepts in the analysis of fatigue crack growth.

Computational fracture mechanics: Overview of numerical methods for fracture mechanics problems, traditional methods in computational fracture mechanics, finite element implementation, design of finite element mesh, linear elastic convergence study.

Text Book

Anderson, T. L., "Fracture Mechanics: Fundamentals and Applications", 3/e, CRC Press, 2005.

Reference Books

Prashanth Kumar, "Elements of Fracture Mechanics", McGraw Hill Education (India) Private Limited, 2009.
Broek, D., "Elementary engineering fracture mechanics". Springer Science & Business Media.2012.
Knott J. K., "Fundamentals of Fracture Mechanics", 3/e, Butterworth Heinemann, 1993.
Suresh, S., "Fatigue of Materials", 2e, Cambridge University Press, 1998.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE338	THEORY OF VIBRATIONS	L-T-P-C: 3-0-0-3

Course Objectives

- Familiarize students with the mathematical modeling and analysis of mechanical vibration systems
- Make students understand the importance of vibration analysis in the design of dynamical systems

Course Outcomes

CO1: Classify different types of vibrations and develop mathematical models of vibratory systems.
CO2: Analyze free and forced vibrations of single degree of freedom systems.
CO3: Estimate the natural frequencies and mode shapes of multi degree of freedom systems.
CO4: Analyze free vibrations of continuous systems

CO-PO Mapping

PO/PSO / CO	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	1	1	1							1	3		
CO3	3	3	1	1	1							1	3		
CO4	3	3	1	1	1							1	3		

Syllabus

Unit 1
Vibration of sdf systems- Free vibration of sdf systems - undamped and damped free vibration-underdamped, overdamped and critically damped systems-estimation of damping by logarithmic decrement.
Forced vibration of sdf systems- Harmonically excited sdf systems-rotating unbalance-support harmonic excitation-vibration isolation-sdf system as a vibration measuring instrument- Half power point method for the estimation of damping- Response to periodic excitation - method of Fourier series.
Types of damping - viscous, Coulomb, structural and material damping models- Equivalent viscous damping.
Response of sdf system to arbitrary excitation (Transient Vibration)- Convolution integral - method of Fourier transforms.

Unit 2
Vibration of two dof systems-Undamped free vibration of the two dof systems -matrix eigenvalue problem - natural frequencies and natural modes - elastic and inertial coupling - coordinate selection to remove coupling- beat phenomenon - response to harmonic excitation- vibration absorbers - orthogonality of natural modes.
Vibration of multi dofsystems-Equations of motion - formulation and solution of matrix eigenvalue problem - computational methods for the solution of matrix eigenvalue problem - decoupling of equations of motion by modal analysis.

Unit 3
Vibration of continuous systems
Transverse vibration of a string - axial vibration of a rod - torsional vibration of a shaft - bending vibration of a beam - formulation and solution of differential eigenvalue problem.

Text 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

Reference Books

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.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE339	THEORY OF ELASTICITY	L-T-P-C: 3-0-0-3

Course Objectives

- Expose students to the theoretical fundamentals of elasticity
- Inculcate knowledge on basic governing equations of elasticity

Course Outcomes

CO1: Apply principles of elasticity theory to estimate stresses and strains in isotropic and non isotropic materials using a tensorial approach.
CO2: Formulate and solve boundary value problems in solid continua using stress and displacement based solution Strategies.
CO3: Formulate and solve planar problems using Airy stress function in rectangular and polar co-ordinates
CO4: Solve specific three-dimensional problems like torsion, bending of non-circular prismatic bar, membrane analogy and simple plate bending

CO-PO Mapping

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

Syllabus

Unit 1
Analysis of Stress and Strain: Stress at a point; stress tensor; stress transformations; principal stresses; octahedral stress; geometrical representation of stress at a point; equations of equilibrium.

Infinitesimal affine transformation for deformation; strain tensor; principal strains; strain-displacement relations for finite and infinitesimal strains; compatibility conditions. Constitutive Equations: General theory; generalized Hooke's law for anisotropic and isotropic materials.

Unit 2
Equations of Elasticity: Common equations of elasticity theory like Mitchel-Beltrami and Navier equations, formulation of the general elasticity problem; boundary conditions

Unit 3
Solution of Some Special Boundary Value Problems: Simplifications; two-dimensional problems in rectangular and polar coordinates; Airy's stress function; a few problems like stress concentration around a circular hole and Boussinesq problem.
A few representative three-dimensional problems; torsion and bending of non - circular prismatic bars (Saint-Venant's solution); membrane analogy, Simple Plate bending

Text Books
Timoshenko S. P. and Goodier J. N. - 'Theory of Elasticity'- McGraw Hill International Editions, 1970 - 3rd Edition
L. S. Srinath - 'Advance Mechanics of Solids' - McGraw Hill Education - 2009 - 3rd Edition

Reference Books

Hartog, J. P. D. - 'Advanced Strength of Materials'- Dover Publications Inc, - 1987

Boresi A. P., Schmidt R. J. and Sidebottom O. M. - 'Advanced Mechanics of Materials' -John Wiley & Sons Inc. - 1993 - 6th Edition

Durelli A. J., Phillips E. A. and Tsao C. H. - 'Introduction to the Theoretical and Experimental Analysis of Stress and Strain' – McGraw Hill, New York - 1958.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE340	INTRODUCTION TO NONLINEAR DYNAMICSAND CHAOS	L-T-P-

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

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

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE311	DESIGN THINKING	L-T-P-C:1-0-3-2

Course Objectives

- Inculcate the fundamental concepts of design thinking
- Develop the students as a good designer by imparting creativity and problem solving ability
- Conceive, conceptualize, design and demonstrate innovative ideas using prototypes

Course Outcomes

CO1: Demonstrate the 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

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

Syllabus

Unit 1
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

Unit 2
Design team-Team formation, Conceptualization: Visual thinking, Drawing/sketching, New concept thinking, Patents and Intellectual Property, Concept Generation Methodologies, Concept Selection, Concept Testing, Opportunity identification
Prototyping: Principles of prototyping, Prototyping technologies, Prototype using simple things, Wooden model, Clay model, 3D printing; Experimenting/testing.

Unit 3
Sustainable product design, Ergonomics, Semantics, Entrepreneurship/business ideas,
Product Data Specification, Establishing target specifications, Setting the final specifications. Design projects for teams.

Text Books
Tim Brown, Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation, HarperCollins Publishers Ltd.
IdrisMootee, Design Thinking for Strategic Innovation,2013, John Wiley & Sons Inc

Reference Books

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,
BjarkiHallgrimsson, Prototyping and model making for product design, 2012, Laurence King Publishing Ltd
Kevin Henry, Drawing for Product designers, 2012, Laurence King Publishing Ltd

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment (Theory) (CAT)	10	
*Continuous Assessment(Lab) (CAL)	40	
End Semester		30

*CA – Can be Quizzes, Assignments, Projects, and Reports

INDUSTRIAL ENGINEERING AND MANAGEMENT STREAM

19MEE341	ENGINEEIRNG ECONOMIC ANALYSIS	L-T-P-C: 3-0-0-3

Course Objective

- Familiarize 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 for the 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	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.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE342	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

PO/PSO / CO	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.

Reference 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.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE343	MANUFACTURING PLANNING AND CONTROL	L-T-P-C: 3-0-0-3

Course Objectives

- To provide an overview of various manufacturing systems
- To familiarize with strategic, tactical and operational planning
- To summarize quantitative methods used in plant location, and layout planning
- To familiarize the concepts of group technology, operations planning and JIT systems
- To impart knowledge on the concepts of operational control through scheduling, cost planning and simulation analysis

Course Outcomes

CO1: understand the manufacturing systems and analyze their impact on productivity
CO2: understand the strategic, tactical and operational planning concepts
CO3: select appropriate plant location and their layout methods
CO4: develop aggregate plans, capacity plans and inventory plans.
CO5: control operations through cost planning, scheduling and simulation analysis.

CO-PO Mapping

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

Syllabus

Overview of manufacturing systems and various issues of interest: Assembly Line, Repetitive batch manufacturing, Cellular manufacturing, FMS, JIT, CIM.
Preplanning: Forecasting, Economic analysis, Aggregate planning, Capacity planning, Inventory planning.
Decision making in design of manufacturing systems: Group technology, Line balancing, Plant layout. Operations planning: MRP, MRP II, Hierarchical planning systems, JIT systems, FMS.
Operation and control: Lot sizing decisions, Production scheduling, Line of balance, Quality planning and control, Cost planning and control. Simulation analysis of manufacturing systems. Case studies.

Text Books

Bedworth, D.D. and J.E.Bailey, Integrated Production Control, System - Management, Analysis and Design. John Wiley, 1983.
Elsayed E.A. and Boucher T.O., Analysis and Control of Production Systems. Prentice Hall, 1985.
King J.R., Production Planning and Control, Pergamon Press, Oxford, 1975.

Reference Books

Bestwick, P.F and Lockyer, K., Quantitative Production Management, Pitman Publications, 1982.
Hax, A.C and Candea, D., Production and Inventory Management.Prentice Hall, 1984.
Johnson, L.A and Momtgomery, D.C., O.R. in Production Planning, Scheduling and Inventory Control.John Wiley and Sons, 1974.
Korgaonkar, M.G., JIT Manufacturing, Macmillan Publication Co, 1992.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MNG331	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

PO/PSO / CO	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
Chandra, P., 'Financial Management: Theory and Practice', 9e, TMH, 2017.
Denzil Watson & Antony Head, 'Corporate Finance- Principles and Practice', 2e, Pearson Education Asia, 2016.
R L Varshney& K L. Maheshwari, 'Managerial Economics', S Chand & Sons, 22e, 2014.

Reference Books

Stephen Blyth, 'An Introduction to Corporate Finance ',McGraw Hill Book Company, 2014.
Eugene F. Brigham & Louis C.Gapenski, 'Financial Management – Theory and Practice',14e, 2015.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MNG332	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

PO/PSO / CO	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 routing and scheduling models – traveling salesman problems – exact and heuristic methods.

Unit 2
Inventory: Inventory Management and risk pooling-managing inventory in the SC. Value of Information-bullwhip effect-lead time reduction.
Supply Chain Integration: Supply chain integration-distributed strategies-push versus pull systems. Distribution Requirements Planning – DRP and demand forecasting, DRP and master production scheduling. DRP techniques – time-phased order point – managing variations in DRP – safety stock determination-Strategic alliances-third party logistics-distribution integration.

Unit 3
Issues in SCM**:** Procurement and outsourcing strategies – framework of e-procurement. International issues in SCM-regional differences in logistics. Coordinated product and supply chain design-customer value and SCM.

Text Book

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

Christopher, M., 'Logistics and Supply Chain Management: Strtegies for reducing Cost and Improving Service', PH, 1999.

Ballou, M., 'Business logistics / Supply chain management', Pearson Education, 2003.

Vollmann, T.E., 'Manufacturing Planning and Control for Supply Chain Management', 5e, McGraw Hill, 2005.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MNG333	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

PO/PSO / CO	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

Kolter, P.,'Marketing Management', Pearson Education 2001.
Ramasamy and Namakumari, 'Marketing Environment: Planning, implementation and control the Indian context', 1990.

Reference Books

Paul, G.E. and Tull, D., 'Research for marketing decisions', Prentice Hall of India, 1975.
Tull, D.S. and Hawkins, 'Marketing Research', Prentice Hall of Inida-1997.
Kotler, P. and Armstrong, G., 'Principles of Marketing' Prentice Hall of India, 2000.
Skinner, S.J., 'Marketing', All India Publishers and Distributes Ltd. 1998.
Govindarajan, M., 'Industrial marketing management', Vikas Publishing Pvt. Ltd, 2003.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MNG334	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

PO/PSO / CO	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 crashing
Resource Consideration - Profiling, Allocation, Levelling.
Introduction to project management software: Primavera/ Microsoft project

Unit 3
Project Execution: Monitoring control cycle, Earned Value Analysis (EVA), Project Control – Physical control, Human control, financial control.
Organizational and Behavioral Issues: Organizational Structure, Selection-Project Manager, Leadership Motivation, Communication, Risk Management.
Project Termination: Extinction, Addition, Integration, Starvation.

Text Books

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

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MNG335	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

PO/PSO / CO	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 implementation issues. 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

L J Krajewski, L.P.RitzmanMalhotra.M and Samir K. Srivastava, 'Operations Management: Processes and Value chains, 11e, Pearson, 2015.

R L Varshney& K L. Maheshwari, 'Managerial Economics', S Chand & Sons, 22e, 2014.

Reference Books

Richard B. Chase, Ravi Shankar, F. Robert Jacobs, 'Operations and Supply Chain Management' McGraw Hill Education (India) Private Limited.14e, 2017.

E S Buffa and R K Sariss, 'Modern Production/Operations Management', Wiley India Private Limited, 8e, 2007.

Harrison.B, Smith.C., and Davis.B.,, 'Introductory Economics', 2e Pr Macmillan, 2013.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE346	MANAGERIAL STATISTICS	L-T-P-C: 3-0-0-3

Course Objective

- To impart the knowledge of basic statistical tools for analysis and interpretation of qualitative and quantitative data for decision making

Course Outcomes

CO1: Apply basic probability and statistics concepts for various business problems
CO2: Perform test of hypothesis
CO3: Compute and interpret the result of regression and correlation analysis for forecasting
CO4: Solve real time problems by applying different decision making methods.

CO-PO Mapping

PO/PSO / CO	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
Levin R. I. and Rubin D. S. - 'Statistics for management' - Pearson Education – 2007 - 5th Edition
Montgomery D. C. and Runger G. C. - 'Applied Statistics and Probability for Engineers' - John Wiley & Sons - 2002 - 3rd Edition

Reference Books

Bain.L. J. and Engelhardt M. - 'Introduction to Probability and Mathematical Statistics' - Duxbury Press - March 2000 - 2nd Edition

Hinkelmann K. and Kempthorne O. - 'Design and Analysis of Experiments : Volume I' - John Wiley & Sons, Inc. - December 2007 - 2nd Edition

Johnson R. A. and Wichern D. W. - 'Applied Multivariate Statistical Analysis' - Prentice-Hall, Inc. - December 2001 - 5th Edition

Myers R. H. - 'Classical and Modern Regression with Applications' - PWS-Kent Publishing Company - March 2000 - 2nd Edition

Devore J. L. - 'Probability and Statistics for Engineering and the Sciences' - Brooks/Cole Publishing Company - December 1999 - 5th Edition

Freund J. E. and Walpole R. E. - 'Mathematical Statistics' - Prentice-Hall Inc. - October 1986 - 4th Edition

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MNG338	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

PO/PSO / CO	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
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.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment (Theory) (CAT)	15	
*Continuous Assessment(Lab) (CAL)	30	
End Semester		35

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE347	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

PO/PSO / CO	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
Besterfiled D. H. - 'Total Quality Management' - Pearson Education Asia – 2015-4th Edition

Reference Books
Evans J. R, and Lidsay W. M. - 'The Management and Control of Quality' - Southwestern (Thomson Learning) - 2002 - 5th Edition
Feigenbaum A. V. - 'Total Quality Management - Vol I &II ' – McGraw Hill - 1991

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Report

19MEE401	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

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

PO/PSO / CO	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

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

Reference Books

Martand T. Telsang, 'Industrial Engineering and Production Management' S Chand; 2nd Rev Edn 2006.
Mahajan M., "Industrial Engineering and Production Management" Dhanpat rai and Sons Publishers, 2005.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continues Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

MANUFACTURING STREAM

19MEE431	CNC MACHINES	L-T-P-C: 3-0-0-3

Course Objectives:

- To impart knowledge on the fundamentals of numerical control, tools, cutting parameters and work holding devices of CNC machine tools
- To familiarize with CNC part programs for turning and machining centers for given components
- To develop the skill to perform verification tests on CNC machines

Course Outcomes

At the end of this course, students will be able to
CO1: Illustrate the features, interpolation schemes and functioning of CNC machines.
CO2: Develop the manual part programming and generate tool paths for a given profile
CO3: Perform various verification tests on CNC machine

CO-PO Mapping

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

Syllabus

Unit 1
Introduction: NC Machines, CNC Machines, CNC Machine Components, Co-ordinate System, Working Principle of Various CNC Systems, Direct Numerical Control, Adaptive Control

Unit 2
Constructional Features of CNC Machines: Introduction-Machine Structure-Guideways-Ball Screws-Accessories of Machining Centre-Spindle Drives and Feed Drives-Control System of NC Machine Tools

Unit 3
CNC Part Programming: Part Programming Fundamentals- G and M Codes-Interpolation Systems-Methods of CNC Part Programming-APT Language-Motion Commands-CNC Part Programming Using CAD/CAM-Computer Automated Part Programming

Unit 4
Tooling and Work Holding Devices: Cutting Tool Material-Preset and Qualified Tools-ISO Specification of Tools-Chip Breakers-Principle of Location-Clamping-Work Holding Devices

Unit 5
Economics and Maintenance: Introduction-Factors Influencing Selection of CNC Machines-Cost of Operation of CNC Machines-Practical Aspect of Introducing a CNC-Maintenance of CNC Machines-Preventive Maintenance Programs

Text Books

M. Adithan, B.S. Pable, 'CNC Machines', NEW AGE; Third edition, 2018

P. M. Agrawal, V. J. Patel, 'CNC Fundamentals and Programming', V. J. Patel Edition : 2nd Edition : 2017

Reference Books

Peter Smid, 'CNC Programming Handbook: A Comprehensive Guide to Practical CNC Programming', Industrial Press Inc.,U.S.; 2nd edition, 2000)

P. N. Rao - 'CAD/CAM, Principles and Applications' - Tata McGraw Hill Publishers – 2004

Mikell P. Groover and Emory W. Zimmers - 'CAD/CAM' - PHI Publishers – 2002

Thomas Crandell, 'CNC Machining and Programming: An Introduction, Industrial Press, Inc.; 2 edition, 2003)

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE432	COMPOSITE MATERIALS AND DESIGN	L-T-P-C: 3-0-0-3

Course Objectives

- To introduce various types of reinforcements and matrices for composites
- To impart knowledge on the fundamentals of design of composites and structure property relations
- To familiarize with suitable tools and methods for manufacturing of composites
- To understand advance composite materials and processes

Course Outcomes

CO1: Identify the importance of base matrix and reinforcements of composites for different applications.
CO2: Select the mould, tool, matrix and reinforcements for composites
CO3: Identify suitable processes and parameters for the manufacture of various composites
CO4: Select appropriate composite materials, design of composites for real time applications.

CO-PO Mapping

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

Syllabus

Unit1
Types of reinforcements, their mechanical properties and functions -ceramics, glass, carbon, boron.silicon carbide, metal, aramid.Forms of reinforcements- particulate, fibre, filaments, whiskers, flakes. Pre-fabricated forms- preforms, prepegs, fabrics, honeycomb.
Type of matrix, its mechanical properties and functions- polymers (thermosets and thermoplastics), metals, ceramics, glass and carbon.Basic principles in the design of composites and selection of matrix and reinforcement.Bonding mechanisms.

Unit 2
Anisotropic behaviourand relationship between structure-mechanical properties.Mechanical testing- tensile, compressive, Intra-laminar shear, Inter-laminar shear and fracture. Polymer Matrix Composites: Types of thermoset and thermoplastic resins. Principles in the selection of matrix and the reinforcements.Process selection criteria.Mould and tool making.Basic manufacturing steps- impregnation, lay-up, consolidation and solidification.

Unit 3
Manufacturing processes for polymer composites- lay-up, compression moulding, extrusion, injection moulding, sheet forming, pultrusion, hot press & autoclave techniques and filament winding. Metal and ceramic matrix composites- wettability of reinforcement to matrix and bonding, methods of manufacturing reinforcements with intermediate wetting layer. Manufacturing processes for metal matrix composites: casting methods- gravity & low pressure die, investment, squeeze, spray forming, compression moulding and thixo-moulding. Manufacturing processes for ceramic matrix composites: reaction sintering, electro-deposition, spray forming, infiltration.
Applications of composites: daily usages- industrial, automotive and aerospace, advanced composites, design-selection and process of composite for new application, case studies.

Text Books

Clyne, T.W. and Withers, P.J., 'An Introduction to Metal Matrix Composites', Cambridge Univ. Press 1993.
Matthews, F.L., and Rawlings, R.D, 'Composite Materials: Engineering and Science', Chapman & Hall, London 1994.

Reference Books

Suresh, S., Martensen, A., and Needleman, A., 'Fundamentals of Metal Matrix Composites', Butterworth, Heinemann, 1993.
Mallick, P. K., 'Fiber-reinforced Composites: Materials, Manufacturing and Design', Marcel Dekker, 1993.
Mazumdar, S.K., 'Composites Manufacturing-Materials, Product, & Process Engineering', CRC Press, 2002.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE433	FUNDAMENTALS OF NANOMATERIALS	L-T-P-C: 3-0-0-3

Course Objectives

- To understand fundamentals of nanotechnology and nanomaterials
- To understand and relate quantum and statistical mechanics fornano technology
- To impart knowledge on nano structures, properties and characterization techniques
- To demonstrate bulk nano material and nano tribology for various applications

Course Outcomes

CO1: Understand fundamentals of nanomaterials
CO2: Understand quantum and statistical mechanics and its relation to nanotechnology
CO3: Understand nano structures and properties
CO4: Select the characterization technique specific to nanomaterials
CO5: Apply the appropriate processes for bulk nano materials and nano tribology

CO-PO Mapping

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

Syllabus

Unit I
Introduction to advanced material science, basic principles of nano material and its relation with properties, Examples nanomaterials in daily life (GMR read heads, NEMS goniometers, health care, energy materials, etc), Foundations of quantum and statistical mechanics for nanomaterials, idea of tunneling, bound state and scattering, notion of quasiparticles, light matter interaction; DOS, bose-einstein and Fermi-dirac statistics,

Unit 2
Properties of individual nanostructures; bulk nanostructured materials; selection rules and spectroscopic techniques; Introduction to characterization of nanomaterials ,size and dimensionality effects; quantum confinement; properties dependent on density of states; single electron tunneling; current-induced forces, current-induced heating and electromigration in nanowires;

Unit 3
Nanotribology; carbon based nanomaterials; biological materials and biomimetic strategies for nanosynthesis; magnetic nanomaterials; nanodevices and nanomachines,
Nano structured bulk material, amorphous Vs crystalline nano material

Text Books
Introductory Nanoscience, by MasuroKuno, Garland Science (2011).
Introduction to Nanotechnology, by Poole and Owen, Wiley Indian Edition (2010).
Nanophysics and Nanotechnology, by Edward L. Wolf, Wiley-VCH (2006).

Reference Books

Nanotechnology, By Lynn E. Foster, Pearson (2011).
Quantum Mechanics, by J. J. Sakurai.
Statistical Mechanics, by Kerson Huang.
Fundamentals and Applications of Nanomaterials, by Z. Guo and Li Tan.
Nanoelectronics and Information technology, by Rainer Waser, Wiley-VCH (2005

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE434	INDUSTRIAL ROBOTICS	L-T-P-C: 3-0-0-3

Course Objectives

- To familiarize robot structures and their workspace and distinguish between different sensors and drives.
- To develop skills in performing spatial transformations and kinematic analysis of robot manipulator.
- To develop knowledge in the Industrial applications of robots using image processing concepts.

Course Outcomes

CO1: Identify the components of a robot and distinguish the types of robot configurations
CO2: Compare, evaluate and choose sensors/drives for robots
CO3: Construct kinematic model of a given manipulator and evaluate whether the inverse kinematic model is solvable
CO4: Examine the need for vision system in a robotic system
CO5: Choose and apply appropriate image processing technique for object recognition in robotic systems
CO6: Design and develop a robotic system for a given industrial application

CO-PO Mapping

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

Syllabus

Unit 1
Evolution of robotics. Robot anatomy- Co-ordinate Systems, Work envelope, types and classification – Specifications – Pitch, Yaw, Roll, Joint Notations, Speed of Motion, Pay Load – Basic robot motions - Point to point control, Continuous path control. Robot Parts and Their Functions – Need for Robots Different Applications.
Robot drive systems: Pneumatic Drives – Hydraulic Drives – Mechanical Drives – Electrical Drives – D.C. Servo Motors, Stepper Motor, A.C. Servo Motors – Salient Features, Applications
End Effectors – Grippers – Mechanical Grippers, Pneumatic and Hydraulic Grippers, Magnetic Grippers, Vacuum Grippers; Two Fingered and Three Fingered Grippers; Internal Grippers and External Grippers; Selection and Design Considerations

Unit 2
Coordinate frames. Mapping: Mapping between rotated frames-Mapping between translated frames- Mapping between rotated and translated frames-Description of objects in space-Transformation of vectors – Rotation-translation combined with rotation-translation of vectors-composite transformation-Inverting a homogenous transform-Fundamental rotational matrices.

Direct Kinematic Model – Mechanical structure and notations-Description of links and joints-Kinematic modeling of manipulator-Denavit-Hartenberg Notation-Kinematic Relationship between adjacent links-Manipulator Transformation Matrix.

Inverse Kinematic Model – Manipulator Workspace-Solvability-Solution techniques-Closed form solution.

Unit 3

Imaging components-image representation-picture coding-object recognition and categorization-visual inspection.Robot cell-design and control layouts.

Robot programming Languages –VAL Programming – Motion Commands, Sensor Commands, End effecter commands, and Simple programs.

Industrial Applications – Material Handling, Process, Assembly, Inspection.Non-Industrial Applications.

Textbook

Fu, K.S., Gonzalez, R.C. and Lee C.S.G. – 'Robotics: Control, Sensing, Vision, and Intelligence' – McGraw Hill, New York, NY – 1987

Reference Books

R K Mittal and I J Nagrath, 'Robotics and Control', Tata McGraw-Hill Publishing Company Limited, New Delhi, 2003.

J Craig, 'Introduction to Robotics: Mechanics and Control', Addison-Wesley, Reading, MA, 1989 (second edition).

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE435	ADDITIVE MANUFACTURING	L-T-P-C: 2-0-3-3

Course objectives

- To provide comprehensive knowledge of the wide range of additive manufacturing processes, capabilities and materials
- To understand the software tools and techniques used for additive manufacturing.
- To create physical objects that facilitates product development/prototyping requirements.

Course outcomes

CO1: Demonstrate appropriate level of understanding on principles of additive manufacturing processes.
CO2: Choose appropriate materials for additive manufacturing processes
CO3: Apply suitable CAD tools and CAD interface for additive manufacturing process
CO4: Develop physical prototypes by identifying suitable process with optimum process parameters

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	2	2									2		2
CO2	2	2	2	2			3						2		2
CO3	2	3	2	2	3							1	2		2
CO4	2	3	3	2		2	2					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)
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, solidification rates,Meso and macro structures,
Process evaluation: process-structure relationships, structure property relationships,
Applications: Prototyping, Industrial tooling, Aerospace, Automobile, Medical etc.,
Quality control and reliability: Defects in FDM, SLS and SLM, Critical process parameters: geometry, temperature, composition, phase transformation, Numerical and experimental evaluation: roles of process parameter combination, process optimization.

CAD in Additive Manufacturing
CAD Modelling for 3D printing: 3D Scanning and digitization, data handling &reduction Methods,
AM Software: data formats and standardization, Slicing algorithms:-uniform flat layer slicing, adaptive slicing,
Process-path generation: Process-path algorithms, rasterisation, 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, Numerical and experimental evaluation.

Text Books
Gibson, I., Rosen, D.W. and Stucker, B., "Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing", Springer, 2015.
Chua, C.K., Leong K.F. and Lim C.S., "Rapid prototyping: Principles and applications", Third edition, World Scientific Publishers, 2010.

Reference Books
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, 2000

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment (Theory) (CAT)	10	
*Continuous Assessment (Lab) (CAL)	40	
End Semester		30

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE436 NANO TECHNOLOGY AND SURFACE ENGINEERING L-T-P-C: 3-0-0-3

Course Objectives

- To impart knowledge of basic nanomaterials for surface engineering
- To introduce various nano-surface coating techniques and properties
- To facilitate material design and hard coatings based on nano techniques
- To familiarize with characterization techniques used for nano-surface engineering

Course Outcomes

CO1: Understand various nano materials for surface engineering
CO2: Understand surface engineering techniques and identify the appropriate manufacturing processes for nano coatings
CO3: Understand ion based surface coatings, gases and environment for coatings
CO4: Analyse the processes behavior for hard and nano coatings
CO5: Select appropriate characterization techniques for nano surface engineering

CO-PO Mapping

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

Syllabus

Unit 1
Introduction to tribology and conventional surface engineering, outlines of conventional surface modification methods-physical vapour depositions, chemical vapourdeposition, Introduction to nano films, glancing angle deposition (GLAD)technique. Transparent polymer nanocomposites, silane coating, silica coating, Nanocomposite processing, melt blending, In situ synthesis, Optical, Thermomechanical and mechanical properties of the nano coatings.

Unit 2
Nanostructures by Ion Irradiation- Introduction, Implantation, Sputtering , Cleaning, roughening of surface for improving the adhesion of coatings, Ion beam assisted deposition (IBAD) and ion beam deposition (IBD) of monoatomic ions or clusters, microencapsulation, decorative and golden PVD coatings, concept of color, reactive gas flow, Influence of oxygen in the layers.
Ion bombardment, TiN (ZrN) + Au coatings , nanostructured TiN/ZrN coatings, hardness and nanostructure of coatings , chromium nitride coatings, tantalum nitride (TaN) coatings , TiAl (N, C, O) coatings.

Unit 3
Introduction to nanolayered hard coatings, nanostructuring of transition-elements nitrides obtained by cathodic arc evaporation , plasma enhanced chemical vapor deposition, pulsed current in nano coatings.
Nanopowders- instructions for use, defining the working conditions.

Characterization of coatings- hardness, adherence and internal stresses, mechanical behavior and machining performances.
Determining internal stresses by radius of curvature measurements (Stoney's method), determining residual stresses using x-ray diffraction, high temperature oxidation resistance of nanocomposite coatings.

Text Book

Nanomaterials and Surface Engineering, Edited by Jamal Takadoum, publisher: ISTE Ltd and John Wiley & Sons, Inc. 2009. ISBN 978-1-84821-151-31.

Reference Book

Nanomaterials and Surface Engineering, Jamal Takadoum (Editor), March 2010, Wiley

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE437	ADVANCED CASTING TECHNOLOGY	L-T-P-C: 3-0-0-3

Course Objectives:

- To understand the advanced casting processes and equipment
- To facilitate usage of software packages in design and application for advanced casting methods
- To impart knowledge on the characterization and inspection methods for advanced casting

Course Outcomes:

After successful completion of this course the student will be able to
CO1: Design the basic tooling requirements for advanced casting process
CO2: Select suitable process for manufacturing of casting components
CO3: Analyse the liquid metal flow and solidification characteristics using casting software
CO4: Identify the defects in castings and suggest improvements

CO-PO Mapping

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

Syllabus

Unit 1
Melt processing techniques for ferrous and non-ferrous alloys such as stainless steels, nickel, titanium alloys. Vacuum melting equipment and practice.
Elementary aspects of pattern and mould design using CAD softwares. Resin-bonded mould and core making processes and machines. Special casting processes and their applications- low pressure die casting, investment casting, squeeze casting, thixo-forming. Illustrations of automotive and aerospace applications.

Unit 2
Gating and riser design - principles of fluid flow, governing equations, heat transfer applied to casting solidification, governing equations, boundary conditions for different casting methods, concept of directional solidification, gating and risers, application of simulation methods. Use of casting software in solving practical problems.

Unit 3
Casting defects and remedies. Inspection methods - visual, penetrant, magnetic, metallurgical, X-ray and Gamma ray radiography and Mechanization and Automation

Text Book
Jain P. L. - 'Principles of Foundry Technology' - Tata McGraw Hill, New Delhi - 2011 - 3rd Edition

Reference Books
Heine R. W., Loper C. R., and Rosenthal P. C. - 'Principles of Metal Castings' - Tata McGraw Hill, New Delhi - 1997 - 2nd Edition
Beeley- P. R.- 'Foundry Technology' - Butterworth Scientific, London - 2001

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE438	ADVANCED MANUFACTURING PROCESSES	L-T-P-C: 3-0-0-3

Course Objectives

- To impart knowledge on process parameters for nonconventional and micromachining
- To understand high speed machining and its characteristics.
- To impart an understanding of advanced grinding and various laser material processing techniques.

Course Outcomes

After the completion of course, student will be able to
CO1: select appropriate nonconventional processes for machining and micromachining for specific applications.
CO2: understand the requirements for high speed machining processes.
CO3: choose the applications of modern grinding technology.
CO4: assess the process parameters and capabilities of laser material processing techniques.

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	1								2	2		
CO2	2	1		1								1	2		
CO3	1	1										1	1		
CO4	1	1		1								1	1		

Syllabus

Unit 1
Non-traditional manufacturing processes - chemical machining – electro chemical machining - ultrasonic machining - physical setup, metal removal rate, process parameters, process capabilities, and applications.
Electrical discharge machining - wire EDM - abrasive flow machining - physical setup, metal removal rate, process parameters, process capabilities, and applications

Unit 2
High-speed machining: high performance machining of components. Application of HSM, improved material removal rate, surface finish and integrity, accuracy, economic considerations.

Unit 3
Modern grinding technologies, high speed and high performance grinding.Hard machining using single point tools.
Laser applications in manufacture: Cutting, welding, surface treatment, automation and in-process sensing.

Text Book
SeropeKalpakjian and Steven R. Schmid - 'Manufacturing Engineering and Technology' - Prentice Hall – 2013 - 7th Edition

Reference Books
Benedict G. F. - 'Non-Traditional Manufacturing Processes' - Marcell Dekker Inc., NY - 1987
Krar S. F. and Gill A. - 'Exploring Advanced Manufacturing Technologies' -Industrial Press - 2003

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE439 ADVANCED MATERIALS AND PROCESSES L-T-P-C: 3-0-0-3

Course Objectives

- To introduce composites and advanced materials and their applications
- To familiarize manufacturing, characterization of composite and aerospace alloys
- To provide knowledge about behaviour and applications of smart and nano-materials

Course Outcomes

CO1: interpret the properties and structure of composite and advanced material.
CO2: identify the appropriate fabrication technique for a composite and aerospace alloys
CO3: examine the different behaviour of materials for aerospace applications
CO4: summarize the properties and applications of smart and nano-materials

CO-PO Mapping

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

Syllabus

Unit 1
Composite Materials: Types of metal matrices and reinforcements and their properties, bonding mechanisms, structure-property relationships, preforms, design of composites. Physical and Mechanical properties. Characterization of microstructures and macrostructures. Fabrication techniques - metal infiltration, pressure and vacuum casting methods. Case studies.

Unit 2
Aerospace Alloys: High strength Aluminium and Magnesium alloys, Nickel and Cobalt based Superalloys, Titanium alloys, their structures, structure-property relationships, heat treatment. Directional solidification and single crystal turbine blades.Case studies.

Unit 3
Smart Materials: Concept of shape memory, crystal structure, phase transformation mechanism and characteristics, properties, classification, applications.
Nanomaterials: properties, classification, characterization, materials behaviour, fabrication and applications.

Text Books
Clyne T. W. and Withers P. J. - 'An Introduction to Metal Matrix Composites' - Cambridge University Press - 2003
Duerig T. W, Melton K. N., Stöckel D. and Wayman C. M. - 'Engineering Aspects of Shape Memory Alloys' - Butterworth Heinemann - 1990

Reference Books

'Handbook of Nanostructured Materials and Nanotechnology' - Academic Press - 2000
Wang Z. I., Liu Y. and Zhang Z. - 'Handbook of Nanophase and Nanostructured Materials: Vol 1. Synthesis' - Kluwer Academic/Plenum Publishers - 2002
Sinha A. K. - 'Physical Metallurgy Handbook' - McGraw Hill - 2002

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE440 ADVANCED METROLOGY AND SENSING SYSTEMS L-T-P-C: 3-0-0-3

Course Objectives

- To impart knowledge on the fundamentals of high precision measurements, laser metrology and Coordinate Measuring Machine (CMM)
- To facilitate an understanding on functioning and applications of machine vision system for quality control

Course Outcomes

CO1: Understand the various methods of high precision measurements and Ultrasonic techniques
CO2: Apply the methods of laser interferometry, Atomic Force techniques to measure surface topography and interpret the results
CO3: Understand and apply suitable programming commands to measure the critical features of a component using CMM
CO4: Select suitable Machine Vision system for image acquisition, processing and interpret the results for on-line quality control

CO-PO Mapping

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

Syllabus

Unit 1
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. Laser Metrology: Laser Interferometer, Alignment Telescope, laser scanners. On-line and in-process measurements - diameter, surface roughness, Micro holes, surface topography measurements, straightness and flatness measurement, speckle measurements

Unit 2
Coordinate Measuring Machine: CMM Types, Applications - Non-contact CMM using Electro optical sensors for dimensional metrology - Non-contact sensors 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.

Unit 3
Edge detection techniques, Normalization, Grey scale correlation – Reflectance map concepts; surface roughness and texture characterization - photogrammetry. Application of Machine Vision in inspection - Measurement of length, diameters, Surface roughness - automated visual inspection - 3D and dynamic feature extraction. On-line Quality control: On-line feedback quality control variable characteristics - control with measurement interval, one unit, and multiple units control systems for lot and batch production.

Text Books

Bechwith-Marangoni-Lienhard, "Mechanical Measurements", Pearson Education Asia, Sixth Edition, 2009.
Marshall A. D. and Martin R. R. - 'Computer Vision, Models and Inspection' - World Scientific - 1998

Reference Books

NelloZuech - 'Understanding and Applying Machine Vision' - Marcel Dekker - 2000 - 2nd Edition
John A. Bosch, Giddings, and Lewis Dayton - 'Coordinate Measuring Machines and Systems' - Marcel Dekker - 1999
ASTE - 'Handbook on Industrial Metrology' - Prentice Hall - 1992

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE441	ADVANCED WELDING TECHNOLOGY	L-T-P-C: 3-0-0-3

Course Objectives

- Elucidate the concepts of continuity, mechanism, physics, and design elements in welding process
- Comprehend the characteristics of weldable materials and welding technologies
- Demonstrate the importance of modelling and simulation of welding process
- Develop intellectual skills for correlating the microstructural evolution with the defects and properties of weldments

Course Outcomes

CO1: Describe welding processes, welding symbols, joint configurations, and heat source characteristics
CO2: Formulate governing equations and boundary conditions to simulate the thermal phenomenon in the course of a welding process
CO3: Evaluate the microstructural evolution on the properties of weldments
CO4: Identify appropriate techniques for detecting the welding defects

CO/PO Mapping

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

Syllabus

Unit 1
Overview of welding processes and their classification, types of joints, edge preparation, weld symbols, weld nomenclature, bead geometry, power density, heat sources - Gaussian distribution of heat flux, welding techniques - linear and orbital. Arc characteristics. Voltage-current characteristics. Types of welding manipulators and their applications.
Advanced welding processes: submerged arc, TIG, MIG, electro-slag, ultrasonic, electron beam and laser beam welding. Case studies and applications - industrial, automotive and aerospace.

Unit 2
Thermal modeling and simulation of welding processes - governing heat transfer equations and boundary conditions for various types of welding processes. Estimation of cooling rates. Prediction of mechanical properties, micro/macro-structures of weldments and heat-affected zone. Prediction of weld defects such a crack, segregation, lack of fusion. Modeling and simulation of pulsed arc processes. Use of softwares for simulation.
Solidification behaviour of fusion weld: structural zones, epitaxial growth, weld pool shape and columnar grain structures. Weldability of metals- steels, stainless steels, aluminium, copper, nickel and titanium alloys.

Unit 3
Microstructures of weldment.Segregation of alloying elements.Impact of micro/macro-structures and segregation on mechanical properties.Pre- and post-treatment. Effects of heat flow on residual stresses and distortion. Weldability tests.

Welding defects - causes and remedies.Methods of testing weldments - mechanical, pressure and leak testing.Inspection methods - visual, penetrant, magnetic, ultrasonic, x-ray and gamma radiography.Use of imaging techniques for online monitoring.

Text Books

Khanna O. P. - 'A Text Book on Welding Technology' – Dhanpat Rai and Sons, New Delhi - 2013
Parmar R. S. - 'Welding Process and Technology' - Khanna Publishers, Delhi - 1992

Reference Books

Little R. L. - 'Welding and Welding Technology' - Tata McGraw Hill Publishing Company Limited, New Delhi - 1989
Grong O. - 'Metallurgical Modelling of Welding' - The Institute of Materials - 1997 - 2nd Edition
Kou S. - 'Welding Metallurgy' - John Wiley Publications, New York - 2003 - 2nd Edition.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE442	MICRO-MANUFACTURING	L-T-P-C: 3-0-0-3

Course Objectives

- To impart knowledge on principles and working of various micro-machining processes and its applications
- To facilitate an understanding of micro-fabrication, micro metrology and its applications

Course Outcomes

CO1: Understand the basic concepts of micro-machining processes
CO2: select suitable micro-machining process for a given application
CO3: apply various micro-fabrication process for fabrication of a given component
CO4: Appreciate the requirements of various micro-metrological instruments

CO-PO Mapping

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

Syllabus

Unit 1
Micromachining – definition - principle of mechanical micromachining - Classification of micromachining and nanofinishing processes - Molecular dynamics simulations of machining at atomic scale.
Diamond Turn Machining (DTM) - components of DTM – requirements of DTM - material removal mechanism – molecular dynamics - tool geometry. Abrasive Jet Micromachining - erosion mechanism - powder feeding - microstructure fabrication.Ultrasonic micromachining – basic elements - mechanism of material removal - micro-hole drilling, contour machining, micro-de-burring, machining of ceramic materials.Electrochemical micromachining.

Unit 2
Micro-electric discharge micromachining – principle - Micro EDM system development - process parameters - Analytical Modeling.Laser micromachining techniques and their applications.Focused Ion Beam machining. Electro chemical spark micromachining – mechanism - equipment. Electron beam micromachining – mechanism-process parameters - applications.

Unit 3
Microfabrication - Materials for Microsystems manufacture - Substrates and Wafers, active substrate materials, silicon and silicon components. Photolithography based micro fabrication processes - Photo resist development. Additive and subtractive techniques – CVD –PVD – etching - chemical, plasma - resists removal. Large aspect ratio micro manufacturing - LIGA, Deep Reactive Ion Etching.
Micro Metrology - Scanning Electron Microscopy, optical microscopy, atomic force microscope, molecular measuring machine, Micro-CMM, Transmission electron microscope – principles - applications.

Text Books
Madou M. J. - 'Fundamentals of Microfabrication' - CRC Press - 2009 - 2nd Edition
Jain V. K. - 'Introduction to Micromachining' - Narosa Publishing House - 2010

Reference Books

Ran Hsu, T. R. 'MEMS & Microsystems: Design and Manufacturing' - Tata McGraw- Hill - 2002
Mohamed Gad-el-Hak - 'The MEMS Handbook' - CRC Press - 2002

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE443	NON-DESTRUCTIVE TESTING	L-T-P-C: 3-0-0-3

Course objectives

- To impart knowledge on various NDT methods
- To describe appropriate techniques to detect the defects in components
- To impart knowledge on quantification and calibration of equipment

Course outcomes

CO1: Apply the various NDT techniques to identify the defects
CO2: Select the suitable NDT techniques for various defects
CO3: Identifying the nature and quantifying the defects
CO4: Understand the instruments and interpretation on techniques

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	1		
CO3	2	1							1			1	1		
CO4									1			1	1		

Syllabus

Unit 1
Introduction: Non-Destructive testing - Relative Merits and Limitations - NDT vs Mechanical testing. Dry technique and Wet technique – Principle – Applications - Advantages and Limitations.Dyes - Developers – Cleaners. Fluorescent penetrant test.Liquid penetrant inspection.
Radiography: X-rays and Gamma rays, Properties of X-rays relevant to NDT - Absorption of rays - scattering. Types and use of Filters – screens - Geometric factors, Film type and Processing. Characteristics of films graininess, Density, Speed, Contrast. Characteristic curves. Characteristics of Gamma rays - fluoroscopy – X-ray – Radiography.Safety with X-rays and Gamma rays.

Unit 2
Ultrasonic Testing: Types of Ultrasonic Waves - Principles of wave propagation - Characteristics of ultrasonic waves - Attenuation. Production of ultrasonic waves - Couplants. Inspection methods - pulse echo, Transmission and Resonance techniques. Thickness measurement.Types of scanning. Test block - Reference blocks.

Unit 3
Techniques for Specific Purposes: Magnetic particle inspection - Principles – Applications - Magnetization methods - Magnetic particles, demagnetization. Eddy current testing - Thermal inspection Principle, Application - Instrumentation of Thermal Inspection. Holography.Acoustic Emission.Pressure and Leak Testing.Chemical Spot Testing. Spark Testing.

Text Books
Cartz L. - 'Non-Destructive testing' - ASM International, Metals Park Ohio, US - 1995
Raj B., Jayakumar T., and Thavasimuthu M. - 'Practical Non-Destructive Testing' - Narosa, New Delhi – 1997

Reference Book

ASM Metals Hand Book, 'Non-Destructive Evaluation and Quality Control' - American Society of Metals, Metals Park Ohio, USA - 1989

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE444	PRODUCT COST ESTIMATION	L-T-P-C: 3-0-0-3

Course Objectives

- To facilitate estimation of time for machining, welding, forging and allied processes.
- To impart knowledge on cost estimation of a product by considering various manufacturing processes.

Course Outcomes

CO1: Identify the various cost elements involved in total cost of the product
CO2: Estimate the cost of manufacturing a component by welding, casting and forging operations
CO3: Calculate the time taken for various machining operations
CO4: Apply appropriate methods for calculating depreciation

CO-PO Mapping

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

Syllabus

Unit 1
Cost estimation: Importance and aims of cost estimation - functions of estimation - difference between estimating and costing - importance of preparing realistic estimates - estimating procedure. Elements of cost, Objectives - elements of costs - ladder of cost - determination of material cost - labour cost - expenses.

Unit 2
Analysis of overhead expenses, Distribution of overhead costs – depreciation - causes of depreciation - methods of calculating depreciation**.**
Estimation of machining time, Calculation of machining time for lathe operations-estimation of drilling time on drilling machine - estimation of time for shaping, planning, milling and grinding**.**

Unit 3
Costing for metal forming and fabrication processes, Estimation of cost in welding- estimation in forging shop - cost estimation of foundry work.

Text Books
Banga T. R. and Sharma S. C. - 'Mechanical Estimating and Costing including Contracting" - Khanna Publishers - 2011
O. P. Khanna - 'Mechanical Estimating and Costing' – Dhanpat Rai Publishers – 1999

Reference Books
Narang G. B. S and Kumar V. - 'Production and Costing' - Khanna Publishers - 2004
Adithan M. and Pabla B. S. - 'Production Engineering Estimating and Costing' - Konark Publishers (P) Ltd. - 1998

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE445 QUALITY CONTROL AND RELIABILITY ENGINEERING L-T-P-C: 3-0-0-3

Course Objectives

- To introduce the principles and techniques of statistical quality control and their applications.
- To familiarize with basic concepts and techniques of reliability engineering

Course Outcomes

CO1: Apply the knowledge of statistics and probability to attain the quality improvement in industries
CO2: Analyze the product quality using statistical tools
CO3: Determine the reliability and maintainability of systems

CO-PO Mapping

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

Syllabus

Unit 1
Introduction: Review of statistics and probability. Quality related costs, contemporary quality engineering philosophy, Quality systems and international standards and 6 Sigma. Control charts for variables: X-bar and R charts, X-bar and S charts; Control charts for individual measurements; Exponentially Weighted Moving Average (EWMA) and Deviation (EWMD) charts.

Unit 2
Control charts for attributes: p, np, c, and u charts Interpretation of control charts. Average Run Length (ARL) Study.Multivariate quality control. Control charts for short production runs, Modified acceptance control charts. Sensitivity analysis- Process capability analysis.
Introduction to Reliability: Concepts and definition of Reliability – Reliability mathematics – failure distributions.

Unit 3
Hazard models – hazard rate function – failure density function – conditional reliability – exponential, Rayleigh, Weibull, Normal and Lognormal distributions – two-parameter exponential and three-parameter Weibull distributions – MTTF, MTBF – design life.
Reliability of simple Systems – Series and parallel configurations – Reliability improvement – redundancy – combined series and parallel systems – High level and low level redundancy – k-out of n system – standby redundancy.
Maintainability – Factors affecting maintainability of systems – Design for maintainability - MTTR – Maintenance – spare provisioning.

Text Books
Montgomery D. C. - 'Introduction to Statistical Quality Control' - John Wiley - 2010
Ebeling C. - 'An Introduction to Reliability and Maintainability Engineering' - Tata McGraw Hill Publishing Company Ltd. – 2004

Reference Books

Eugene G. L. - 'Statistical Quality Control' - McGraw-Hill - 1996
Srinath L. S. - 'Concept in Reliability with an Introduction to Maintainability and Availability' - Associated East-West - 1998
Rao S. S. - 'Reliability Based Design' - McGraw Hill - 1992
O'cconer P. D. T. - 'Practical Reliability Engineering' - John Wiley & Sons Ltd. - 2003

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE446 SIMULATION MODELING 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

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

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

Syllabus

Unit1
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

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE345	SUSTAINABLE MANUFACTURING	L-T-P-C: 3-0-0-3

Course Objectives

- Familiarize the concept of sustainability manufacturing with tools and techniques
- Inculcate knowledge on performing life cycle analysis

Course Outcomes

CO1: Understand the concept of sustainable manufacturing
CO2: Utilise 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

PO/PSO / CO	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 methds-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 Book
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

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continues Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

THERMAL STREAM

19MEE351	COMPUTATIONAL FLUID DYNAMICS	L-T-P-C: 2-0-3-3

Course Objectives

- To study the basic governing equations and understand the basic properties of CFD.
- To understand discretization techniques and solving methods for improving accuracy.
- To inculcate the knowledge required to solve real time physical problems using simulation software.

Course Outcomes

CO1: Understand the classification of PDEs, governing equations
CO2: Understand the basic principles of computational methods
CO3: Apply finite volume method to solve steady and unsteady diffusion, advection-diffusion problems
CO4: Understand Solution algorithms and various discretization schemes.
CO5: Solve engineering problems using CFD software

CO-PO Mapping

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

Syllabus

Unit 1
Introduction to Computational Fluid Dynamics and Principles of Conservation: Continuity Equation, Navier Stokes Equation, Energy Equation and General Structure of Conservation Equations, Classification of Partial Differential Equations and Physical Behaviour, Approximate Solutions of Differential Equations: Error Minimization Principles.

Fundamentals of Discretization: Finite Element Method, Finite Difference and Finite Volume Method, Consistency, Stability and Convergence. 1-D Steady State Diffusion Problems- Source term linearization, Implementation of boundary conditions

Unit 2
1-D unsteady state diffusion problems: implicit, fully explicit and Crank-Nicholson scheme. Finite volume discretization of convection-diffusion problem.
Central difference scheme, Upwind scheme, Exponential scheme and Hybrid scheme, Power law scheme, Generalized convection-diffusion formulation, Finite volume discretization of two-dimensional convection-diffusion problem.

The concept of false diffusion, QUICK scheme, TVD schemes and flux limiter functions.

Unit 3
Finite Volume Discretization of 2-D unsteady State Diffusion type Problems, Solution of Systems of Linear Algebraic Equations: Elimination Methods, Iterative Methods

Discretization of Navier Stokes Equations, primitive variable approach, SIMPLE Algorithm, SIMPLER Algorithm, Unstructured Grid Formulation.
Introduction to Turbulence Modeling, Important features of turbulent flow, General Properties of turbulent quantities, Reynolds average Navier stokes (RANS) equation, Closure problem in turbulence: Necessity of turbulence modeling and applications.
Laboratory practice

Text Books

Versteeg, H.K., and Malalasekara, W, "An Introduction to Computational Fluid Dynamics", The Finite Volume Method, 2007.
Moukalled, F., Mangani, L., &Darwish, M. "The finite volume method in computational fluid dynamics. An Advanced Introduction with OpenFOAM and Matlab", 2016.

Reference Books

Patankar, S.V., "Numerical Heat Transfer and Fluid Flow", Hemisphere Publishing Corporation, 1980.
Anderson, J. D., & Wendt, J., "Computational fluid dynamics" (Vol. 206). New York: McGraw-Hill, 1995.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment (Theory) (CAT)	10	
*Continuous Assessment(Lab) (CAL)	40	
End Semester		30

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE352	GAS DYNAMICS AND JET PROPULSION	L-T-P-

Course Objectives

- To discuss the effect of compressibility in gas flow
- To derive the steady one-dimensional isentropic flow equation
- To discuss the effects of friction and heat transfer on compressible flows through constant area duct
- To familiarize the occurrence of shocks and calculate property changes across a shock wave
- To derive the thrust equation and discuss its application in jet and rocket propulsion

Course Outcomes

CO1: Apply the thermodynamics concepts in relation to compressible flows and derive relationships between various compressible flow parameters
CO2: Understanding of isentropic compressible flows in variable area ducts and apply in design of static components like nozzles and diffusers
CO3: Solve for compressible flow characteristics with friction and heat transfer
CO4: Develop relationship for shocks and determine their characteristics under various conditions
CO5: Analyse the performance of aircraft and rocket propulsion engines

CO-PO Mapping

PO/PSO / CO	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	1	1								1	3		
CO3	3	3	1	1								1	3		
CO4	3	3	1	1								1	3		
CO5	3	3	1	1								1	3		

Syllabus

Unit 1
Basic concepts: Energy and momentum equations of compressible fluid flows - Stagnation states - Mach waves and Mach cone - Effect of Mach number on compressibility. Isentropic flows: Isentropic flow through variable area ducts. (10 hours)
Isentropic Flow: Nozzle and Diffusers, compressors and turbines - Use of Gas tables. Flow through ducts: Flow through constant area ducts with heat transfer (Rayleigh flow) and Friction (Fanno flow) - Variation of flow properties - Use of tables and charts - Generalized gas dynamics. (10 hours)

Unit 2
Normal and oblique shocks: Governing equations - Variation of flow parameters across the normal and oblique shocks - Prandtl Meyer relations – Expansion of supersonic flow, Use of table and charts - Applications. (10 hours)

Unit 3
Jet propulsion: Theory of jet propulsion - Thrust equation - Thrust power and propulsive efficiency - Operation principle - cycle analysis and use of stagnation state performance of ram jet, turbojet, turbofan and turbo-prop engines – Aircraft combustors. (7 hours)
Space propulsion: Types of rocket engines - Propellants - Ignition and combustion - Theory of rocket propulsion – Performance study - Staging - Terminal and characteristic velocity - Applications - Space flights.(8 hours)

Text Book

Yahya S. M. "Fundamentals of Compressible Flow with aircraft and rocket propulsion", 5/e,New Age International publishers, 2016.

Reference Books

Balachandran P. "Fundamentals of Compressible Fluid Dynamics", PHI Learning India Private Ltd., 2009.

John D. Anderson Jr. "Modern Compressible Flow with historical perspective", 2/e, McGraw Hill Publishing company , International Edition, 1990.

Shapiro A. H. "Dynamics and Thermodynamics of Compressible Fluid Flow – Volume I",John Wiley, New York, 1953.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE353	HVAC SYSTEMS & APPLICATIONS	L-T-P-C: 3-0-0-3

Course Objectives

- To introduce basic concepts in refrigeration and air-conditioning
- To impart knowledge on refrigerants for domestic and industrial applications
- To familiarize cooling/ heating load calculations for a given application

Course Outcomes

CO1: Identify the suitability of refrigeration systems
CO2: Select refrigerants and components like evaporator, compressor, condenser, expansion devices etc. based on operational characteristics
CO3: Design of refrigeration and air-conditioning systems using fundamentals of heat and mass transfer principles
CO4: Evaluate the performance of an air-conditioning system
CO5: Estimate cooling / heating load for given application

CO-PO Mapping

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

Syllabus

Unit 1
History of refrigeration, **Refrigeration cycles**: vapour Compression Cycle and vapour absorption systems. Thermodynamic analysis of cycles.**System components**: **Refrigerant Compressors**-Reciprocating, Hermetic, Rotary, Centrifugal Scroll Compressors -Comparison, Construction and Operation characteristics. **Evaporators** - DX coil, flooded type Chillers, Condensing Units and Cooling Towers.

Unit 2
Refrigerants: Desirable properties, Classification, Designation, Alternate Refrigerants, Global Warming Potential & Ozone Depleting Potential aspects
Expansion devices: Automatic Expansion Valves, Capillary Tube & Thermostatic Expansion Valves. **Cycling controls and system balancing:** Pressure and Temperature controls, Range and Differential settings.
Selection and balancing of system components - Graphical method.

Unit 3
Psychrometry: Moist air behaviour - Psychrometric chart - Different Psychrometric process and their analysis.
Air conditioning: Summer and Winter Air conditioning - Cooling Load Calculations - Air Distribution Patterns - Dynamic and Frictional Losses in Air Ducts - Equal Friction Method - Fan Characteristics in Duct Systems.

TextBook
Ramesh Chandra Arora. "Refrigeration and Air Conditioning", Prentice Hall India, 2015.

Reference Books

Stocker W. F. and Jones J. W. 'Refrigeration & Air Conditioning' - McGraw Hill, 1985.
Dossat R. J. "Principles of Refrigeration", John Wiley, 1989.
Goshnay W. B. "Principles and Refrigeration", Cambridge University Press,1982.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE354	POWER PLANT ENGINEERING	L-T-P-C: 3-0-0-3

Course Objectives

- To familiarize various types of power plants and their site selection
- To familiarize thermal power plant operations, mountings, accessories and its economic viability
- To design systems such as chimney, cooling tower and surface condenser for power plants
- To conceptualize the working of nuclear power plants and to create an awareness on environmental and safety aspects

Course Outcomes

CO1: Select a suitable location for a power plant
CO2: Analyse the performance of thermal power plant
CO3: Select fuel handling and ash handling methods in thermal power plants
CO4: Design chimney, cooling towers and condensers for power plants
CO5: Performance analysis of nuclear power plants

CO/PO Mapping

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

Syllabus

Unit 1
Hydrological data - capacity and type -selection - General layout and types of hydroelectric Power Plants.
Steam power plant layout and components - steam generators - functions of feed water heaters- super heaters–air Preheaters - economizers and re-heaters.
Combustion equipment and firing methods- Fuel bed combustion, Mechanical Stokers, Pulverized Coal firing system, Fluidized Bed Combustion, Cyclone furnace, Coal gasifiers. Ash and Dust handling systems
Types of condensers - cooling towers - Water treatment methods

Unit 2
Cogeneration. Elementary treatment of combined cycle power generation.
General layout of diesel power plant and their components - Types of plant layouts - comparison of diesel plant with thermal plant.
Comparison and types of gas turbine power plants and their components, combined gas and steam power plants - Advantages of gas turbine plant over diesel and thermal plants.

Unit 3
General components of Nuclear reactors - types of reactors - location safety and economics of nuclear plants - comparison with thermal power plants.
Economics of power plant operation - variable load operation and economics.

Text Book

Nag .P.K."Power Plant Technology", 4/e,McGraw Hill, 2008..

Reference Books

El WakilM. M. "Power Plant Technology", 5/e, McGraw Hill, 2010.
Weisman.J. and Eckart.R. "Modern Power Plant Engineering",Prentice Hall, 2002.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE355	TURBO MACHINERY	L-T-P-C: 3-0-0-3

Course Objectives

- To classify the turbo-machines based on energy interactions
- To study the performance characteristics of turbo-machines under different operating conditions
- To inculcate knowledge in the thermal design of turbo-machines

Course Outcomes

CO1: Compare the features and working of various turbo machines
CO2: Apply the concepts of energy transformation in turbo machines
CO3: Analyse the performance of Hydraulic pumps and turbines
CO4: Design and evaluate the critical parameters involved in power generation
CO5: Evaluate the performance of axial and centrifugal compressors

CO-PO Mapping

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

Syllabus

Unit 1
Definition and Classification of turbo machines - Specific Work - T-s and h-s Diagram - Incompressible and compressible flow – Losses - Total–to–Total efficiency - Total-to-Static efficiency - Effect of reheat and preheat factor. Degree of reaction. Energy transfer - Euler's equation, velocity triangles.
Dimensional analysis, Dimensionless parameters and their physical significance, specific speed, Hydraulic Pumps: Centrifugal Pumps – Some definitions - Pump output and Efficiencies - Effect of Vane angle – Cavitation - Pump Characteristics - Multistage pumps.

Unit 2
Hydraulic Turbines: Classification of hydraulic turbines - Velocity triangles. Efficiencies of draft tubes - Hydraulic turbine characteristics. Francis and Kaplan turbines - Velocity triangles - Efficiencies of Draft tubes - Turbine characteristics.
Elementary cascade theory, cascade nomenclature, compressor cascade, turbine cascade, cascade efficiency. Dimensional analysis of compressible flow machines, stalling and surging.

Unit 3
Centrifugal Compressors: Constructional details - Stage Pressure rise - Stage Pressure Coefficient - Stage Efficiency - Degree of Reaction - Various Slip factors - Introduction to Fans and Blowers, Working principle, Fan laws, Performance Characteristics.
Axial flow Compressors: general expression for degree of reaction; velocity triangles for different values of degree of reaction, Blade loading and flow coefficient, Static pressure rise, Work done factor.

Steam and Gas Turbines: Axial turbine stages - Stage velocity triangles – Work - Single stage impulse turbine - Speed ratio - Maximum utilization Factor - Compounding of Turbines and its types, Degree of Reaction - Reaction Stages. Inward Flow radial turbine stages (IFR) - Working principle and Performance Characteristics.

Text Book

Yahya S. M. "Turbines, Fans and Compressors",4/e,Tata McGraw Hill Publishing Company Limited ,2011.

Reference Books

Dixon S. L. "Fluid Mechanics & Thermodynamics of Turbomachinery", 6/e, Elsevier, 2012.
Douglas J. F., Gasiorek J. M. &Swaffield J. A. "Fluid Mechanics", Addison-Wesley, 1999.
Valanarasu.A. "Turbo machines", 2/e, Vikas publishing house private limited, 2001.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE356	AUTOMOTIVE TECHNOLOGY	L-T-P-C: 3-0-0-3

Prerequisites: Thermodynamics, Mechanics of Solids, Material Science and Metallurgy

Course Objectives

- To familiarize fundamental knowledge about evolution of automobiles and its construction.
- To impart knowledge on mechanical, electrical and electronic systems of an automotives
- To familiarize the various aspects of performance of automotives and to study the future technology in automotives

Course Outcomes

CO1: Identify the functional requirements of automobile systems and components
CO2: Demonstrate the working principles of steering, suspension and braking system of automobiles
CO3: Make use of advanced electrical and electronics system in automotives
CO4: Realize the advancements in the future of automotive technology

CO/PO Mapping

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

Syllabus

Unit 1
Vehicle and Engine Construction - Chassis, Frame and Body Construction, Engine Types, Construction Details and multi-cylinder engines, Valve Arrangements, Valve Drives, Engine Cooling and Lubrication, Air Supply System, Carburetors, Electronic Fuel Injection Systems, Exhaust Systems
Power Drive Line: Clutch - Types and Construction, Fluid Coupling, Transmissions - Manual, Semi and Automotive Transmission, Continuously Variable Transmission, Overdrives, Torque Converter, Propeller Shaft, Differential and Axles, Front and All Wheel Drive Vehicles

Unit 2
Running Systems: Steering Geometry and Types, Steering Linkages, Power and Power Assisted Steering, Types of Front Axle, Suspension Systems, Suspension Design Consideration Active Suspension, Braking Systems - Hydraulic, Pneumatic Brakes and Power Brakes, Anti-Lock Brake system - Wheels and Tyres, Electrical and Electronic Systems: Electrical Systems – Storage, Charging, Starting and Ignition and Lighting Systems.

Unit 3
Electronic Controls for Engine and Vehicle Body, Electronic Dashboard Instruments, Electronic and Computer Controlled Transmissions, Intelligent Transportation Systems. On-board diagnosis system, Safety and Security systems.
Future Automobiles: Automobile Air Pollution, Pollution Control Norms, Alternate Power Units for Automobiles - Use of Natural Gas, LPG and Hydrogen in Automobiles as Fuels, Fuel Cells, Electric and Hybrid Vehicles

Text Books

Heisler H. - 'Advanced Engine Technology' - SAE - 2012
William H. Crouse, Donald Anglin – 'Automotive Mechanics' - McGraw Hill Education (India) Private Limited- 2006 - 10th Edition

Reference Books

Garrett T. K., Newton K., and Steeds W. - 'Motor Vehicles' - Butterworth Heinemann - 2001
Fenton J. - 'Handbook of Automotive Body and System Design' - Professional Engineering Publishing, UK - 2005
Giri N. K. - 'Automobile Mechanics', Khanna Publishers, New Delhi - 2006 - 8th Edition
Bishop R. - 'Intelligent Vehicle Technology and Trends' - AR Tech House Inc. – 1999

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE357	SOLAR AND WIND POWER TECHNOLOGIES	L-T-P-C: 3-0-0-3

Pre-requisites: Thermodynamics, Fluid Mechanics and Heat Transfer

Course Objectives

- To introduce the conversion technologies related to solar and wind power
- To familiarize the photovoltaic and thermal conversion of solar radiation
- To inculcate the feasibility of harvesting wind power

Course Outcomes

CO1: Develop knowledge in solar radiation, its measurement and associated conversion technologies
CO2: Compare the different forms of solar thermal collectors
CO3: Understand the basics of wind energy conversion
CO4: Assess potential of wind energy as an alternate form of non-conventional energy

CO/PO Mapping

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

Syllabus

Unit 1
Properties of Sun Light- Solar Radiation - Atmospheric effects - Solar Geometry - Measuring Instruments - Estimation of Solar Radiation. Solar cell physics & characteristics - Stand Alone PV System, Cost analysis and pay back calculations; Environmental and safety issues.
Solar Thermal Collectors – Flat plate collector construction and analysis – Thermal resistance network model –Heat transfer correlations – Concentrating type collectors – Construction and working – Tracking mechanisms.

Unit 2
Solar thermal energy utilisation – Heliostats with central receiver – Solar air heater – Solar chimney; Solar thermal power plants– Low, medium and high temperature systems – Performance analysis.
Solar water heaters – Thermosyphon heaters – Active and passiveheating. Solar Ponds – Convective and non-convective ponds – Salt gradient solar pond – Experimental studies; Water desalination using solar still; Solar refrigeration.

Unit 3
Meteorology of wind: Global circulation, Forces influencing wind, Local Wind systems,
Wind Turbines: Types, Rotor elements; Horizontal and vertical axis wind turbines, Power in the wind, Power extracted from wind, Betz limit, Lift and drag coefficients, thrust and torque, power coefficient, thrust coefficient, axial interference factor. Pitch and stall regulation,
power curve, energy calculation.

Text Books

*John A. Duffie and W. A. Beckman, "*Solar Engineering of Thermal Processes*", John Wiley and Sons, 2013.*

*ErichHau, "*Wind Turbines- Fundamentals: Technologies, Application, and Economics*". Springer –VerlagBerlin - Heidelbeg, 2000*.

Reference Books

*Wenham SR, "*Applied Photovoltaic*", 2/e, Earthscan Publications Ltd, 2007.*

*G.N. Tiwari, "*Solar Energy-Fundamentals, Design, Modeling and Applications*", Narosa Publishers, 2002.*

*Joshua Earnest and Tore Wizelius, "*Wind Power Plants and Project Development*", PHI Learning Pvt. Ltd., New Delhi, 2011*.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE358	IC ENGINES AND EMISSION	L-T-P-C: 3-0-0-3

Course Objectives

- To familiarize mixture requirement for SI and CI for complete combustion using thermodynamic analysis
- To familiarize normal and abnormal combustion from pressure data and interpret its effect on engine performance.
- To introduce the effect of boosting devices on engine performance, emission, heterogeneous combustion and spray behaviour
- To appraise the need for alternate fuels and methods to reduce emissions

Course Outcomes

CO1: Analyze thermo-chemistry of combustion by applying thermodynamic laws in engine cycles
CO2: Understand and analyse the operation of internal combustion engines
CO3: Elucidate the effect of supercharging and turbo-charging on engine performance
CO4: Understand various fuel-metering systems like CRDI, PFI, GDI diesel fuel injection system and latest technology in fuel injection systems in SI and CI engines
CO5: Understand emission control techniques in engines, based on emission standards/norms and to recommend modification in engine for using alternate fuels

CO-PO Mapping

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

Syllabus

Unit 1
Spark Ignition engines: Mixture requirement-Fuel injection systems. Stochiometric combustion-combustion with excess air-equivalence ratio
Stages of combustion: Normal and Abnormal combustion-Knock. Combustion chambers.Simple thermodynamic analysis of SI engine combustion. (13 hours)

Unit 2
Compression ignition engines: Nature of combustion in IC engines-Direct and Indirect injection systems- Air motion-Combustion Chambers-Spray penetration and evaporation. Supercharging - Turbo charging. Thermodynamic analysis of CI engine combustion. WankelEngine: Operation & applications. Hybrid engines.
Thermo chemistry: Pollutant formation, Instrumentation to measure pollutants-Pollutant calculation-Effect of air-fuel ratio.

Unit 3
Emission standards: EGR on engine emissions-Emission standards-Emission control devices. Thermal & catalytic exhaust clean-up-catalysts-automotive catalytic converters-Engine modifications to reduce emissions. Heat release analysis of IC engines.

Alternate Fuels: Engine modifications for alternate fuels (liquid and gaseous fuels), homogenous charge compression ignition engines.Additives for enhancing performance and pollution control.

Text Books

Heywood, J. B., 'Internal Combustion Engine Fundamentals', McGraw-Hill, First Indian edition, 2017.
BS VI emission norms (ARAI)

Reference Books

Ferguson, C.R, 'Internal Combustion Engines', John Wiley, 1989.
Degobert, P., 'Automobiles and Air Pollution', SAE, 2002
B.P.Pundir, 'IC Engines Combustion and Emissions',Narosa Publishing House, 2010

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE359	ADVANCED FLUID MECHANICS	L-T-P-C: 3-0-0-3

Course Objectives

- To familiarize kinematic and dynamic behaviour of fluid flow
- To introduce Navier-Stokes equationpertinent to steady and unsteady flows
- To introduce flow dynamics over immersed bodies
- To impart knowledge on origin and nature of turbulence

Course Outcomes

CO1: Evaluate instantaneous fluid velocity and track the fluid particles in the flow field, compute flow rate and pumping power of the fluid
CO2: Solve benchmark problems using NSE to estimate the velocity profile and shear stress
CO3: Apply NSE in real time engineering problems to model low and high Reynolds number flow and boundary layer flows
CO4: Estimate the total drag and lift forces associated with structures immersed in the fluid
CO5: Predict the length scale of eddies and Reynolds stress

CO-PO Mapping

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

Syllabus

Unit 1
Fundamentals of Fluid Dynamics
Differential approach - the Material Derivative, Integral Approach – RTT, Flow visualization - Path Lines, Streamlines, streaklines, Rate of Deformation, Vorticity and Circulation, The Stream Function Equation, The Vorticity Transport Equation, Conservation Equations – mass, momentum, energy, Boundary Conditions.

Exact Solution of Navier Stokes Equation
Couette (wall–driven) steady flow, Poiseuille(Pressure driven)steady duct flow, and Unsteady Duct Flow

Unit 2
Approximate Solution of Navier Stokes Equation
Creeping flow, inviscid region of flow, Irrotational flow – uniform flow, source, sink, doublelet, vortex, Hele – ShawRankine half body, Rankine Oval, Superposition principle
Boundary Layer Theory
Boundary Layer concept, Boundary layer equations for 2D flows, Blasius Similarity Solution, Karman Momentum integral Equation, Boundary layer thicknesses, Boundary Separation with various pressure gradient, Laminar and Turbulent boundary layers and sports ball dynamics

Unit 3

Flow Over Bodies: Drag And Lift

Drag and Lift, Friction and Pressure Drag, Reducing Drag by Streamlining, Flow Separation, Drag Coefficients of Common Geometries, Parallel Flow over Flat Plates, Friction Coefficient Flow over Cylinders and Spheres, D'Alembert's Paradox. Effect of Surface Roughness, Lift - End Effects of Wing Tips Lift Generated by Spinning

Introduction to turbulence

Nature of Turbulence, Origin of turbulence, Characterization of turbulence,Kolmogorov Hypothesis and Energy Cascade, Reynolds modification of Navier-Stokes equations, Reynolds stresses, Turbulence Models – Prandtl Mixing length Model

Text Book

Robert W. Fox, Alan T. McDonald, &Philip J., "Fluid Mechanics", 8/e, John Wiley & Sons Inc., 2017

Reference Books

Ronald L. Panton, "Incompressible Flow", 4/e,John Wiley & Sons Inc., 2011
Pijush K. Kundu, Ira M. Cohen,& David M. Dowling, "Fluid Mechanics", 5/e, Academic Press., 2012
Yunus A Cengel& John Cimbala, "Fluid Mechanics: Fundamentals and Applications", 3/e McGraw Hill., 2017
K Muralidhar and G Biswas, "Advanced Engineering Fluid Mechanics", 3/e,Narosa Publishing House.,2001

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE360	ELECTRIC VEHICLE DESIGN	L-T-P-C: 3-0-0-3

Course Objectives

- To familiarize with the basic electric components configuration for the Electric Propulsion unit.
- To expose utilization of different Energy storage system and Hybridization.
- To inculcate the knowledge while resolving issue of Energy management system

Course Outcomes

CO1: Understand the Electric components in detail.
CO2: Apply controls of different motors for drive system efficiency.
CO3: Understand various Energy storage devices including the Hybridization.
CO4: Apply Energy management system strategies to solve problems

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										2		
CO2	3	1	2										2		
CO3	3	1	1				2						2		
CO4	3	1	1				2						2		

Syllabus

Unit 1

Electric Propulsion unit: Introduction to Electric Vehicle Dynamics
Introduction to electric components used in electric vehicles.
Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives.
Configuration and control of Switch Reluctance Motor drives, drive system efficiency.

Unit 2

Energy Storage: Introduction to Energy Storage Requirements Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis.
Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis.
Hybridization of different energy storage devices.

Unit 3

Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles
Classification of different energy management strategies, comparison of different energy management strategies
Implementation issues of energy management strategies.

Text Book

Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals", CRC Press, 2003.

Reference Books

MehrdadEhsani, YimiGao, Sebastian Longo, KambizEbrahimi, "Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design", CRC Press, Third edition.
James Larminie, John Lowry, "Electric Vehicle Technology" Wiley, Second edition.2012.
SandeepDhameja, "Electric Vehicle Battery Systems", Newnes, 2001

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE344	BIOMASS ENERGY CONVERTION TECHNIQUES	L-T-P-C: 3-0-0-3

Pre-requisites: Engineering Chemistry, Thermodynamics, Heat Transfer

Course Objectives

- To introduce the energy conversion technologies related to biomass
- To familiarize the properties of biomass and its energy products
- To analyze the feasibility of power production from biomass sources

Course Outcomes

CO1: Develop knowledge in properties of biomass and energy conversion process
CO2: Compare the characteristics of products obtained from biomass pyrolysis
CO3: Understand the basics of biomass gasification and gasifier design
CO4: Assess the potential of electrical power production from biomass

CO-PO Mapping

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

Unit I
Biomass as energy source – Sources – Biomass conversion processes – Biological – Thermal – Chemical – Hybrid conversions – Application of biomass conversion products – Biomass properties for conversion process – Physical properties : Particle size, distribution, heat capacity and thermal conductivity – Thermal properties : Proximate, Ultimate and heating value analysis – Biomass pretreatment processes – Biodiesel and bioethanol : Sources and extraction methods.

Unit II
Torrefaction – products obtained – properties of torrified biomass – Physical and chemical – composition changes – torrefaction as pretreatment process – Pyrolysis – types – effects of process parameters – Product characterization techniques – oxidation stability – Bio-oil upgradation - applications – Liquefaction – direct and indirect methods – advanced liquefaction techniques.

Unit III
Biomass gasification – chemistry – types of gasifiers – gasifier design : TDR, throughput, A/F ratio and equivalence ratio calculations – advanced gasification – fluidized bed gasifier – component design – cold fluidization tests – Electrical power production - Biomass combustion – types of combustors – Co-combustion and Co-firing – applications – Eutectic point of biomass ash.

Text book
Sergio C. Capareda "Introduction to Biomass Energy Conversions", 2019, CRC Press, Taylor and Francis Group.
Sergio C. Capareda "Introduction to Renewable Energy Conversions", 2019, CRC Press, Taylor and Francis Group.

References

Erik Dahlquist, "Biomass as Energy Source: Resources, systems and applications", Sustainable Energy Developments series, 2012, CRC Press, Taylor and Francis Group.
Anju Dahiya, "Bioenergy : Biomass to Biofuels", 2014, Academic press, Elsevier Publication.
D.P.Kothari, K.C Singal and Rakesh Ranjan "Renewable Energy Sources And Emerging Technologies", 2011, PHI Learning Private Ltd, New Delhi.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
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