KLE Technological University
Creating Value, Leveraging Knowledge

Curriculum Structure and Curriculum Content for the Academic Batch 2023-27
School of Mechanical Engineering
Program: Bachelor of Engineering

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Vision and Mission of KLE Technological University

Vision

KLE Technological University will be a national leader in Higher Education–recognised globally for innovative culture, outstanding student experience, research excellence and social impact.

Mission

KLE Technological University is dedicated to teaching that meets highest standards of excellence, generation and application of new knowledge through research and creative endeavors.

The three-fold mission of the University is:

- To offer undergraduate and post-graduate programs with engaged and experiential learning environment enriched by high quality instruction that prepares students to succeed in their lives and professional careers.

- To enable and grow disciplinary and inter-disciplinary areas of research that build on present strengths and future opportunities aligning with areas of national strategic importance and priority.

- To actively engage in the Socio-economic development of the region by contributing our expertise, experience and leadership, to enhance competitiveness and quality of life.

As a unified community of faculty, staff and students, we work together with the spirit of collaboration and partnership to accomplish our mission.

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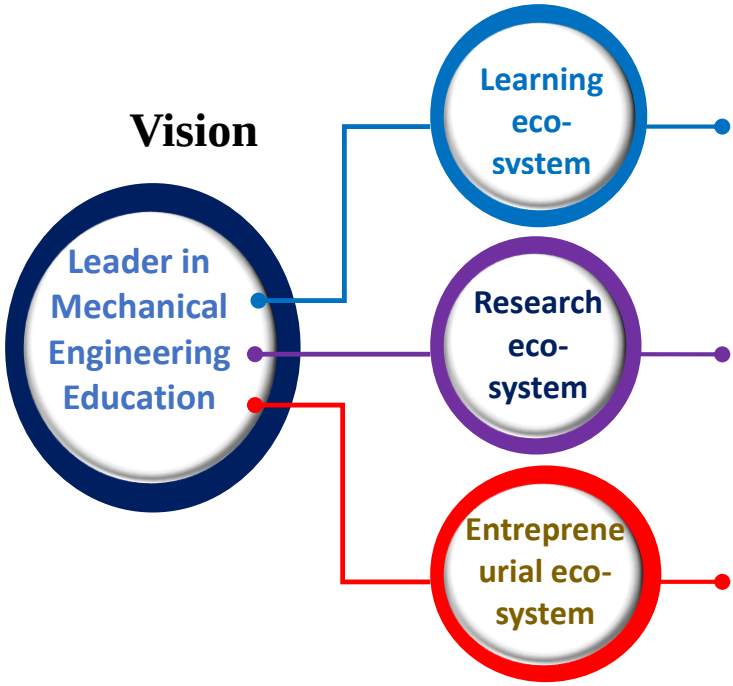
Vision and Mission Statements of the School

Vision

KLE Tech - School of Mechanical Engineering will be a national leader in mechanical engineering education - recognized for innovative culture, outstanding research and societal outreach.

Mission



Offer programs in an **engaging and experiential learning environment**, preparing students for success in their lives and professional careers.

Engage in Mechanical-discipline and inter-disciplinary research aligned to areas of national importance and priority.

Contribute to **socio-economic development** of the region for enhanced quality of life.

KLE Tech School of Mechanical Engineering shall accomplish its mission by working in a team, with the spirit of collaboration and partnership.

Program Educational Objectives/Program Outcomes and Program-Specific Objectives

Program Educational Objectives -PEOs
School of Mechanical Engineering accomplishments that graduates are expected to attain after 3 to 5 years of graduation
1. Apply problem solving skills Graduates will demonstrate technical competence in mechanical engineering domain as they apply problem solving skills to conceive, analyze, design and develop products, processes and systems.
2. Embrace leadership roles Graduates will actively embrace leadership roles and strive hard to achieve professional and organizational goals with adherence to professional and ethical values, team expectations and sensitivities.
3. Contribute to society Graduates will be committed to practice of engineering in industry and government organizations meeting the growing expectations of stake holders and also contribute to the societal development.
4. Pursue new career opportunities Graduates will actively participate in on-going professional development opportunities, engage in continuous updating and adapting core knowledge and abilities to compete in the ever-changing global enterprise and . . .
Program Outcomes-POs
PO1: Engineering Knowledge: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to develop to the solution of complex engineering problems.
PO2: Problem Analysis: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development. (WK1to WK4)
PO3: Design/Development of Solutions: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required. (WK5)
PO4: Conduct Investigations of Complex Problems: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions. (WK8)
PO5: Engineering Tool Usage: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems. (WK2 and WK6)
PO6: The Engineer and The World: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment. (WK1, WK5, and WK7).
PO7: Ethics: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9).

PO8: Individual and Collaborative Team work: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.
PO9: Communication: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences.
PO10: Project Management and Finance: Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.
PO11: Life-Long Learning: Recognize the need for, and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change. (WK8)
Program Specific Objectives -PSOs
PSO1: Modeling and Optimization: Use modern CAD/CAE tools and appropriate standards to develop/optimize components/systems.
PSO2: Modern Manufacturing: Apply the knowledge of advanced manufacturing processes for developing the component/system with emphasis on productivity, quality and cost.
PSO3: Technology Integration: Develop innovative solutions through contemporary technology integration to address real-life problems.

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Curriculum Structure-Overall

Semester: 1 to 8								Total Program Credits:176
Course with course code	I	II	III	IV	V	VI	VII	VIII
	Single Variable Calculus (18EMAB101)	Multivariable Calculus (18EMAB102)	Calculus & Integral Transforms (Diploma Students) (15EMAB231) 4-0-0	Vector Calculus & Differential Equations (Diploma Students) (15EMAB241) 4-0-0	Numerical methods and Statistics (Diploma Students) (24EMAB301) 3-0-0	Professional Aptitude & Logical Reasoning (16EHSC301) 3-0-0	Heat and Mass Transfer (24EMEC401) 3-0-0	Program Elective - 6 (15EMEE4XX) 3-0-0
	Engineering Physics (22EPHB102)	Engineering Chemistry (22ECHB101)	Statistics and Integral Transforms (15EMAB201) 4-0-0	Numerical Methods and Partial Differential Equations (19EMAB206) 3-1-0	Design of Machine Elements (23EMEC301) 3-0-0	Fluid Mechanics & Hydraulic Machines (24EMEC301) 4-0-0	IC Engines (25EMEC401) 2-0-0	Open Elective (15EMEO45X) 3-0-0
	C Programming for Problem solving (18ECSP101)	Engineering Mechanics (15ECVF102)	Mechanics of Materials (22EMEF201) 3-0-0	Fundamentals of Machine Design (22EMEC202) 3-0-0	Finite Element Methods (23EMEC303)3-0-0	Metrology and Quality Engineering (23EMEC304) 3-0-0	Program Elective – 3 (XXEMEE4XX) 3-0-0	Internship – Training *(18EMEI493) 0-0-6*
	Engineering Exploration (22ECRP101)	Computer Aided Engineering Drawing (15EMEP101)	Manufacturing Processes (22EMEC201) 4-0-0	Machines & Mechanisms (22EMEC203) 3-0-0	Programming Industrial Automation Systems(24EMEC302) 2-0-2	Mechatronics System Design (24EMEP302) 0-0-3	Program Elective – 4 (XXEMEE4XX) 3-0-0	Capstone Project (20EMEW402) 0-0-11
	Basic Electrical & Electronics Engineering (21EEXF101)	Problem Solving with Data Structures (18ECSP102)	Engineering Thermodynamics (15EMEC202) 3-0-0	Engineering Materials (15EMEF202) 4-0-0	Program Elective-1 (XXEMEE3XX) 3-0-0	Program Elective – 2 (XXEMEE3XX) 3-0-0	Program Elective – 5 (XXEMEE4XX) 3-0-0	Internship– Project (20EMEW494) 0-0-11
	Basic Mechanical Engg. (22EMEF101)	Design Thinking for Social Innovation (20EHSP101)	Control Systems (19EMEC201) 2-1-0	Mechatronics (24EMEC201) 2-0-1	CAD Modeling & PLM Lab(24EMEP301) 0-0-3	Metrology and Quality Engineering Lab (25EMEP301) 0-0-1	Thermal Engineering Lab (19EMEP401) 0-0-1	
	Applied Physics Lab (21EPHP102)	Professional Communication (15EHSH101)	Manufacturing Processes Lab (22EMEP201) 0-0-2	Microcontroller & Interfacing (24EMEC202) 3-0-1	Automation Lab (25EMEP302) 0-0-2	Minor Project (24EMEW301) 0-0-6	Senior Design Project (20EMEW401) 0-0-6	
			Control Systems Lab (22EMEP202) 0-0-1	Generative AI (24EMEP201) 0-0-2	FEM Lab(23EMEP301) 0-0-1	Industry Readiness &Leadership Skills (22EHSH302)0.5-0-0	CIPE/EVS (15EHSA401) Audit	
			Machine Drawing Lab (22EMEP203) 0-0-2	Machines & Mechanisms Lab (15EMEP204) 0-0-1	Mini Project 15EMEW301) 0-0-3			
			Corporate Communication (22EHSH201) 0.5-0-0	Engineering Materials Lab.(15EMEP202) 0-0-1	Arithmetical Thinking & Analytical Reasoning (22EHSH301) 0.5-0-0			
				Problem Solving & Analysis (22EHSH202) 0.5-0-0				
Credits	**22**	**22**	**22.5**	**25.5**	**22.5**	**23.5**	**21**	**17**

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Curriculum Structure-Semester-wise

Semester – I ←

No	Code	Course	Category	L-T-P	Credits	Contact Hours	ISA	ESA	Total	Exam Duration (in hrs)
1	18EMAB101	Single Variable Calculus	BS	4-1-0	5	6	50	50	100	3 hours
2	22EPHB102	Engineering Physics	BS	3-0-0	3	3	50	50	100	3 hours
3	18ECSP101	C Programming for Problem solving	ES	0-0-3	3	6	80	20	100	3 hours
4	22ECRP101	Engineering Exploration	ES	0-0-3	3	6	80	20	100	3 hours
5	21EEXF101	Basic Electrical & Electronics Engineering	ES	4-0-0	4	4	50	50	100	3 hours
6	22EMEF101	Basic Mechanical Engineering	ES	2-1-0	3	4	50	50	100	3 hours
7	21EPHP102	Applied Physics Lab	BS	0-0-1	1	2	80	20	100	3 hours
TOTAL				13-2-7	22	31				

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Semester – II

No	Code	Course	Category	L-T-P	Credits	Contact Hou	ISA	ESA	Total	Exam Duration (in hrs)
1	18EMAB102	Multivariable Calculus	BS	4-1-0	5	6	50	50	100	3 hours
2	22ECHB101	Engineering Chemistry	BS	3-0-0	3	3	50	50	100	3 hours
3	15ECVF102	Engineering Mechanics	ES	4-0-0	4	4	50	50	100	3 hours
4	15EMEP101	Computer Aided Engineering Drawing	ES	0-0-3	3	6	80	20	100	3 hours
5	18ECSP102	Problem Solving with Data Structures	ES	0-0-3	3	6	80	20	100	3 hours
6	20EHSP101	Design Thinking for Social Innovation	HSS	0-1-1	2	4	80	20	100	3 hours
7	15EHSH101	Professional Communication	HSS	1-1-0	2	3	50	50	100	3 hours
TOTAL				12-3-7	22	32				

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Semester- III

No	Code	Course	Category	L-T-P	Credits	Contact Hours	ISA	ESA	Total	Exam Duration (in hrs)
---	15EMAB231	Calculus & Integral Transforms **(Diploma Students)**	BS	4-0-0	4	4	50	50	100	3 Hours
1	15EMAB201	Statistics and Integral Transforms	BS	4-0-0	4	4	50	50	100	3 Hours
2	22EMEF201	Mechanics of Materials	ES	3-0-0	3	3	50	50	100	3 Hours
3	22EMEC201	Manufacturing Processes	PSC	4-0-0	4	4	50	50	100	3 Hours
4	15EMEC202	Engineering Thermodynamics	PSC	3-0-0	3	3	50	50	100	3 Hours
5	19EMEC201	Control Systems	PSC	2-1-0	3	4	50	50	100	3 Hours
6	22EMEP201	Manufacturing Processes Lab	PSC	0-0-2	2	4	80	20	100	2 Hours
7	22EMEP202	Control Systems Lab	PSC	0-0-1	1	2	80	20	100	2 Hours
8	22EMEP203	Machine Drawing Lab	PSC	0-0-2	2	4	80	20	100	2 Hours
9	22EHSH201	Corporate Communication	HS	0.5-0-0	0.5	1	100	--	100	2 Hours
TOTAL				**16.5-1-5**	**22.5**	**29**				

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Semester- IV

No	Code	Course	Category	L-T-P	Credits	Contact Hou	ISA	ESA	Total	Exam Duration (in hrs)
---	15EMAB241	Vector Calculus & Differential Equations **(Diploma Students)**	BS	4-0-0	4	4	50	50	100	3 Hours
1	19EMAB206	Numerical Methods and Partial Differential Equations	BS	3-1-0	4	5	50	50	100	3 Hours
2	22EMEC202	Fundamentals of Machine Design	PSC	3-0-0	3	3	50	50	100	3 Hours
3	22EMEC203	Machines & Mechanisms	PSC	3-0-0	3	3	50	50	100	3 Hours
4	15EMEF202	Engineering Materials	ES	4-0-0	4	4	50	50	100	3 Hours
5	24EMEC201	Mechatronics	PSC	2-0-1	4	4	80	20	100	2 Hours
6	24EMEC202	Microcontroller & Interfacing	PSC	2-0-1	3	4	80	20	100	3 Hours
7	15EMEP204	Machines & Mechanisms Lab	PSC	0-0-1	1	2	80	20	100	2 Hours
8	15EMEP202	Engineering Materials Lab.	PSC	0-0-1	1	2	80	20	100	2 Hours
9	24EMEP201	Generative AI	PSC	0-0-2	2	4	80	20	100	2 Hours
10	22EHSH202	Problem Solving & Analysis	HS	0.5-0-0	0.5	1	100	--	100	2 Hours
TOTAL				**17.5-1-4**	**25.5**	**32**				

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Semester- V ←

No	Code	Course	Category	L-T-P	Credits	Contact Hours	ISA	ESA	Total	Exam Duration (in hrs)
-	24EMAB301	Numerical methods and Statistics **(Diploma Students)**	BS	3-0-0	3	3	50	50	100	3 hours
1	23EMEC301	Design of Machine Elements	PSC	3-0-0	3	3	50	50	100	3 hours
2	23EMEC303	Finite Element Methods	PSC	3-0-0	3	3	50	50	100	3 hours
3	24EMEC302	Programming Industrial Automation Systems	PSC	2-0-2	4	6	80	20	100	2 hours
4	XXEMEE3XX	Program Elective-1(XXEMEE3XX)	PE	3-0-0	3	3	50	50	100	3 hours
5	24EMEP301	CAD Modeling & PLM Lab	PSC	0-0-3	3	6	80	20	100	2 hours
6	25EMEP302	Automation Lab	PSC	0-0-2	2	4	80	20	100	2 hours
7	23EMEP301	FEM Lab	PSC	0-0-1	1	2	80	20	100	2 hours
9	15EMEW301	Mini Project	PRJ	0-0-3	3	6	50	50	100	3 hours
10	22EHSH301	Arithmetical Thinking & Analytical Reasoning	HS	0.5-0-0	0.5	1	100	--	100	2 hours
TOTAL				**11.5-0-11**	**22.5**	**34**				

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Semester- VI ←

No	Code	Course	Category	L-T-P	Credits	Contact Hours	ISA	ESA	Total	Exam Duration (in hrs)
1	16EHSC301	Professional Aptitude & Logical Reasoning	PSC	3-0-0	3	3	50	50	100	3 hours
2	24EMEC301	Fluid Mechanics & Hydraulic Machines	PSC	4-0-0	4	4	50	50	100	3 hours
3	23EMEC304	Metrology and Quality Engineering	PSC	3-0-0	3	3	50	50	100	3 hours
4	24EMEP302	Mechatronics System Design	PSC	0-0-3	3	6	80	20	100	2 hours
5	XXEMEE3XX	Program Elective - 2	PE	3-0-0	3	3	50	50	100	3 hours
6	25EMEP301	Metrology and Quality Engineering Lab	PSC	0-0-1	1	2	80	20	100	2 hours
7	24EMEW301	Minor Project	PRJ	0-0-6	6	12	50	50	100	2 hours
8	22EHSH302	Industry Readiness &Leadership Skills	HS	0.5-0-0	0.5	1	100	--	100	2 hours
TOTAL				**13.5-0-10**	**23.5**	**32**				

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Semester- VII ←

No	Code	Course	Category	L-T-P	Credits	Contact Hours	ISA	ESA	Total	Exam Duration (in hrs)
1	24EMEC401	Heat and Mass Transfer	PSC	3-0-0	3	3	50	50	100	3 hours
2	25EMEC401	IC Engines	PSC	2-0-0	2	2	50	50	100	2 hours
3	XXEMEE4XX	Program Elective – 3	PE	3-0-0	3	3	50	50	100	3 hours
4	XXEMEE4XX	Program Elective – 4	PE	3-0-0	3	3	50	50	100	3 hours
5	XXEMEE4XX	Program Elective – 5	PE	3-0-0	3	3	50	50	100	3 hours
6	19EMEP401	Thermal Engineering Lab	PSC	0-0-1	1	2	80	20	100	2 hours
7	20EMEW401	Senior Design Project	PW	0-0-6	6	12	50	50	100	3 hours
8	15EHSA401	CIPE/EVS	CNC	Audit	0	2	50	50	100	3 hours
TOTAL				**14-0-7**	**21**	**30**				

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Semester- VIII ←

No	Code	Course	Category	L-T-P	Credits	Contact Hour	ISA	ESA	Total	Exam Duration (in hrs)
1	15EMEE4XX	Program Elective - 6 (15EMEE4XX)	PE	3-0-0	3	3	50	50	100	3 Hours
2	15EMEO45X	Open Elective (15EMEO45X)	OE	3-0-0	3	3	50	50	100	3 Hours
3	18EMEI493	Internship – Training *(Optional In place of 1 & 2)*		0-0-6	6	----	80	20	100	3 Hours
4	20EMEW402 / 20EMEW494	Capstone Project / Internship – Project	PW	0-0-11	11	22	50	50	100	3 Hours
TOTAL				**6-0-17**	**17**	**28**				

Semester	I	II	III	IV	V	VI	VII	VIII	**Total**
Credits	22	22	22.5	25.5	22.5	23.5	21	17	176

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List of Open Electives

Sr. No	Name of the Course	Course Code
1.	Introduction to Nano-Science & Nano Technology	15EMEO401
2.	Nano Technology	15EMEO402
3.	Design of Experiments	15EMEO403
4.	Engine Management Systems	15EMEO404

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List of Program Electives

Sr. No	Name of the Course	Course Code
1	Mechanical Vibration	15EMEE301
2	Product Innovation	24EMEE305
3	Advanced Machining Processes	15EMEE305
4	Advanced Welding Technology	25EMEE308
5	Smart Manufacturing Systems	25EMEE304
6	Fundamentals of Robotics	25EMEE305
7	Additive Manufacturing Processes	22EMEE301
8	Turbo Machines	18EMEE303
9	Thermal Management of EV Battery Systems	22EMEE302
10	Advanced CAE – I	25EMEE301
11	Bionic Design	22EMEE303
12	Enterprise Resource Planning-I	24EMEE301
13	Fundamentals of Product Lifecycle Management	24EMEE302
14	Advanced Statistics and Machine Learning	19EMEE302
15	Failure Analysis in Design	15EMEE302
16	Smart Manufacturing Technologies	25EMEE306
17	Mobile Robotic Systems	25EMEE307
18	Computer Integrated Manufacturing	15EMEE306
19	Green Hydrogen	22EMEE306
20	Advanced CAE – II	25EMEE302
21	Biomechanics	22EMEE307
22	Mechanics of Composite Materials	25EMEE401
23	Design of Automotive Power Train	15EMEE402
24	Design & Analysis of Experiments	25EMEE403
25	Operations Management	15EMEE405
26	Supply Chain Management	15EMEE406
27	Modern Trends in Manufacturing	15EMEE417
28	Design of Jigs, Fixtures and Press Tools	24EMEE404
29	Operations Research	24EMEE401
30	Computational Heat Transfer and Fluid Flow	15EMEE407

31	Design of Thermal Systems	24EMEE402
32	Fundamentals of Gas Turbines	15EMEE408
33	HVAC Systems	24EMEE405
34	Optimization Methods	24EMEE408
35	Aircraft Systems and Design	15EMEE413
36	Industrial Engineering: Methods & Practices	15EMEE414
37	Advanced Energy technology	15EMEE415
38	Thermal Management of Electronic Equipment	15EMEE416
39	Noise, Vibration and Harshness (NVH)	23EMEE301
40	Product Design & Development	19EMEE303
41	Design for Additive Manufacturing (DfAM) Lab	22EMEE305
42	Enterprise Resource Planning-II	24EMEE303
43	Advanced Product Lifecycle Management	24EMEE304
44	Vehicle Structure and Design Optimization	19EMEE301
45	Machine Learning Applications	19EMEE307
46	Dynamics & Durability of Vehicles	19EMEE401
47	Facets of Project Analysis	24EMEE407

Program: UG		**Semester: I**
Course Title: Single variable Calculus		**Course Code: 18EMAB101**
L-T-P: 4-1-0	**Credits: 05**	**Contact Hours: 6 hrs / week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 50	**Examination Duration: 3hrs**	

Unit I

1. Functions, Graphs and Models **07 hours**

Functions, types of functions, transformations and models (Linear, exponential, trigonometric).
MATLAB: Graphing functions, Domain-Range and Interpreting the models

2. Calculus of functions and models **13 hours**

Limit of a function, Infinite limits- graph, Continuity and discontinuity, Intermediate value theorem statement, Roots of the equation using Bisection Method and Newton- Raphson Method
Interpretation of derivative as a rate of change, All the rules of derivatives (List only), Maxima, Minima and optimization problems. Curvature and Radius of Curvature, Indeterminate forms, L- Hospital's rule- Examples
MATLAB: optimization problems. Curvature problems

Unit II

3. Infinite Series **06 hours**

Definition, Convergence of series, Tests of convergence – p-series, Alternating series. Power series, radius of convergence, Taylor's and Maclaurin's series, Applications of Taylor's and Maclaurin's series
MATLAB: Convergence of series

4. Integral calculus **14 hours**

Tracing of standard curves in Cartesian form ,Parametric form and Polar form; Beta and gamma function, relation between them, evaluation of integrals using Beta and gamma functions; Applications to find arc length, Area, Volume and surface area (Cartesian, parametric and polar curves). Approximate integration- Trapezoidal rule, Simpson's 1/3 rule
MATLAB: problems on arc length, area, volume and surface area

Unit III

5. Ordinary differential equations of first order **10 hours**

(a) Introduction to Initial Value problems. Linear and Bernoulli's equations, Exact equations and reducible to exact form, Numerical solution to Initial Value problems-Euler's method, Modified Euler's method and Runge-Kutta method
(b) Applications of first order differential equations-Orthogonal trajectories growth and decay problems, mixture problems, Electrical circuits, falling bodies.
MATLAB: Solve differential equations

Text Books

1. James Stewart, Early Transcendentals - Calculus, Thomson Books, 7th edn. 2010.

Reference Books

1. Hughues-Hallett Gleason, Calculus Single and Multivariable, Wiley India Ed, 4ed, 2009.
2. George B Thomas, Thomas Calculus, Pearson India, 12th edn., 2010

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Program: UG		**Semester: I**
Course Title: Engineering Physics		**Course Code: 22EPHB102**
L-T-P: 3-0-0	**Credits: 03**	**Contact Hours: 3 Hrs / week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 03 Hrs**	

UNIT-I

1. Concept of Motion- Kinematics in One Dimension:

Introduction, motion diagrams, particle model, position and time, linear velocity and acceleration, uniform motion, instantaneous velocity, finding position from velocity, motion with constant acceleration, free fall motion on an inclined plane, instantaneous acceleration, numericals. **06 Hrs**

2. Kinematics in Two Dimensions:

Introduction to vectors, properties of vectors, co-ordinate systems and vector components, vector algebra. Position, velocity and acceleration vectors, projectile motion, relative motion, uniform circular motion, velocity and acceleration in uniform circular motion, non-uniform circular motion and angular acceleration, numericals. **06 Hrs**

3. Force and Motion:

Concept of force, identifying forces, a virtual experiment, Newton's first law, Newton's second law, free-body diagrams, applications. **04 Hrs**

UNIT – II

4. Dynamics I:

Equilibrium using Newton's second law, friction, drag, Newton's third law, analyzing interacting objects, Newton's third law, applications. **05 Hrs**

5. Dynamics II:

Motion in a plane, dynamics in two dimension, velocity and acceleration in uniform circular motion, dynamics of uniform circular motion, fictitious forces, non-uniform circular motion, numericals. 06 Hrs

6. Impulse and Momentum:

Momentum and impulse, problems, conservation of momentum, inelastic collisions, explosion, momentum in two dimensions, numericals**.** **05 Hrs**

UNIT – III

7. Quantum Mechanics:

Introduction, dual nature of matter waves, De-Broglie concept of matter waves, Davission and Germer Experiment, Heisenberg's uncertainty principle, 1-D Schrodinger wave equation (qualitative). Physical significance of wave function, particle in a box (qualitative), Eigen functions and Eigen values, discretization of energy**.** **03 Hrs**

8. Nanoscience and its applications:

Introduction, length scales, scaling effect (surface-volume ratio, quantization, dandling bonds, defects and self-assembly-qualitative), density of states and confinement of electron energy states in 3D, 2D, 1D and 0D systems (qualitative treatment), change in material properties from bulk to nanostructures, variation of physical properties (mechanical, optical, electric, magnetic, chemical) from bulk to thin films to nano-materials, nano-particle examples: metal (magnetic and non-magnetic), Graphene, carbon nanotubes, biological nanoparticles. **05 hrs**

Text Books

1. Randall D Knight, Physics for Scientists and Engineers, Pearson publication, 3e (2008)
2. Aurther Beiser, Concepts of Modern Physics, 6e, Tata McgrawHills, (2003)
3. Sulbha Kulkarni, Nanotechnology Principles and practices, 3e, Springer.

Reference Books

1. John W Jewett and Raymond A Serway, Physics for Scientists and Engineers with modern physics, Cengage publication, India Edition, 9e (2014)
2. Hans C Ohanian & John T Markert, Physics for Engineers and Scientists, W W Norton and Company, Vol-1, 3e (2006)
3. A.K. Bandopadhya, Nanomaterials, New Age Publishers, (2004)
4. S.K. Prasad, Advanced nano technology, Discovery publishing house Pvt. Ltd New Delhi

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Program: UG		**Semester: I**
Course Title: C Programming for Problem Solving		**Course Code: 18ECSP101**
L-T-P: 0-0-3	**Credits: 3**	**Contact Hrs: 6 hrs/week**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hrs: 78	**Exam Duration: 3 hrs**	**Semester: I**

1	Introduction to Problem solving Introduction to algorithms / flowcharts and its notations, top-down design, elementary problems.	3 hrs
2	Basics of C programming language Characteristics and uses of C, Structure of C program, C Tokens: Keywords, Identifiers, Variables, Constants, Operators, Data-types, Input and Output statements.	15 hrs
3	Decision control statements Conditional branching statements: if statement, if else statement, else if ladder, switch statement, unconditional branching statements: break, continue. Introduction to Debugging Skills Introduction to Test Driven Programming.	12 hrs
4	Iterative statements while, do while, for, nested statements	10 hrs
5	Functions Introduction, Function declaration, definition, call, returns statement, passing parameters to functions, introduction to macros. Introduction to Coding Standards	10 hrs
6	Arrays and Strings Introduction, Declaration, accessing elements, Storing values in arrays, Operations on one dimensional array, Operations on two dimensional arrays, Introduction to Code Optimization and refactoring	15 hrs
7	Pointers Introduction, declaring pointer, pointer variables, pointer expression and arithmetic, passing arguments to functions using pointers, pointers and arrays, passing an array to a function.	08 hrs
8	Structures and Unions Introduction, passing structures to functions, Array of structures, Unions	05 hrs

Text Books

1. R.G.Dromey, How to Solve it by Computer, 1ed, PHI, 2008.
2. Yashvant Kanetkar, Let us C ,15th ed, BPS Publication, 2016.

Reference Books

1. B W Kernighan, D M Ritchie, The Programming language C, 2ed, PHI, 2004.
2. B S Gottfried, Programming with C, 2ed, TMH, 2006.
3. B.A. Forouzan, R.F. Gilberg, A Structured Program Approach Using C, 3ed, CENGAGE Learning, 2008.

Program: Bachelor of Engineering		**Semester: I**
Course Title: Engineering Exploration		**Course Code: 22ECRP101**
L-T-P: 0-0-3	**Credits: 3**	**Contact Hrs: 6 hrs/week**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hrs: 72	**Exam Duration: 3 hrs**	

Content	Hrs
Module 1: Introduction to Engineering and Engineering Study Introduction to Engineering and Engineering Study: Difference between science and engineering, scientist and engineer needs and wants, various disciplines of engineering, some misconceptions of engineering, Expectation for the 21st-century engineer, and Graduate Attributes.	**03 Hrs**
Module 2: Engineering Design Engineering Design Process, Problem definition formulation process, Concept generation- Function tree, Functional structure, Morphological chart, and Concept selection- Pugh Chart, Product Architecture. Prototyping and testing.	**09 Hrs**
Module 3: Mechanisms and Resource Specifications (MRS) Mechanism, types of mechanisms, degree of freedom, linkages, four-bar linkage mechanism, actuators & their types, torque, governing equations, FOS, motor sizing, motor selection, mass acquisition using software, power adapters, types of adapters, power calculations & adapter selection.	**09 Hrs**
Module 4: Platform-Based development Introduction to various platform-based development (Arduino) programming and its essentials, Introduction to sensors, transducers, and actuators and its interfacing with Arduino.	**15 Hrs**
Module 5. Project Management Introduction to Project Management, Significance of teamwork, Significance of Agile practices, Significance of documentation.	**03 Hrs**
Module 6. Engineering Ethics Identifying Engineering as a Profession, Significance of Professional Ethics, Code of Conduct for Engineers, Identifying Ethical Dilemmas in different tasks of engineering, Applying Moral Theories and codes of conduct for resolution of Ethical Dilemmas.	**03 Hrs**
Module 7. Sustainability in Engineering Introduction to sustainability, Sustainability leadership, Life cycle assessment, carbon foot print.	**06 Hrs**
Course Project Reviews	**24 Hrs**
Scheme for In-Semester assessment (ISA)	

Name of the Module	Hours	% Weightage
1. Introduction to Engineering & Engineering study	3	5
2. Engineering Design	9	10*
3. Mechanisms and Resource Specifications (MRS)	9	5
4. Platform based development	15	10
5. Project Management.	3	10*
6. Engineering Ethics	3	5
7. Sustainability in Engineering	6	5
8. Course Project Reviews	24	30*
a. Virtual Implementation (VI)		VI-10
b. Physical Implementation (PI)		PI-15

c. Performance Testing (PT)			PT-05
Total	72		80
Assessment will be done in course projects			
Scheme for End-semester Assessment (ESA)			
ESA	Hours	% Weightage	Marks
Functionality (FT)	03	20	04
Individual Learning (IL)			06
Project Report (PR)			05
Video Documentation (VD)			05

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Program: Bachelor of Engineering			**Semester: I**
Course Code: 21EEXF101	**Course Title: Basic Electrical and Electronics Engineering**		
L-T-P-Self Study: 4-0-0-0	**Credits: 4**	**Contact Hrs: 4 hrs / week**	
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**	
Teaching Hrs: 47		**Exam Duration: 3 hrs**	

Content	**Hrs**
Unit – 1	
Chapter 1: Introduction to Electrical & Electronics Technology Electrical Power Generation (convention and renewable energy sources, with PV elaborated), transmission, distribution, utilization (Electric Vehicle as a case study), Electrical and Electronic Systems, concept and power of abstraction, lumped circuit abstraction, and its limitation.	02 hrs
Chapter 2: The Circuit Abstraction Energy storage and dissipating elements (RLC), Ideal and practical sources, series and parallel circuits, concept of order of the system, voltage dividers, RC, RL, RLC with KCL and KVL, Mesh and Nodal analysis with an example.	10 hrs
Chapter 3: Introduction to Transformer and Electric Drive Electromagnetic principles, classification of electric machines – static and rotary, transformers, motors, PMDC, stepper, BLDC, single and three-phase induction motors, selection of motors for various applications. Safety measures.	10 hrs
Unit – 2	
Chapter No. 4: Semiconductor Devices and its Applications Fundamentals of semiconductors, PN junction diode, BJT, FET, Thyristors, Integrated circuits, Linear application – Transistors and Operational amplifiers, oscillators (Op-Amp based), Nonlinear application – Power electronics converters.	10 hrs
Chapter No. 5: Digital Abstraction Concept of digital abstraction, Number systems, base conversion – binary, decimal, hexadecimal, BCD, Gray code, Boolean algebra, logic gates, combinational circuits, - half adders, full adders, half subtractor and full subtractor using k-maps for 2 or 3 variables, sequential circuits – registers, counters.	10 hrs
Chapter No. 6: Mechatronic Subsystem Power supply, Introduction to sensors and actuators, signal conditioning and interfacing, Control logic design for mechatronic applications.	5

Text Books

1. Anant Agarwal and Jefferey H. Lang, Foundations of Analog and Digital Electronic Circuits, Morgan Kaufmann -Elsevier, 2005
2. Hughes, Electrical and Electronic Technology, 12th Edition, Pearson, 2016.

References

1. N.P.Mahalik, Mechatronics - Principles, Concepts and Applications, Tata McGraw-Hill, 2011
2. K.A Krishnamurthy and M.R.Raghuveer, Electrical, Electronics and Computer Engineering for Scientist and Engineers, 2, New Age International Publishers, Wiley Eastern, 2001
3. George Kennedy, Electronic Communication Systems, 4, Tata McGraw Hill, 2000
4. Morris Mano, Digital Logic and Computer Design, 21st Indian print Prentice Hall India, 2000
5. Boylestead Nashelsky, Electronic devices & Circuit theory, 6, Prentice Hall India, 2000
6. David A Bell, Electronic Devices and Circuits, PHI New Delhi, 2004
7. Ramakant Gayakwad, Operational Amplifiers & applications, 3, PHI, 2000
8. W.Bolton, Mechatronics - Electronic Control Systems in Mechanical and Electrical Engineering, 3, Pearson Education, 2005
9. Ernest O Doeblin, Dhanesh N Manik, Measurement Systems, 6th Edition, MGH; 2017

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Program: Bachelor of Engineering		**Semester: I**
Course Title: Basic Mechanical Engineering		**Course Code: 22EMEF101**
L-T-P: 2-1-0	**Credits: 3**	**Contact Hours: 4 hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 3 hrs**	

Unit I

1.Introduction to Mechanical Engineering: **2 Hrs**

Mechanical Engineering, Mechanical Engineers' top ten achievements, Branches of Mechanical Engineering, Mechanical product Example: Pressure Cooker.

2. Power Transmission Drives: **6 Hrs**

Overview Design Application: • Belt Drives (Flat belt), Length of Belt. Velocity Ratio, Initial Tension. Ratio of Tensions. Power Transmitted, Numerical Problems. • Gears. Spur Gear, Rack and Pinion, Worm Gear, Bevel Gear, Helical Gears and Elliptical gear. Speed, Torque, and Power in Gear pair. Simple and Compound Gear trains. Numerical Problems. Hydraulic transmission system.

Unit II

3. Manufacturing Engineering: **6 Hrs**

What is manufacturing? Classification of Manufacturing Processes, Metal joining processes- Soldering, brazing, and welding (Arc and gas welding). Machine tools- Lathe, Milling, Drilling Grinding (working principle and operations). CNC machines, Robotics and its applications. Additive manufacturing techniques.

4. IC engines and Electric powertrains: **4 Hrs**

Internal Combustion Engines: Classification, IC engine parts, 4 Stroke SI and CI Engine, Comparison of 2stroke and 4 stroke engine, comparison of CI and SI engine, Problems on Engine Performance. Electric drives. Hybrid drives- series and parallel layout.

Unit III

5. Refrigeration and Air conditioning: **3 Hrs**

Refrigeration system, vapour compression refrigeration system, vapour absorption system, refrigerants and their properties. Air conditioning system.

6. Fluid movers: **3 Hrs**

Pumps, Blowers and Compressors and their working principle

Tutorial Content

1. Virtual Prototyping: 2D sketching, 3D modelling-Extrude, Revolve, Pattern and Sheet Metal Assembly. 8 Hrs

2. **8 Hrs**

- Visit to workshop: welding shop, sheet metal shop, machine Shop.
- Demonstration of various machine tools such as lathe, milling, drilling and grinding machines and safety precautions in workshop.
- Assembly and disassembly of bicycle and demonstration on welding (electric arc welding, gas welding).
- Demonstration and exercise on sheet metal work.

Text Books

1. Jonathan Wickert and Kemper Lewis, An Introduction to Mechanical Engineering, Third Edition, Cengage Learning, 2013
2. K.R. Gopalkrishna, Sudhir Gopalkrishna, S.C. Sharma, A Text Book of Elements of Mechanical Engineering, 30th Edition, Subhash Publishers, Bangalore, 2010
3. Dr. N. Krishnamurthy, Dr. H. S. Manohar, Mr. Sagar M. Baligidad, Elements of Mechanical Engineering, First Edition, Sunstar Publisher, 2014

Reference Books

1. SKH Chowdhary, AKH Chowdhary, Nirjhar Roy, The Elements of Workshop Technology, Vol I & II, 11th edition, Media Promoters and Publishers, 2001
2. Roger Timings, Basic Manufacturing, Third edition, Newnes, An imprint of Elsevier, 2010

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Program: BE		**Semester: I**
Course Title: Applied Physics lab (ES)		**Course Code: 21EPHP102**
L-T-P: 0-0-1	**Credits: 01**	**Contact Hrs: 02 Hrs/week**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hrs: 20	**Exam Duration: 03 Hrs**	

LIST OF EXPERIMENTS

1. Experimental data error analysis.
2. Centripetal force.
3. Young's modulus.
4. Coefficient of friction.
5. V-I Characteristics of pn- Junction diode and plotting DC load line.
6. Hysteresis loss.
7. Verification of Kirchoff's KVL and KCL (DC Circuits)
8. Use of measuring instruments (RPS & FG) and calibration of oscilloscope
9. Realization of basic gates (Using IC's)
10. Zener diode characteristics and voltage regulation (line and load regulation).

OPEN ENDED EXPERIMENT

1. Realization of a ±5/12V regulated power supply
2. Stepper motor drive

SCHEME OF EVALUATION:

Students Assessment through ISA (80%) + ESA (20%)

In Semester Assessment: (80%)	Assessment	Weightage in Marks
	Performance	3 x 10=30
	Presentation of records	1 x 10=10
	Viva Voce	2 x 10=20
	Conduct of a lab test	10
	Open ended experiment	10
	ISA Total	80
End Semester Assessment (20%)	Write up + performance + results + viva	20
	ESA Total	20
ISA (80%) + ESA (20%)	Total	100

Program: UG		**Semester: II**
Course Title: Multivariable calculus		**Course Code: 18EMAB102**
L-T-P: 4-1-0	**Credits: 05**	**Contact Hours: 6 Hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 05	**Examination Duration: 3hrs.**	

Unit I

1. **Partial differentiation** **12 hours**
   Function of several variables, Partial derivatives, Level curves, Chain rule, Errors and Approximations. Extreme value problems. Lagrange's multipliers.
2. **Double integrals** **08 hours**
   Double integrals- Rectangular and polar coordinates, Change the order of integration. Change of variables, Jacobian. Application of double integrals
   MATLAB: optimization problems, application of double integrals

Unit II

3. **Triple integrals** **07 hours**
   Triple integrals, Cartesian, change to Cylindrical and Spherical coordinates Application of Triple integrals
4. **Calculus of Vector Fields** **13 hours**
   Vector fields, Gradient and directional derivatives. Line and Surface integrals. Independence of path and potential functions. Green's theorem, Divergence of vector field, Divergence theorem, Curl of vector field. Stokes theorem.
   MATLAB: application of Triple integrals, Vector calculus problems

Unit III

5. **Differential equations of higher orders** **(5+5) hours**
   (a) Linear differential equations of second and higher order with constant coefficients, The method of Variation of parameters. Initial and boundary value problems.
   (b) Applications of second order differential equations-Newton's 2^{nd} law, electrical circuits, Simple Harmonic motion. Series solution of differential equations. Validity of Series solution of Differential equations.
   MATLAB: application of differential equations

Text Books

1. James Stewart, Early Transcendental Calculus- Thomson Books, 7ed 2010

Reference Books

1. Hughues-Hallett Gleason, Calculus Single and Multivariable, Wiley India Ed, 4ed, 2009.
2. George B Thomas, Thomas Calculus, Pearson India, 12ed, 2010

Program: UG		**Semester: II**
Course Title: Engineering Chemistry		**Course Code: 22ECHB101**
L-T-P: 3-0-0	**Credits: 03**	**Contact Hours: 3 hrs / week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 03 Hrs**	

Unit-I

1. Chemical Bonding and Molecular Structure

Chemical bonding – Types, Ionic bond: Formation of NaCl molecule, factors influencing the formation of ionic bond – ionization energy, electron affinity and lattice energy, Born–Haber's cycle, calculation of lattice energy of NaCl molecule and properties of ionic compounds; Covalent bond: atomic orbital theory – formation of H_2 molecule, polar and nonpolar covalent bonds – H_2 and HCl molecules, dipole moment, calculation of percentage of ionic character and properties of covalent compounds. Hybridization: sp, sp^2 and sp^3 hybridization - geometry of BeF_2, BF_3 and CH_4 molecules. VSEPR Theory: regular and irregular geometry, geometry of $SnCl_2$, NH_3 and H_2O molecules. **06 Hrs**

2. **Electrochemical Energy Systems**

Electrode potential, Nernst equation; Formation of a cell; Reference electrodes: Calomel electrode - determination of electrode potential; Numerical problems on E, E_{cell} and E^0_{cell}. Batteries: classification, characteristics, Lead - acid battery and Lithium ion battery. Fuel cells: Types of fuel cells; Methanol - Oxygen fuel cell. **06 Hrs**

3. **Polymer Chemistry**

Polymers, properties, classification, free radical mechanism of addition polymerization by taking ethylene as an example. Commercial polymers: plexi glass and polyurethane. Polymer composites: carbon fibre and epoxy resin – synthesis, properties and applications. Conducting polymers: Polyaniline – synthesis, mechanism of conduction in doped polyaniline and its applications. **04 Hrs**

Unit – II

4. Plating Techniques

Technological importance of plating techniques, Types of plating, Electroplating: Definition, electroplating of Gold by acid cyanide bath, determination of Throwing Power of plating bath by Haring Blum cell and numerical problems. Electroless plating: advantages of electroless plating over electroplating, electroless plating of Copper and its application in the manufacture of printed circuit board (PCB). **03 Hrs**

5. Wafer Technology

Introduction, physical and chemical properties of silicon, metallurgical grade silicon, purification of silicon; chemical vapor deposition (CVD) process, zone refining process. Crystal growth: preparation of single crystal silicon by Czhochralski crystal pulling technique and numerical problems. Crystal slicing and wafer preparation; Fabrication process: thermal oxidation, diffusion, ion implantation, numerical problems, epitaxial growth, masking, photolithography; wet etching and dry etching. **10 Hrs**

6. Material Chemistry

Liquid crystals: classification of liquid crystals, applications of liquid crystals in display systems. Glass: properties, smart glass: electrochromic, thermochromic and photochromic smart glass - properties and applications. Thermoelectric and Piezoelectric materials - meaning, properties and applications. **03 Hrs**

Unit – III

7. Water Chemistry

Water: sources, impurities in water, potable water: meaning and specifications (as per WHO standards). Hardness: determination of total hardness of water by EDTA method and numerical problems. Purification of water: Flash distillation, Reverse Osmosis, Electro-dialysis - principle, process and applications. **04 Hrs**

8. Instrumental Methods of Measurement

Advantages over conventional methods. Electro analytical methods: Potentiometer - principle, methodology and applications. Opto-analytical methods: Colorimeter - Principle, methodology and applications. Spectral methods of analysis: UV Spectrophotometer - Instrumentation and applications. **04 Hrs**

Text Books

1. A text Book of Engineering Chemistry, 1st edition, Dara. S. S, S. Chand and Co. Ltd., 2009
2. A text Book of Engineering Chemistry, 16th edition, Jain P.C and Jain M, Dhanpat Rai, 2006
3. Engineering Chemistry, 3rd Edition, Krishnamurthy. N., Vallinayaga. P. and Madhavan. D., PHI/E Books Premium, 2014.

Reference Books:

1. Text book of Inorganic Chemistry, P. L. Soni, Sultan Chand, 1999, New Delhi.
2. Inorganic chemistry: Principles of structure and reactivity, , 4th Edition, James E. Huheey, Ellen A. Keiter, Richard L. Keiter, Okhil K. Medhi, Dorling Kindersley (India) Pvt. Ltd., 2006, New Delhi.
3. Concise Inorganic Chemistry ELBS, 5th Edition, J.D. Lee, Wiley, 2008, New York.
4. Hand book of batteries, 3rd edition, David Linden, Thomas B Reddy, McGraw Hill publications, 2001, New York.
5. Polymer Science, 6th edition, Gowariker V.R, Viswanatan N.V, Sreedhar J., New Age International (P) ltd., 2007, New Delhi.
6. Text Book of Polymer Science, 3rd edition, Fred W. Billmeyer, John Wiley and Son's, 1984, New York.
7. VLSI Technology, 2nd Edition, S. M. Sze, McGraw-Hill Series in Electrical and Computer Engineering, 1998, New York.
8. Solid State Devices & Technology, 4th Edition, V. Suresh Babu, Sanguine Technical Publishers, 2005, Bangalore.
9. Materials Science and Engineering: An introduction, 9th Edition, Callister William D, John Wiley and Sons, 2007, New York.
10. Instrumental Methods of Chemical Analysis, 5th edition, Gurdeep R Chatwal, Sham K Anand, Himalaya Publishing House, Pvt. Ltd, 2010, Mumbai.

Program: UG		**Semester: II**
Course Code: 15ECVF102	**Course Title: Engineering Mechanics**	
L-T-P: 4-0-0	**Credits: 4**	**Contact Hrs./Week: 4**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hrs.: 50	**Exam Duration: 3 hours**	

No	Content	Hrs.
	Unit I	
1	**Chapter 1: Overview of Civil Engineering** Evolution of Civil Engineering Specialization, scope and role. Impact of Civil Engineering on National economy, environment and social & cultural fabric. Challenges and Opportunities for Civil Engineers Civil Engineering Marvels, Future challenges, Higher education and Research.	**04**
2	**Chapter 2: Coplanar concurrent force system** Introduction to Engineering Mechanics: Basic idealizations – Particle, Continuum, Body, Rigid body, Deformable body, Definition of force and its elements; Laws of Mechanics – Parallelogram law of forces, Principle of transmissibility, Law of Superposition, Newton's laws of motion. Classification of force systems 3 hrs. Resultant of coplanar concurrent force system: Definitions – Resultant, composition & Resolution of a force, Equilibrium, Equilibrant, Formulae for resultant of forces and resolution of a force. Numerical problems on resultant of forces. 4 hrs. Equilibrium of coplanar concurrent force system: Conditions of equilibrium, Action & Reaction, Free body diagram, Lamis' theorem. Numerical problems on equilibrium of forces. 5 hrs.	**12**
3	**Chapter 3 : Coplanar non-concurrent force system 5 hrs.** Resultant of a force system: Moment, moment of a force, couple, moment of a couple, Characteristics of couple, Equivalent force-couple system, Numerical problems on moment of forces and couples, on equivalent force-couple system. Varignon's principle of moments, Resultant of coplanar- non-concurrent force systems and numerical problems.	**05**
	Unit II	
4	**Chapter 4:Equilibrium of a force system 5 hrs.** Conditions of equilibrium, types of support and loading for a statically determinate beam, Reactions at support connections, Numerical problems on equilibrium of force systems and support reactions for a statically determinate beam.	**18**
5	**Chapter 5:Static Friction8 hrs.** Introduction, types of friction, definition, limiting friction, coefficient of friction, laws of Coulomb friction, angle of friction and angle of repose, cone of friction. Wedge and belt friction theory. Derivation of belt friction formula. Numerical problems on, impending motion on horizontal and inclined planes (including connected bodies); wedge friction; Ladder friction and Belt friction.	

6	**Chapter 6: Centroid of Plane Figures** Introduction, Definition, Methods of determining the centroid, axis of reference, axis of symmetry, Locating the centroid of simple plane figures (triangle, semicircle, quarter of a circle and sector of a circle etc,.) using method of integration, Numerical problems on Centroid of simple built up sections. 5 hrs.	
	Unit – III	
7	**Chapter 7: Second moment of area (Plane figures)** Introduction, Definition, Method of determining the second moment of area, Section Modulus, Radius of gyration, perpendicular and Parallel axis theorems, Polar second moment of area, second moment of area of simple plane figures (triangle, rectangle, semicircle, circle etc,.) using method of integration, Numerical problems on MI of simple built up sections. 5 hrs..	**11**
8	**Chapter 8: Kinetics of a particle- Work, Power, Energy** Introduction – Kinematics and Kinetics, Definitions – work, power and energy. Work done by a force (constant, gravitational and spring forces) in rectilinear motion. Numerical problems, Kinetic energy of a particle, principle of work and energy. 6 hrs.	

Text Book

1. Beer, F.P. and Johnston, R., Mechanics for Engineers: Statics, MGH, New York, 1988.
2. Bhavikatti, S.S., and Rajashekarappa K.G., Engineering Mechanics, 3rd edn., New Age International, 2008.
3. Kumar, K.L., Engineering Mechanics, 3ed., Tata McGraw Hill Publishing Company, New Delhi, 2003.
4. Punmia, B.C., Jain, A. and Jain, A., Mechanics of Materials, Lakshmi Publications, New Delhi, 2006

References

1. Jagadeesh, T.R. and Jayaram, *Elements of Civil Engineering*, Sapna Book House, 2006.
1. Ramamrutham, S., Engineering Mechanics, Dhanpat Rai Publishing Co., New Delhi, 1998.
2. Singer, F.L., *Engineering Mechanics*, 3rd edition Harper Collins, 1994.
3. Timoshenko, S.P. and Young, D.H., Engineering Mechanics, 4th edition, MGH, 1956.
4. Irving H Shames, Engineering Mechanics, 3rd edition, PHI Pvt. Ltd, New Delhi- 110 001, 1995.

Program: Bachelor of Engineering		**Semester: II**
Course Title: Computer Aided Engineering Drawing		**Course Code: 15EMEP101**
L-T-P: 0-0-3	**Credits: 3**	**Contact Hours: 6 hrs/week**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hours: 72	**Examination Duration: 2 hrs**	

1.Projections of Points and Lines : **12 Hrs**

Introduction to Engineering Drawing, BIS conventions, drawing sheets and instruments. Types of lines, method of dimensioning. Introduction to projection. Principal of orthographic projection, 1st angle and 3rd angle method of projections, their symbolic representation. Projection of the points located in different quadrants. Introduction to projections of lines, lines perpendicular to one plane, lines parallel to both HP & VP, lines parallel to one plane and inclined to the other. Projections of straight lines inclined to both HP and VP.

2. Projections of Plane surfaces and Solids : **15 Hrs**

Introduction to projections of plane surfaces, plane surfaces parallel to one plane and perpendicular to other. Plane surfaces perpendicular to one plane and inclined to other plane. Introduction to various types of solids, projections of prisms and cylinders in simple position where the axis is perpendicular to either HP or VP or parallel to both HP and VP. Projections of pyramids and cones in simple position where the axis is perpendicular to either HP or VP or parallel to both HP and VP. Introduction to frustum and truncated solids, projections of frustum of pyramids and cones.

3. Development of lateral Surfaces : **12 Hrs**

Introduction to development of lateral surfaces, parallel line development method, development of prisms and their truncations. Introduction to radial line development, development of pyramids and truncations. Development of cylinders and cones and their truncations. Development of transition pieces by triangulation method.

4. Conversion of Pictorial views into Orthographic projections : **18 Hrs**

Introduction to Isometric drawings. Conversion of pictorial or isometric views into orthographic projections by manual mode of drawings. Introduction to CAD Software and practice. Conversion of pictorial or isometric views into orthographic projections using CAD software.

5. Conversion of Orthographic projections into isometric views : **15 Hrs**

Conversion of orthographic projections into isometric views using CAD software.

Text Books

1. Engineering Drawing - N.D. Bhatt & V.M. Panchal, 48th edition, 2005-Charotar Publishing House.
2. Engineering Graphics - K.R. Gopalakrishna, 32nd edition, 2000- Subash Publishers Bangalore.
3. AutoCAD 2014 – Sham Tikku, Perdue University
4. A Primer on Computer Aided Engineering Drawing Published by V T U Belgaum, 2006.
5. Machine Drawing - K.R. Gopalakrishna, 12nd edition, 2007- Subash Publishers Bangalore.

Reference Books

1. Fundamentals of Engineering Drawing with an Introduction to Interactive Computer Graphics for Design and Production-Luzadder Warren J., Duff John M., Eastern Economy Edition, 2005-Prentice-Hall of India Pvt. Ltd., New Delhi.

Program: Bachelor of Engineering	**Semester: II**	
Course Code:18ECSP102	**Course Title: Problem Solving with Data Structures**	
L-T-P: 0-0-3	**Credits: 3**	**Contact Hrs: 6 hrs /week**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hrs: 78	**Semester: II**	**Exam Duration: 3 hrs**

1	**Chapter No. 1 Introduction to Data Structures** Review of C: Structures, Pointers, Dynamic Memory Allocation and File Manipulation Operations, Introduction to Data Structures, Data structure Operations.	**15 Hrs**
2	**Chapter No 2 :Lists** Concept of lists: Abstract data type, Definition, Representation of linked lists in Memory, Variants of Lists: Singly Linked List, Doubly Linked lists, Circular linked lists, Operations: Traversing, Searching, Insertion and Deletion. Applications of Linked lists – Polynomials, long integer addition and other applications.	**18Hrs**
3	**Chapter No. 3 : Stacks and Recursion** Stack: Definition, Operations, Stack ADT Implementation of stack operations. Polish notation: Infix to postfix conversion, evaluation of postfix expression, parenthesis matching and other applications. Recursion	**18Hrs**
4	**Chapter No. 4 : Queues** Queue: Definitions, Queue ADT, Variants of Queues: Linear queue, circular queue, priority queue, double ended queue and multiple queues. Applications of queue.	**15Hrs**
5	**Chapter No. 5 : Binary trees** Binary Tree: Definition, Terminology and representation, Binary Search Tree: Traversals and its applications.	**12Hrs**

Text Books

1. Data Structures Using C and C++ - Y. Langsam, M. Augenstein and A. M. Tenenbaum, Prentice - Hall of India Pvt. Ltd. Edition- 2, 2006
2. Data Structures with C - Seymour Lipschutz, Tata McGraw Hill India LTD, EdItion-1, 2011

Reference Books

1. Data Structures and Algorithms Made Easy – Narshiman Karumunchi, Career Monk Publications, Edition-2, 2017.
2. Data Structure Through C - Yashavant P Kanetkar, BPB Publication, Edition-2.
3. Problem Solving in Data structures and Algorithms Using C – Hemath Jain, Taran Technologies Private Limited, Edition-1, 2016
4. Introduction to Algorithms - Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein. The MIT Press, Edition-3, 2009.
5. Data Structures through C in Depth, S.K. Srivastava, Deepali Srivastava, BPB Publications, 2004
6. Online platform: www.Hackerrank.com
7. https://www.geeksforgeeks.org/

Program: UG			**Semester: II**
Course Code: 20EHSP101		**Course Title: Design Thinking for Social Innovation**	
L-T-P: 0-1-1		**Credits: 2**	**Contact Hrs.: 4 Hrs/week**
ESA Marks: 80		**ISA Marks: 20**	**Total Marks: 100**
Teaching Hrs.: 28			**Exam Duration: 3 hrs.**

Module		Topics	Assignments	Support activities / Tools
KNOWLEDGE, TOOLS & DEVELOPMENT	Course sensitization	1. Introduction to Social Innovation: • Awakening social consciousness (www.yourstory.com) • Social Innovation and Leadership • Engineering& Social innovation (EPICS) (Connecting SI Course to Mini Project, Capstone Project, Campus Placements) • Course Overview • Students' Self Introduction Activity • Group formation Activity	<u>Reading assignments</u> • Read the handout on "The Process of Social Innovation" by Geoff Mulgan • Design thinking for Social Innovation <u>Written Assignments</u> • Writing about Akshaya Patra in class. (Background information about Akshaya patra and the Social Cuase it is addressing) • Brainstorming Session on Social Innovators in Class	• Class activity on Behavioral Blocks to Innovation Discussion on the behavioural blocks. • Introducing oneself with three Adjectives- Appreciating diversity and discovering self • Group Formation Activity (Forming square) (Making four equilateral triangles out of popsicle sticks to enhance group cohesiveness amongst the group mates)
	Create Mindsets	Seven Mindsets: 1. Empathy (Example of The Boy and the Puppies) 2. Optimism (Person Paralyzed waist down / Glass Halh full Half Empty) 3. Iteration (Thomas Alva Edison) 4. Creative Confidence (Origamy – Josef Albers) 5. Making it 6. Embracing Ambiguity (Confusion is the Welcome doormat at the door of Creativity) 7. Learning from Failure (Designing Website first and then asking the stakeholders about the website)	<u>Reading assignments</u> • Handout on " Create Mindsets"	• (How to train the Dragon? Common Video for all the mindsets) • Watching in Class TED Talk on "How to build youir Creative Confidence by David Kelley – IDEO Founder)

		(Spending one lakh for the business which is never launched)		
	Process of Social Innovation	Engage Community study and Issue Identification	<u>Reading assignments</u> • Handout on Community Study and Issue Identification • Case Study on "EGramSeva" • Case Study on "Janani Agri Serve" <u>Class Presentations</u> • Initial observations being made by the group (Literature Survey of Places of Hubli- Dharwad) www.readwhere.com • Detailed interaction / engagements with the society and finalize the social issue for intervention Use template 1: Frame your Design Challenge	• Activity on Observation skills To know how to use one's observation skills in understanding the social conditions • Experience sharing by senior students • Brainstorming Deliberations on the initial observations and arrive at the "Social Issue" • Familiarization of the respective templates with the help of sample case study
		PEER REVIEW		
		2. Inspiration • Plan for the Research • Development of Interview guide • Capture your Learnings	<u>Reading assignments</u> • Handout on Overview of Inspiration <u>Class Presentations</u> • Entirety of the Social Issue • Identification of the Stake Holders (Examples on Fluoroscent Curtain and Students' Punctuality for Class) • Interview Questions (Role Play on Interview with Stakeholders) • Category wise Learnings capture Use template 2: Plan your Research Template 3. Development of Interview Guide Template 4. Capture your Learning	• Familiarization of the respective templates with the help of sample case study

		3. Ideation 3.1 Synthesis • Search for meaning • Create "How might we" question	<u>Reading assignments</u> • Handout on Overview of Ideation-Synthesis <u>Class Presentations</u> • Create insights • "How might we" questions Use template 5: Create Insights Template 6: Create "How Might We' Questions	• Familiarization of the respective templates with the help of sample case study
		3.0 Ideation 3.2 Prototyping • Generate Ideas • Select Promising Ideas • Determine what to prototype • Make your prototype • Test and get feedback	<u>Reading assignments</u> • Handout on Overview of Ideation-Prototyping <u>Class Presentations</u> • Story board-demonstrating the possible solutions Use template 7: Select your best ideas Template 8 : Determine what to prototype	• Brain storming • Familiarization of the respective templates with the help of sample case study • Activity on Risk management • Activity on Resource management Structure building games
		PEER REVIEW		
		4.0 Implementation • Create an action plan • Community Partners (if any) • Budgeting & Fundraising 1. Peer to Peer 2. Crowd Funding 3. Giving Kiosks 4. Donation 5. Envelop Funding 6. Marathons/ Walkathons 7. Conducting Yoga Classes (www.causevox.com / www.blog.fundly.com) • Duration • Ethical concerns • Launch your solution • Feedback (Impact)	<u>Reading assignments</u> • Handout on Overview of Implementation <u>Class Presentations</u> • Pilot implementation plan with required resources and Budget indicating stake holders & their enagement	• Familiarization of the respective templates with the help of sample case study

		5.0 Reflect Reflection of the overall learning by the students	<u>Reading assignments</u> • Handout on Overview of students Reflection Use template 9: Reflection on the Process <u>Class Presentations</u> Final Presentation- After Implementation	• Familiarization of the respective templates with the help of sample case study

← BACK TO SEMESTER II

Program: UG		**Semester: II**
Course Code: 15EHSH101	**Course Title: Professional Communication**	
L-T-P-: 1-1-0	**Credits: 2**	**Contact Hrs: 3 Hrs/week**
ESA Marks: 50	**ISA Marks: 50**	**Total Marks: 100**
Teaching Hrs: 42		**Exam Duration: 3 hrs**

Content	Hrs
Chapter No. 1. Basics- English Communication Course Introduction, Explanation of template mix-ups with correct usages & necessity of grammar in error detection, Usage of tenses	**9 hrs**
Chapter No. 2. Vocabulary and grammar Vocabulary, Word Formation and Active and Passive Voice	**6 hrs**
Chapter No. 3. Bouncing Practice Definition and types of bouncing and its practice with examples, reading skills, free style speech. Individual presentation.	**6 hrs**
Chapter No. 4. Rephrasing and Structures Comprehension and Rephrasing, PNQ Paradigm and Structural practice	**8 hrs**
Chapter No. 5. Dialogues Introduction of dialogues, Situational Role plays,	**3 hrs**
Chapter No. 6. Business Communication Covering letter, formal letters, Construction of paragraphs on any given general topic.	**9 hrs**

References

1. Collins Cobuild Advanced Learner's English Dictionary, Harper Collins Publishers, 9th Edn., 2018
2. Raymond Murphy - Intermediate English Grammar, Cambridge University Press
3. Martin Hewings- Advanced English Grammar, Cambridge University Press.

← BACK TO SEMESTER III

Program: Bachelor of Engineering		**Semester: III**
Course Title: Calculus and Integral Transforms		**Course Code: 15EMAB231**
L-T-P: 4-0-0	**Credits: 4**	**Contact Hours: 4 Hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 50	**Examination Duration: 3 Hrs**	

Unit I

1. Differential Calculus **5 Hrs**

Differentiation of standard functions of first and higher orders, Taylor's and Maclaurin's series expansion of simple functions for single variable.

2. Integral Calculus **7 Hrs**

Evaluation of integrals, properties, Beta and Gamma functions, relation between Beta and Gamma functions simple problems , Approximate integration- Trapezoidal rule, Simpson's 1/3 rule

3. Fourier Series **10 Hrs**

Fourier series, Evaluation of Fourier coefficients, Waveform symmetries as related to Fourier co-efficient, Exponential form of the Fourier series, half range Fourier series. Practical Harmonic Analysis.

Unit II

4. Fourier Transform **8 Hrs**

Exponential Representation of non-periodic signals, Existence of Fourier transforms properties of Fourier Transform: symmetry, scaling, shifting, Fourier transform of Sine and Cosine Convolution theorem.

5. Laplace Transforms **10 Hrs**

Definition, transforms of elementary functions- transforms of derivatives and integrals- Properties. Periodic functions, Unit step functions and Unit impulse functions. Inverse Transforms- properties- Initial and final value theorems and examples; Convolution Theorem. Applications to differential equations

Unit III

6. Ordinary differential equations of first order **5 Hrs**

Introduction, order and degree of equation, Solution of first order first-degree differential equations – variable separable methods, Linear differential equations, Bernoulli's equations, Initial value problems

7. Complex analysis **5 Hrs**

Function of complex variables. Limits, continuity and differentiability. Analytic functions, C-R equations in Cartesian and polar forms, construction of Analytic functions (Cartesian and polar forms).

Text Books

1. Grewal B S, Higher Engineering Mathematics, 38ed, Khanna Publication, New Delhi, 2001
2. Bali and Iyengar, A text book of Engineering Mathematics, 6ed, Laxmi Publications, 2003

Reference Books

1. James Stewart, Calculus- Early Transcendentals Thomson Books, 5e 2007

Program: Bachelor of Engineering		**Semester: III**
Course Title: Statistics and Integral Transforms		**Course Code: 15EMAB201**
L-T-P: 4-0-0	**Credits: 4**	**Contact Hours: 4 Hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 50	**Examination Duration: 3 Hrs**	

Unit I

1. Curve fitting and regression: **5 Hrs**

Introduction to method of least squares, fitting of curves y = a + bx, $y = ab^x$, $y=a + bx + cx^2$, correlation and regression. Applications to civil Engineering problems

2. Probability: **8 Hrs**

Definition of probability, addition rule, conditional probability, multiplication rule, Baye's rule. (no proof) Discrete and continuous random variables- PDF-CDF- Binomial, Poisson and Normal distributions (Problems only).

3. Tests of Hypothesis- 1 **7 Hrs**

Sampling, Sampling distribution, Standard error, Null and alternate hypothesis, Type -I and Type- II errors, Level of significance. Confidence limits, testing of hypothesis for single mean and difference of means (large samples). Applications to civil Engineering problems

Unit II

4. Tests of hypothesis-2 **10 Hrs**

T-test (test for single mean, paired t-test), Chi Squared distribution, analysis of variance (one-way and two-way classifications). Case studies of designs of experiments (CRD, RBD). Applications to civil Engineering problems

5. Laplace Transforms **10 Hrs**

Definition, transforms of elementary functions- transforms of derivatives and integrals- Properties. Periodic functions, Unit step functions and Unit impulse functions.

Inverse Transforms- properties- Initial and Final value theorems, examples, Convolution Theorem. Applications to differential equations.

Unit III

6. Fourier Series **5 Hrs**

Fourier series representation of a function, Even and odd functions, half range series, Practical Harmonic Analysis

7. Fourier Transform **5 Hrs**

Exponential Representation of non-periodic functions, Existence of Fourier transforms properties of Fourier Transform: Fourier Sine and Cosine transforms.

Text Books

1. Gupta S C and Kapoor V K, Fundamentals of Mathematical Statistics, 9ed, Sultan Chand & Sons, New Delhi, 2002
2. J. Susan Milton, Jesse C. Arnold, Introduction to Probability and Statistics: Principles and Applications for Engineering and the Computing Sciences, 4th Ed, TATA McGraw-Hill Edition 2007.
3. Kreyszig, E, Advanced Engineering Mathematics, 8ed, John Wiley & sons, 2003.

Reference Books

1. Kishor S Trivedi, probability and statistics with reliability queuing and computer science applications, PHI, 2000.
2. Miller, Freud and Johnson, Probability and Statistics for Engineering by, 5ed, PHI, 2000.
3. Potter M C, Jack Goldberg and Aboufadel E F, Advanced Engineering Mathematics, 3ed, Oxford Indian

← BACK TO SEMESTER III

Program: Bachelor of Engineering		**Semester: III**
Course Title: Mechanics of Materials		**Course Code: 22EMEF201**
L-T-P: 3-0-0	**Credits: 3**	**Contact Hours: 3Hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 3 Hrs**	

Unit I

Chapter 1. Stresses and Strains: **10 Hrs**

a. Normal and shear stress, bearing stress, deformation, strain, stress-strain diagram, Hooke's law, working stress and factor of safety, Saint-Venant's principle, analysis of bars of constant and varying sections, Elongation of a bar due to its self-weight, volumetric strain, elastic constants.

b. Principle of super position, stresses and strains in composite section, statically indeterminate structures, thermal stresses.

Chapter 2. Shear Force and Bending Moment in Beams: **5 Hrs**

Types of beams, supports and loads, shear force and bending moment diagrams for simply supported, overhanging and cantilever beams subjected to point loads, uniformly distributed load, uniformly varying load and couple.

Unit II

Chapter 3. Stresses in Beams: **5 Hrs**

Bending stress, flexure formula, section modulus, bending stresses in beams of different cross sections, economic sections, shear stresses in beams, and shear stress across rectangular, I and T sections.

Chapter 4. Torsion and Buckling: **5 Hrs**

Torsion of circular shafts, torsional equation, power transmitted by solid and hollow circular shafts. Buckling: Elastic instability, critical load, Euler's equation for columns with different end conditions, Rankine's formula.

Chapter 5. Compound stresses: **5 Hrs**

State of stress at a point, transformation of plane stress, principal planes and principal stresses, analytical method for determining principal stresses, maximum shear stress and their planes, Mohr's circle for plane stress.

Unit III

Chapter 6. Deflection of Beams: **5 Hrs**

Deflection and slope of a beam, differential equation of the elastic curve, equations for deflection, slope and moment, deflection and slope for simply supported, overhanging and cantilever beams subjected to point loads, uniformly distributed load and couple using double integration and Macaulay's method.

Chapter 7. Thin and Thick Cylinders: **5 Hrs**

Thin walled pressure vessels, cylindrical vessels; hoop stress, longitudinal stress and maximum shear stress, change in dimensions of cylinder (diameter, length and volume), thick cylinders subjected to internal and external pressures (Lame's equation).

Text Books

1. Andrew Pytel and Jaan Kiusalaas, Mechanics of Materials, 2nd Edition, Cengage Learning, 2012.
2. R.C. Hibbeler, Mechanics of Materials, 9th Edition, Pearson Education, 2018.

Reference Books

1. James M. Gere and Barry J. Goodno, Mechanics of Materials, 8th Edition, Nelson Engineering International Edition, 2012.
2. Ferdinand Beer, Jr. E. Russell Johnston, John Dewolf and David Mazurek, Mechanics of Materials, 7th Edition, McGraw-Hill Education, 2014.

Program: Bachelor of Engineering		**Semester: III**
Course Title: Manufacturing Processes		**Course Code: 22EMEC201**
L-T-P: 4-0-0	**Credits: 4**	**Contact Hours: 4 Hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 50	**Examination Duration: 3 Hrs**	

Unit I

1. Introduction to Manufacturing Processes : **2 Hrs**

Definition of manufacturing, Manufacturing sectors and their significance to the economy of a country, Classification of production processes and systems, Criteria for selection of a process for production, Sustainable manufacturing, Manufacturing costs, and Global competitiveness

2. Casting & special casting processes : **12 Hrs**

Casting: Introduction, Green sand molding, Pattern & core making: Pattern types, allowances and materials, Core & core making methods, Molding methods and machines, Principles of gating, Risers and gating ratio. Special Casting Processes: CO2 molding, Shell molding, Investment casting, Die casting, Centrifugal casting processes, and Continuous casting process. Melting Furnaces: Introduction and types. General Design considerations and defects in castings, Cleaning and fettling operations, Testing methods

3. Fabrication Processes : **6 Hrs**

Classification of joining processes, Soldering, Brazing, Mechanical fastening, Welding, Preparation of base metal and joint. Arc welding, Gas welding, TIG, MIG, FCAW, Thermit welding, Spot, seam and projection welding, Ultrasonic welding, Electron beam welding, and Laser welding. Adhesive joining: Types and applications

Unit II

4. Fundamentals of Metal Cutting **10 Hrs**

Principles of metal cutting, Introduction to Lathes, Drilling and Milling machines: Operations, Numerical on machining time calculations. Finishing operations: Grinding, Superfinishing, Honing, and Lapping methods

Geometry of cutting tools, Cutting tool materials, Mechanism of chip formation, Merchant's circle diagram, Cutting fluids, Thermal aspects of machining, Types of tool wear & wear mechanisms, Tool life, Machinability & its criteria, Numerical on force analysis and tool life

5. Forming Processes : **5 Hrs**

Bulk deformation processes: Forging, Rolling, Extrusion, and Drawing. Sheet metal working processes: Shearing, Bending, Deep drawing. Selection of equipment

6. Non-traditional Manufacturing Processes **05 Hrs**

Abrasive-Jet machining, Water-Jet machining, Ultrasonic machining, Electric-discharge machining, Laser beam machining, Electron beam machining, Electrochemical machining. Additive manufacturing: Classification, Stereo-lithography, Laminated object manufacturing, 3D printing, Applications

Unit III

7. Introduction to Micro-manufacturing and Nano-manufacturing **05 Hrs**

Semiconductors and Silicon, Lithography, Etching, Micromachining of MEMS devices, LIGA and related microfabrication processes, Mesoscale manufacturing, Nanoscale manufacturing

8. Introduction to Digital Manufacturing **05 Hrs**

A conceptual framework, Lean Production System, Technology roadmap for Industry 4.0, Comparison of existing Industry 4.0 maturity and readiness model, Data analytics in manufacturing, Role of Augmented reality, Virtual factory, Cyber security in manufacturing

Text Books

1. Kalpakjian S., and Schmid S.R., Manufacturing Engineering & Technology, 7th edition, Pearson Education, 2014.
2. Mikell P. Groover, Fundamentals of Modern Manufacturing, 5th edition, John Wiley & Sons, 2012.

Reference Books

1. Juneja B. L. and Sekhon G. S., Fundamentals of Metal Cutting and Machine Tools, 3rd edition, New Age International Limited, 2008.
2. Rosenthal, P., Heine L., Principles of Metal Casting, Tata McGraw Hill, 1997.
3. John A. Schey, Introduction to Manufacturing Processes, 3rd edition, Tata McGraw Hill, 1999.
4. Mikell P. Groover, Automation, Production Systems, and Computer-Integrated Manufacturing, 4th edition, Prentice Hall, 2014.
5. Pandey P. C. and Shan H. S., Modern Machining Processes, 1st edition, Tata McGraw Hill, 2013.
6. Rao P. N., Manufacturing Technology: Volume-1, 3rd edition, Tata McGraw Hill, 2008.
7. Rao P. N., Manufacturing Technology: Volume-2, 3rd edition, Tata McGraw Hill, 2013.
8. Ustundag Alp, and Cevikcan Emre, Industry 4.0: Managing the Digital Transformation, Springer series in Advanced Manufacturing, 2018.

Program: Bachelor of Engineering		**Semester: III**
Course Title: Engineering Thermodynamics		**Course Code: 15EMEC202**
L-T-P: 3-0-0	**Credits: 3**	**Contact Hours: 3 Hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 3 Hrs**	

Unit I

Chapter 1. Introduction: **07 Hrs**

Basic Concepts: Thermodynamics systems (control mass, control volume and Isolated systems) and surroundings, Properties, State, Processes and cycles, Thermodynamic equilibrium. Heat and work transfer across boundaries, Quasi-static processes. Zeroth law, First law for a closed system undergoing a cycle and undergoing a change of state, Internal energy as a system property. Application of first law to different thermodynamic processes. First law applied to flow processes (derivation of Steady Flow energy equation) and its application to Nozzles, turbines, heat exchangers, boilers, pumps, compressors and throttling devices. Problem solving

Chapter 2. Second Law of Thermodynamics: **08 Hrs**

Thermal reservoirs, heat engine, heat pump and refrigerator. Statements of second law of thermodynamics. PMM I and PMM II, Reversible and irreversible processes, Carnot cycle and its efficiency, Carnot's theorem. Thermodynamic temperature scale.

Unit II

Chapter 3. Entropy: **07 Hrs**

Entropy a property of a system, Clausius theorem and Clausius inequality, Principle of increase of entropy, entropy change during various processes. Exergy and energy, Problem Solving. (07 hr)

Chapter 4. Gas and Vapor Power Cycles: **08 Hrs**

Gas power cycles: Otto cycle and its efficiency, Diesel cycle and its efficiency, expression for mean effective pressure, Comparison between the two cycles. Problem Solving.

Vapor power cycle: Carnot cycle, work done and cycle efficiency, draw backs, ideal and actual Rankine cycle, network done, cycle efficiency and work ratio. Methods of improving cycle efficiency (reheat Rankine cycle) Problem Solving.

Unit III

Chapter 5. Reciprocating air compressor: **05 Hrs**

Introduction, Classification, Work required for single and double stage air compressors, efficiencies of air compressor, Effect of intercooling, condition for minimum work, . Problem Solving.

Chapter 6. Clean Energy Conversion: 05 Hrs

thermionic and thermoelectric converters, photovoltaic generators, MHD generators, fuel cells. Energy Payback, GHG mitigation.

Text Books

1. Michael J Moran & Howard N Shapiro, Fundamentals of engineering thermodynamics, 9th Edition, Wiley Stud, 2018.
2. Yunus A. Cengel, Michael A. Boles, Mehmet Kanoglu, Thermodynamics an Engineering approach, 9th Edition, Tata McGraw, 2019
3. Andrea M. Mitofsky, Direct Energy Conversion, A.T. Still University, 2018

Reference Books

1. Conduct experiment on nozzle to demonstrate the steady flow energy equation.
2. Conduct experiment on zeroth law of thermodynamics and prove the concept Kelvin temperature scale.
3. Conduct experiment to determine entropy change of a system.
4. Determine the –i) flash and fire point and ii) calorific value of the given fuel (solid/gaseous).
5. Determine the coefficient of performance of the vapour compression refrigeration system.

6. Conduct experiment on diesel engine to investigate the performance based on concept of air standard cycles.
7. Conduct an experiment to draw the heat balance sheet for a diesel engine.

Program: Bachelor of Engineering		**Semester: III**
Course Title: Control Systems		**Course Code: 19EMEC201**
L-T-P: 2-1-0	**Credits: 3**	**Contact Hours: 4 Hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 30	**Examination Duration: 3 Hrs**	

Unit I

1. Introduction to Control System: **3 Hrs**

Generalized configurations and functional description of control systems. Control system design. Examples of Control System.

2. Modeling of Physical Systems: **8 Hrs**

Introduction, Differential equations of physical systems, The Laplace Transform, Order of system; The transfer function of linear and rotational Mechanical systems, Gear Train, Electrical systems, Electro-mechanical System, Thermal systems, Block representation of system elements and Reduction of block diagrams.

Unit II

3. System Response: **6 Hrs**

Introduction, Poles, Zeros, and System Response. First-order system response to step, ramp and impulse inputs. Second-order system response to step input; Un-damped, Under damped, Critical damped and Over damped systems, Time response specifications. Design of 1st and 2nd order system.

4. System Stability: **5 Hrs**

Introduction to stability. Stability analysis by time response, S-plane and Routh-Hurwitz Criterion. Effect of gain adjustment, addition of pole and addition of zero on system response and system stability. Defining the Root locus, General rules for constructing root loci, Sketching the Root locus.

Unit III

5. Frequency Domain Analysis: **4 Hrs**

Nyquist stability criteria, Bode Plots. Stability analysis using bode plots.

6. Control Action: **4 Hrs**

Introduction to PID controller design. Types of Controllers, Mathematical modeling of PID, ON-OFF controller, Effect of Proportional, Derivative and Integral elements on system behavior, Design of Controller for given simple applications. Controller Design using root locus.

Text Books

1. Richard C Dorf and Robert H. Bishop, Modern Control Systems, 12th edition, Addison Wesley
2. A. Anandkumar, Control Systems, 2nd edition, PHI Learning Private Limited, 2014.

Reference Books

1. Katsuhiko Ogata, Modern Control Engineering, 5th edition, Pearson Publications.
2. Norman S. Nise, Control. Systems, 6th edition, John Wiley & Sons

← BACK TO SEMESTER III

Program: Bachelor of Engineering		**Semester: III**
Course Title: Manufacturing Processes Lab		**Course Code: 22EMEP201**
L-T-P: 0-0-2	**Credits: 2**	**Contact Hours: 4 Hrs/week**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hours: 48	**Examination Duration: 2 Hrs**	

Lab Exercises	Hrs
1. Conventional machining: Machining practices involving machining time calculation and estimation of machining cost for the jobs for turning, taper turning, threading, and knurling.	06
2. Assembly: To manufacture and assemble parts for Industrial Products which involve turning, milling, tapping/slot milling, etc.	08
3. Machinability study: Machinability studies in turning, drilling and milling operations.	02
4. Non-conventional machining: Demonstrate the effect of process parameters in electric-discharge machining, laser cutting, and plasma arc machining for a given geometry.	02
5. Forming processes: Design, Modeling, and Analysis of Bulk deformation and Sheet Metal forming processes using the simulation tool.	02
6. RPT (3D printing): Demonstrate a product in a 3D printing machine for a given component drawing.	02
7. CNC machining: Prepare a CNC program and conduct turning & milling machining for a given component.	20
8. Process Planning: Prepare a process plan for a given component (Open-ended)	06

Text Books

1. Kalpakjian S., and Schmid S.R., Manufacturing Engineering & Technology, 8th edition, Pearson Education, 2020.
2. Mikell P. Groover, Fundamentals of Modern Manufacturing, 7th edition, John Wiley & Sons, 2019.

Reference Books

1. Juneja B. L. and Sekhon G. S., Fundamentals of Metal Cutting and Machine Tools, 3rd edition, New Age International Limited, 2008.
2. Rosenthal, P., Heine L., Principles of Metal Casting, Tata McGraw Hill, 1997.
3. John A. Schey, Introduction to Manufacturing Processes, 3rd edition, Tata McGraw Hill, 1999.
4. Mikell P. Groover, Automation, Production Systems, and Computer-Integrated Manufacturing, 4th edition, Prentice Hall, 2014.
5. Pandey P. C. and Shan H. S., Modern Machining Processes, 1st edition, Tata McGraw Hill, 2013.

Program: Bachelor of Engineering		**Semester: III**
Course Title: Control Systems Lab		**Course Code: 22EMEP202**
L-T-P: 0-0-1	**Credits: 1**	**Contact Hours: 2 Hrs/week**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hours: 48	**Examination Duration: 2 Hrs**	

Experiments	No of Session
1. Demo of Quanser Mechatronics Sensor kit, DAQ card, DC Motor Control Trainer module, Inverted Pendulum Trainer module with NI ELVIS Platform.	01
2. Scaffolding exercises to explore MATLAB / Simulink software package.	02
3. Modelling of physical systems and its response analysis • First order system physical modeling (RC-Circuit) and study the effect of time constant on system. • Second order system physical modeling (RLC-Circuit) and study the effect of damping ratio on system. • Simulation of Spring-mass damper system by varying damping coefficient.	03
4. Design and investigate the effects of various controllers on a system. • Modelling of P, PD, PI and PID controller and study the effect of controller on Spring-mass damper system.	02
5. System identification of DC motor. • Implementation of control strategies and Position control of DC motor through virtual models using MATLAB.	02
6. Control of an Inverted Pendulum on a Cart	01
7. Control of a Linear Electric Actuator	01

Text Books

1. Richard C Dorf and Robert H. Bishop, Modern Control Systems, 12th edition, Addison Wesley
2. A. Anandkumar, Control Systems, 2nd edition, PHI Learning Private Limited, 2014.

Reference Books

1. Katsuhiko Ogata, Modern Control Engineering, 5th edition, Pearson Publications.
2. Norman S. Nise, Control. Systems, 6th edition, John Wiley & Sons.
3. Data sheets provided by manufactures.

Program: Bachelor of Engineering		**Semester: III**
Course Title: Machine Drawing Lab		**Course Code: 22EMEP203**
L-T-P: 0-0-2	**Credits: 2**	**Contact Hours: 4 Hrs/week**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hours: 52	**Examination Duration: 2 Hrs**	

Laboratory Content

1. Sectional views : **14 Hrs**

Sectional views of machine parts involving half section, full section, offset section, revolved section and local section.

2. Threaded Fasteners : **10 Hrs**

Threaded screws and their conventional representations. BSW thread, American sellers thread, ISO metric thread, square thread and acme thread.
Drawing of bolts and nuts; Hexagonal nut and bolt, Square nut and bolt.

3. Geometrical dimensioning & tolerance and Blueprint reading **10 hrs**

Introduction to limits, fits and tolerance; hole and shaft base systems, types of fits, identification of fits. Basic principles of geometrical dimensioning and tolerance (GD&T) and its symbols. Surface finish representations in the drawing.
Reading of part and assembly drawings - Blueprint reading.

4. Parts and assembly drawing using both manual drawing instruments and CAD tool **18hrs**

Assembly such as: (1) Socket and spigot cotter joint (2) Strap joint with gib and cotter (3) Flanged coupling (4) Screw jack.

Text Books

1. Machine Drawing by K. R. Gopalakrishna, Subhas Publications, 22nd Edition - 2013.
2. Machine Drawing by N. D. Bhat& V. M. Panchal, Charotar Publishing House.
3. AutoCAD 2018 Training Guide, Sagar Linkan, BPB Publications, 2018 Edition.

Reference Books

1. Engineering drawing practice for schools and colleges SP 46:2003 (BIS).

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Program: Bachelor of Engineering		**Semester: IV**
Course Title: Vector Calculus and Differential Equations		**Course Code: 15EMAB241**
L-T-P: 4-0-0	**Credits: 4**	**Contact Hours: 4 Hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 50	**Examination Duration: 3 Hrs**	

Unit I

1. Vector Algebra **6 Hrs**

Vectors, Vector addition, multiplication (Dot and Cross products), Triple products, Vector functions, Vector differentiation, Velocity and Acceleration of a vector point function

2 Partial differentiation **7 Hrs**

Function of several variables, Partial derivatives, Chain rule, Errors and approximations

3 Multiple integrals **7 Hrs**

Double integral, Evaluation by change of order, change of variables, simple problems, Triple integrals, simple problems

Unit II

4 Vector Calculus **13 Hrs**

Vector fields, Gradient and directional derivatives, Line and Surface integrals. Independence of path and potential functions. Green's theorem, Divergence of vector field, Divergence theorem, Curl of vector field. Stokes theorem

5 Differential equations of second order **7 Hrs**

Differential equations of second and higher orders with constant coefficients, method of variation of parameters.

Unit III

6 Partial differential equations **10 Hrs**

(a) Introduction, classification of PDE, Formation of PDE, Solution of equation of the type Pp + Qq = R, Solution of partial differential equation by direct integration methods, method of separation of variables.
(b) Modeling: Vibration of one-dimensional string-wave equation and heat equation. Laplace equation. Solution by separation of variables method

Text Books

1. Grewal B S, Higher Engineering Mathematics, 38 ed, Khanna Publication, New Delhi, 2001
2. Bali and Iyengar, A text book of Engineering Mathematics, 6 ed, Laxmi Publications(p) 2003

Reference Books

1. James Stewart, Early Transcendentals Calculus- Thomson Books, 5 ed, 2007

Program: Bachelor of Engineering		**Semester: IV**
Course Title: Numerical Methods and Partial Differential Equations		**Course Code: 19EMAB206**
L-T-P: 3-1-0	**Credits: 4**	**Contact Hours: 5 Hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 3 Hrs**	

Unit I

1. Interpolation techniques 8 Hrs

Finite differences, Forward, Backward and central difference operators. Newton Gregory forward and backward interpolation formulae. Sterling's and Bessel's formulae for central difference, Newton's divided difference formula for un equal intervals. Heat transfer problem, gas law problem-shear stress problem-using interpolation.

Python: Interpolation problems related to Mechanical engineering 7 Hrs

2. Matrices and System of linear equations

Introduction to system of linear equations, Rank of a matrix by elementary row transformations. Consistency of system of linear equations, solution of system by Direct methods - Gauss elimination, Gauss Jordon method. Solution of homogenous system AX=0, Eigenvalues and Eigenvectors of a matrix.

Python: Matrices, system of linear equations by Gauss elimination, Gauss Jordon and eigenvalue problems

Unit II

3. Numerical solution of linear equations 5 Hrs

Solution of system of equations by Iterative methods- Guass-Seidal method. Largest Eigenvalue and the corresponding Eigenvector by power method. Spring mass system Falling parachutist using system of equations.

Python: Application problems on mechanical engineering

4. Partial differential equations 10 Hrs

Introduction, classification of PDE, Formation of PDE, Solution of equation of the type Pp + Qq = R, Solution of partial differential equation by direct integration methods, method of separation of variables. Modeling: Vibration of one-dimensional string-wave equation and heat equation. Laplace equation. Solution by method of separation of variables.

Python: Solution of Partial differential equations

Unit III

5. Finite difference method. 10 Hrs

(a) Finite difference approximations to derivatives, finite difference solution of parabolic PDE explicit and Crank-Nicholson implicit methods. Engineering Problems: Temperature distribution in a heated plate

(b) Hyperbolic PDE-explicit method, Elliptic PDE-initial-boundary value problems. Vibration of a stretched string, steady-state heat flow.

Python: Finite difference solution of Partial differential equations.

Text Books

1. Kreyszig E., Advanced Engineering Mathematics, 8ed, John Wiley & sons, 2003.
2. Potter M C, Jack Goldberg and Aboufadel E F, Advanced Engineering Mathematics, 3ed, Oxford Indian Edition, 2005.
3. Grewal B S, Higher Engineering Mathematics, 38ed, TATA McGraw-Hill, 2001.

Reference Books

1. Burden R L and Douglas Faires J, Numerical Analysis, 7ed, Thomson publishers, 2006.
2. Simmons G F and Krantz S G, Differential Equations, TATA McGraw-Hill, 2007.
3. Sastry S S, Introductory method for numerical analysis, 3ed, PHI, 2003
4. Chapra S C and Canale R P, Numerical methods for Engineers, 5ed, TATA McGraw-Hill, 2007.

Program: Bachelor of Engineering		**Semester: IV**
Course Title: Fundamentals of Machine Design		**Course Code: 22EMEC202**
L-T-P: 3-0-0	**Credits: 3**	**Contact Hours: 3 Hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 3 Hrs**	

Unit I

1. Introduction to Machine Design 3 Hrs

Machine Design, Basic Procedure of Machine Design, Design of Machine elements, Design synthesis, Use of Standards in Design, Selection of prepared sizes, Aesthetic considerations in design, Ergonomic considerations in design, Concurrent Engineering.

2. Design against Static Load 6 Hrs

Modes of failure, factor of safety, eccentric axial loading, design of machine parts, Stress Concentration, Stress Concentration Factors, Reduction of Stress Concentration. Theories of Elastic failure, Maximum Principal Stress Theory, Maximum Shear Stress Theory, Distortion-Energy Theory, Selection and use of failure Theories.

3. Design against Reversing load 5 Hrs

Fluctuating Stresses, Fatigue Failure, Endurance Limit, Low cycle, and High Cycle Fatigue, Notch Sensitivity, Endurance Limit- Approximate Estimation, Reversed Stresses-Design for Finite and Infinite Life

Unit II

4. Design against Fluctuating load 4 Hrs

Soderberg and Goodman equations. Fatigue design under combined stresses. Impact Stresses.

5. Design of Belt Drives 5 Hrs

Introduction to Belt drives, Materials for Belts, Advantages, and disadvantages of V belts over flat belt drives, Dimensions of standard V grooved pulley, Power transmission, Number of belts, Centre distance, Pitch length of the belt, Ratio of driving tensions, Design procedure of V belts.

6. Shafts and Keys 7 Hrs

Transmission Shafts, Shaft Design on Strength Basis, Shaft Design on Torsional rigidity Basis, ASME Code for shaft design, Design of Shafts subjected to combined bending and twisting. Keys, Saddle and Sunk keys, Design of square and flat Key.

Unit III

7. Temporary Joints 5 Hrs

Bolted joint –simple analysis, eccentric load perpendicular to the axis of the bolt, eccentric load parallel to the axis of bolt

8. Permanent Joints 5 Hrs

Welded Joints, Strength of Butt Welds, Strength of Parallel fillet Welds, Strength of Transverse Fillet Welds, Eccentric Loaded welded joints, Riveted Joints, Types of riveted joints, Types of failures, Design of butt and lap joints for Boilers.

Text Books

1. V.B. Bhandari, Design of Machine Elements, Fourth Edition, TMGH, New Delhi, 2017.

Reference Books

1. T. Krishna Rao, Design of Machine Elements (Volume I), 2nd Edition, I K International Publishing House Pvt. Ltd., New Delhi, 2015.
2. Farazdak Haideri, Mechanical Engineering Design (Volume I), 2nd Edition, Nirali Prakashan, 2012.
3. K. Mahadevan and Balaveera Reddy, Design Data Hand Book, CBS Publication, Fourth Edition. 2016.

Program: Bachelor of Engineering		**Semester: IV**
Course Title: Machines & Mechanisms		**Course Code: 22EMEC203**
L-T-P: 3-0-0	**Credits: 3**	**Contact Hours: 3 Hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 3 Hrs**	

Unit I

Chapter 1. Fundamentals of Kinematics: 7 Hrs

Links, pairs, Mechanisms, machines, structure, and Inversions. Identifying types of links, pairs, Drawing Kinematic Diagram and finding mobility of linkages, Inversions of Four bar mechanism, single slider crank mechanism, and double slider crank mechanism. Steering gear mechanism, Hook's joint analysis,

Chapter 2. Kinematic Analysis of Mechanisms: 8 Hrs

Velocity analysis by Instantaneous centre method, Velocity and acceleration analysis by Relative velocity method for different mechanism.

Unit II

Chapter 3. Kinematic analysis of Gear and Gear Trains: 5 Hrs

Terminology of gears , backlash in gears, Law of gearing, velocity of siding, length of path of contact, arc of contact, Contact ratio Numerical,, Epicyclic gear train with Numericals

Chapter 4. Cams: 5 Hrs

Introduction, classification of followers and cams. Displacement diagrams for roller follower with SHM and analysis, displacement diagrams for followers with UV&R and analysis. Design of cam profile

Chapter 5. Balancing of masses: 5 Hrs

Necessity of balancing, Static and Dynamic balancing, Balancing of several masses in single and several masses in multiple planes, Balancing of reciprocating masses, Balancing of multi cylinder inline engine.

Unit III

Chapter 6. Turning Moment Diagrams and Flywheel: 5 Hrs

Dynamics of engine mechanism, Turning Moment Diagrams' for machines , Energy stored in a flywheel , Design of flywheel

Chapter 7. Gyroscope: 5 Hrs

Effect of gyroscopic couple on airplane and Ship, Stability of two wheel and four wheel drives moving in a curved path.

Text Books

1. R. L. Norton, Kinematics and Dynamics of Machinery, 2nded, Tata McGraw Hill, New Delhi. 2012
2. David Myszka, Machines and Mechanisms- Applied Kinematic Analysis, 3rded, PHI, New Delhi 2009

Reference Books

1. John Uicker, Gordon Pennock , Joseph Shigley, Theory of Machines and Mechanisms, 4thed, Oxford University Press-NEW DELHI. 2009
2. S. S. Rattan, Theory of Machines, 2nded, Tata McGraw Hill Publishing Company Ltd., New Delhi. 2006

Program: Bachelor of Engineering		**Semester: IV**
Course Title: Engineering Materials		**Course Code: 15EMEF202**
L-T-P: 4-0-0	**Credits: 4**	**Contact Hours: 4 Hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 50	**Examination Duration: 3 Hrs**	

Unit I

Chapter 1. Introduction to Engineering Materials: 7Hrs

Overview of material types (metals, ceramics, polymers, and composites); historical perspective and modern developments; basic material properties (mechanical, thermal, electrical, magnetic), Sustainability in the context of Engineering materials selection.

Chapter 2. Materials for Sustainability: 6Hrs

Recycling processes, the concept of Life Cycle Assessment (LCA), LCA significance in evaluating the sustainability of materials, Renewable, recyclable, and biodegradable materials, Material selection for sustainability.

Chapter 3. Atomic Structure and Interatomic Bonding: 7Hrs

Atomic structure and bonding; Macro-Micro-Nano: The scale of structures, Crystal Structures, Imperfections in solids and their roles in affecting the behavior of materials; diffusion, Fick's laws of diffusion, Diffusion in crystalline and non-crystalline solids, Influence of lattice structure on diffusion.

Unit II

Chapter 4. Mechanical Properties of Materials: 5Hrs

Stress-strain diagrams to show ductile and brittle behavior of materials, linear and nonlinear elastic behavior of materials, mechanical properties in elastic and plastic range, Effect of strain rate and temperature on tensile properties, Fatigue: Types of fatigue loading with example, mechanism of fatigue, fatigue properties, fatigue testing and SN diagram; Creep: Description of phenomenon with examples, stages of creep, creep properties.

Chapter 5. Phase Diagrams and Heat Treatment: 5Hrs

Solid solutions, Hume Rothery rules, substitutional and interstitial solid solutions, intermediate phases, Gibbs phase rule, construction of equilibrium diagrams, equilibrium diagrams involving complete and partial solubility, the iron-carbon system; heat treatment processes (annealing, quenching, tempering).

Chapter 6. Ferrous and Nonferrous metals: 5Hrs

Properties, composition and uses of cast irons and steels, AISI and BIS designation of steels. Aluminum, Magnesium and Titanium alloys; Exotic alloys.

Chapter 7. Polymers, Ceramics, and Composites: 5Hrs

Production, properties, and applications of polymers, ceramics, and composites; thermoplastics and thermosets, elastomers, mechanical and thermal properties of ceramics, engineering applications of ceramic, polymer materials and composites.

Unit III

Chapter 8. Corrosion and Degradation of Materials: 05Hrs

Fundamental principles and mechanisms of corrosion; Different types of corrosion, such as uniform corrosion, localized corrosion, galvanic corrosion, Methods and techniques for preventing and controlling corrosion; Principles and procedures of corrosion testing techniques, Degradation of non-metallic materials.

Chapter 9. Materials Selection for Eco-design: 05Hrs

Materials Performance Requirements, Selection Criteria- economic and environmental considerations; Matching materials to design, strategy- translation, screening, ranking and documentation; Introduction to systems thinking in materials science- Interconnectedness, Boundaries and Interfaces.

Text Books:

1. William Callister, Materials Science and Engineering, John Wiley & Sons. Inc., 10th Edition, January 2018 (ISBN: 978-1-119-40549-8).
2. Michael Ashby and D R H Jones, Engineering Materials: An Introduction to Properties, Applications and Design- 5th Edition, Butterworth-Heinemann, December 2018.
3. Julian M. Allwood and Jonathan M. Cullen, "Sustainable Materials: With Both Eyes Open", UIT Cambridge Ltd.; second edition April, 2012.

Reference Books

1. Donald Askeland and Pradeep Phule, The Science and Engineering of Materials Thompson Learning, 7th Edition, CENGAGE Learning, 2019.

Program: Bachelor of Engineering		**Semester: IV**
Course Title: Mechatronics		**Course Code: 24EMEC201**
L-T-P: 2-0-1	**Credits: 3**	**Contact Hours: 4 Hrs/week**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hours: 30	**Examination Duration: 2 Hrs**	

Unit - 1

1. Introduction to Mechatronics: 04 hrs

Definition & overview of Mechatronics, Key elements, Types of Simulation, Mechatronics system Design approach, examples of mechatronic systems.

2. Signal conditioning: 10 hrs

Introduction, Amplification, Filtering, Isolation and Protection, Linearization, Multiplexing, ADC and DAC Process; Data Acquisition System (DAQ), AC/DC Bridges, Modulation and Demodulation. Sequential circuits, flip-flops, clocked and edge triggered flipflops, timing specifications, asynchronous and synchronous counters, counter design with state equations, Registers, serial in serial out shift registers. Computational systems:

Case studies (like Washing machine, Automatic Camera) to illustrate integration of all components.

Unit - 2

3. Sensors: 10 hrs

Introduction, Characteristics and selection of Sensors: Displacement, Position, Velocity, Acceleration, proximity, Temperature, Liquid Level, Light intensity, Force, Torque, Power, Pressure and Flow rate measurement.

4. Actuators: 06 hrs

Relay, Solenoid, DC motor, Stepper motor, AC and DC Servo motor, Drive Circuits

Text Books

1. Tilak Thakur, Mechatronics, 1st edition, Oxford Higher Education, 2016.
2. W. Bolton, “Mechatronics”, 2nd edition, Pearson Ed, 2001

References

1. Devdas Shetty, Richard Kolk, “Mechatronics System Design”, 2nd edition, Cengage Learning, 2010.

Program: Bachelor of Engineering		**Semester: IV**
Course Title: Microcontroller & Interfacing		**Course Code: 24EMEC202**
L-T-P: 2-0-1	**Credits: 3**	**Contact Hours: 4 Hrs/week**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hours: 30	**Examination Duration: 2 Hrs**	

Unit – 1

Chapter 1: Microprocessors and Microcontroller 4hrs

Introduction, Microprocessors, and Microcontrollers, A Microcontroller Survey, RISC & CISC CPU Architectures, Harvard & Von-Neumann Computer architecture.

Architecture of 8051 and Arduino ATmega32:
Microcontroller Hardware, Input / Output Pins, Ports and Circuits, semiconductor Memories, Interfacing external RAM & ROM memories

Chapter 2: Addressing Modes and Operations (Arduino ATmega32) 5hrs

Addressing modes, stack concept, and Instruction sets, Data transfer, Arithmetic Operations, Logical Operations, Program Branch, Rotate and Swap Operations

Chapter 3: Arduino ATmega32 Programming in 'C' 6 hrs

Data Types and Time delays in (Arduino ATmega32) C, I/O Programming, Logic operations, Data Conversion programs, Data serialization, Shift and rotate instructions in AVR

Unit – 2

Chapter 4: Counter/Timer Programming in (Arduino ATmega32) 5 hrs

Introduction, Timer SFRs, Programming (Arduino ATmega32) Timers, Programming Timer0 and Timer1, in (Arduino ATmega32), timer programming in normal mode, CTC Mode, Fast PWM, Counter Programming in (Arduino ATmega32),

Chapter 5: Serial Communication 5 hrs

Basics of Serial Communication, (Arduino ATmega32) connections to RS-232, (Arduino ATmega32) Serial Communication modes, Programming, Serial port programming in C.

Chapter 6: Interrupts 5 hrs

Introduction to interrupts, interrupts vs. polling, classification of interrupts, interrupt priority, interrupt vector table, interrupt service routine, The JUMP and CALL, Program range, jump calls, and Subroutines Interrupts and Returns, Example Problems.

Text books

1. The AVR microcontroller and embedded system using assembly and c by Muhammad ali mazidi, sarmad naimi,sepehr naimi 1st edition, published in 2010, Publisher: Pearson Education
2. Embedded system design with the Atmel AVR microcontroller I and II by Steven F Barret, 1st edition, published in 2009. Publisher: Morgan & Claypool.
3. Practical AVR Microcontrollers by Alan Trevennor, 1st edition published in 2012, Publisher: Apress

Reference Books

1. Experimenting With AVR Microcontroller by Alan Trevennor, 1st edition published in 2009. publisher: Elektor International Media Edition.
2. Microchip AVR Microcontroller Primer Programming and Interfacing by Steven F Barret Daniel J Pack , 1st edition, published in 2007, Publisher: Prentice Hall.
3. Atmel ATmeg32 Datasheet , Microchip Technology.

Program: Bachelor of Engineering		**Semester: IV**
Course Title: Microcontroller & Interfacing Lab		**Course Code: 22EMEP204**
L-T-P: 0-0-1	**Credits: 1**	**Contact Hours: 2 Hrs/week**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hours: 24	**Examination Duration: 2 Hrs**	

Experiments	No of sessions
1. Write a program to demonstrate the blinking of LED in PIC16F877A	01
2. Write a program to demonstrate a counting machine which count from 0000 to 9999 and display on 7 segment LED display using PIC16F877A	01
3. Write a program to read the values from the temperature sensor (LM35) and display the temperature in degree Celsius on LCD display using PIC16F877A	01
4. In bank lockers there is requirement of password protection to open the locker. Develop an application Using a 4*3 keypad and LCD to secure the lockers by providing password protection.	01
5. Write a program to measure the distance of an object using ultrasonic Sensors and display the distance in terms of centi-meter and inch. Make the connections as per the schematic and develop the flowchart and the code to perform the required operation.	01
6. Write a program to control the speed and direction of DC, stepper and servo motors.	02
7. Design a development board using Atmega328 or PIC 18 using eagle/ Dip-trace	01
8. Develop a printed circuit board (PCB) for your designed Atmega328 or PIC18 development board.	01
9. Design a programmer for your PIC18 development board to burn the program using PICkit2 or any similar software's	01
10. Develop a printed circuit board (PCB) for your designed and validated programmer which can burn programs on the PIC16 or PIC18 ICs.	01
11. Write a program on Py-board microcontroller using python programming and image processing to detect the tennis ball.	01

Program: Bachelor of Engineering		**Semester: IV**
Course Title: Machines & Mechanisms Lab		**Course Code: 15EMEP204**
L-T-P: 0-0-1	**Credits: 1**	**Contact Hours: 2 Hrs/week**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hours: 24	**Examination Duration: 2 Hrs**	

Experiments

1. Introduction to software and exercises 4 Hrs
2. Determination of the Mobility of linkages 2 Hrs
3. Velocity and Acceleration analysis on applications of slider crank mechanisms 2 Hrs
4. Velocity and Acceleration analysis on applications of 4 bar mechanisms 2 Hrs
5. Kinematic analysis of a Epicyclic Gear Train 2 Hrs
6. Determination of gyroscopic couple and verification of gyroscopic law 2 Hrs
7. Balancing of a system of rotating masses in a single plane 2 Hrs
8. Balancing of a system of rotating masses in a Multiple plane 2 Hrs
9. Kinematic analysis of a cam follower pair for specific inputs 4 Hrs
10. Construction of the best suited mechanism and analysis of the mechanism using traditional and/or modern tools for a specific application 2 Hrs

Text Books

1. David Myszka, Machines and Mechanisms- Applied Kinematic Analysis, 3rdEdition, PHI,

Reference Books

1. John Uicker, Gordon Pennock, Joseph Shigley, Theory of Machines and Mechanisms, 4th Edition, Oxford University Press, New Delhi
2. A brief introduction to MSC.ADAMS-user manual, McNeil Schindler Corp (MSC), USA.
3. "Make it Kit", Educational Mechanism construction kit.

Program: Bachelor of Engineering		**Semester: IV**
Course Title: Engineering Materials Lab		**Course Code: 15EMEP202**
L-T-P: 0-0-1	**Credits: 1**	**Contact Hours: 2 Hrs/week**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hours: 24	**Examination Duration: 2 Hrs**	

Experiment

1. Introduction to the Laboratory-Overview of Destructive and Non-Destructive Testing methods. (Awareness about the ASM hand books and ASTM standards) 2 Hrs
2. Non-destructive test experiments

a. Ultrasonic flaw detection. b. Magnetic particle inspection c. Dye penetration testing, To study the defects of castings and welded specimens. 2 Hrs

3. Evaluation of the tensile strength, Compression strength, Shear strength, Bending/ Torsion strength and Impact strength.
   Ex: Should be able to Describe the differences between the tensile behavior of the metal sample and that of polymer sample, considering that the student performs the test on two different materials family. 8 Hrs
4. To study wear characteristics of ferrous, non-ferrous and composite materials for different loading.
   Computation of wear parameters: wear rate, wear resistance, specific wear rate, frictional force, coefficient of friction, wear coefficient. 2 Hrs
5. To study the microstructure of the ferrous and nonferrous alloy and to perform grain size analysis and volume fraction analysis. 2 Hrs
   - Familiarization with the procedure for preparation of a material specimen for microscopic examination.
   - Familiarization with compound optical microscopes and metallography.
   - Examination of surface characteristics of engineering materials.
   - Grain size determination of metals and analysis.
6. To analyze given SEM Micrographs (Microstructure and fracture surface morphology) and conclude on the structure and mode of fracture. 2 Hrs
   (Familiarization with the advanced characterization of metals by Scanning electron microscopy).
7. Computer Modeling of Stress Concentration, Crack Opening and Crack Propagation
   Understand the occurrence of stress concentration at geometrical discontinuities.
   Determine the stress concentration factor at a geometrical discontinuity. 2 Hrs
8. Design an experiment to investigate the spring characteristics of any given spring. 2 Hrs
9. Synthesize a novel composite material which is reinforced with a natural fiber in a polymer matrix and perform the mechanical characterization for investigation of mechanical properties, which is desirable for specified engineering applications.
   Perform a parametric analysis which affects the mechanical properties of prepared composites using a statistical approach and find the correlation of those parameters with properties of composites. 2 Hrs

Text Books

1. William Callister, Materials Science and Engineering, John Wiley & Sons. Inc., 10th Edition, January 2018 (ISBN: 978-1-119-40549-8).
2. Michael Ashby and D R H Jones, Engineering Materials: An Introduction to Properties, Applications and Design- 5th Edition, Butterworth-Heinemann, December 2018.

Reference Books

1. Donald Askeland and Pradeep Phule, The Science and Engineering of Materials Thompson Learning, 7th Edition, CENGAGE Learning, 2019.

2. George Murray, Charles V. White, Wolfgang Weise, Introduction to Engineering Materials, 2nd Edition, CRC Press, 07-Sep-2007

Program: Bachelor of Engineering		**Semester: IV**
Course Title: Gen AI for All		**Course Code:** 24EMEP201
L-T-P: 0-0-2	**Credits:** 2	**Contact Hours:** 2 Hrs/week
ISA Marks: 80	**ESA Marks:** 20	**Total Marks:** 100
Teaching Hours: 48	**Examination Duration:** 2 Hrs	

Module 1: Gen AI Introduction and Playground (6 labs)

Lab 1-4: Basic Training of Python (Enabler for Hugging Face)

Lab 5: Introduction to Generative AI

- Overview of Generative AI: Definition and basic principles, Historical context and evolution of generative models
- Key Concepts and Terminology: Generative vs. discriminative models, Overview of neural networks and deep learning
- Applications of Generative AI: Creative arts: Art, music, and literature, Practical applications: Text generation, image synthesis, and more

Lab 6: Introduction to Hugging Face AI community

- Overview:
- Building one example for text, Image, Audio and Video

Module 2: Gen AI Experimentation Lab – (4 labs) Text tools, Audio tools, Image tools and Video tools

Lab 1: Hands-on Experimentation with Text Generation

- Introduction to Hugging Face Transformers
- Text Generation with Pre-trained Models
- Practical Exercise: Generating creative content (stories, poetry) using Hugging Face models

Lab 2: Hands-on Experimentation with Audio Generation

- Introduction to Audio Generative Models: Overview of audio synthesis and transformation techniques, Understanding different types of audio generative models
- Using Pre-trained Audio Models with Hugging Face: Accessing and utilizing pre-trained audio generation models, Practical examples: Creating synthetic audio and transforming audio files

Lab 3: Hands-on Experimentation with Image Generation

- Introduction to Image Generative Models: Overview of Generative Adversarial Networks (GANs), Understanding the architecture and functioning of GANs
- Using Pre-trained GANs with Hugging Face: Accessing and utilizing pre-trained image generation models, Practical , examples: Creating artwork and manipulating images
- Practical Exercise: Generating and enhancing images using Hugging Face GANs

Lab 4: Hands-on Experimentation with Video Generation

Module 3: Gen AI Project Studio – (4 labs)

- An example to showcase walkthrough of tools with one case study
- Faculty will pick the respective domain project and demonstrate the building of project

Module 4: Gen AI Showcase – (10 labs)

- Domain specific example to showcase GenAI based solution and report
- Students in a team of 2-4 demonstrate the building of project for selected application

← BACK TO SEMESTER V

Program: Bachelor of Engineering		Semester: V
Course Title: Numerical Methods and Statistics		Course Code: 24EMAB301
L-T-P: 3-0-1	Credits: 4	Contact Hours: 6Hrs/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 40	Examination Duration: 3 Hrs	

Unit I

1. **Numerical Methods 8 hrs**
   Introduction to numerical methods. Roots of equations using Bisection Method, Newton- Raphson Method, Finite differences, Forward, Backward Operators. Newton Gregory forward and backward interpolation formulae. Newton's divided difference formula for un equal intervals. Numerical solution of first order ODE, Euler's and Modified Euler's method, Runge Kutta 4^{th} order method. Implementation using python-programming
2. **Matrices and System of linear equations 8 hrs**
   Introduction to system of linear equations, Rank of a matrix by elementary row transformations. Consistency of system of linear equation solution of system by (i) Direct methods-Gauss elimination, Gauss Jordon method (ii) Iterative methods- Guass-Seidal method. Eigenvalues and Eigenvectors of a matrix. Largest Eigenvalue and the corresponding Eigenvector by power method. Implementation using python-programming.

Unit II

3. **Curve fitting and regression 5 hrs**
   Introduction to method of least squares, fitting of curves $y = a + bx$, $y = ab^x$, $y=a + bx +cx^2$, correlation and regression.
4. **Probability 9 hrs**
   Definition of probability, addition rule, conditional probability, multiplication rule, Baye's rule. (no proof) Discrete and continuous random variables- PDF-CDF- Binomial, Poisson and Normal distributions (Problems only).

Unit III

5. **Sampling distributions 10 hrs**
   (a) Sampling, Sampling distribution, Standard error, Null and alternate hypothesis, Type-I and Type-II errors, Level of significance. Confidence limits for means (large sample).
   (b) Testing of hypothesis for means. large and small samples and student's t- distribution and Confidence limits for means (small sample).

Text Books

1. Bali and Iyengar, A text book of Engineering Mathematics, 6ed, Laxmi Publications(p) Ltd, 2003
2. Chapra S C and Canale R P, Numerical methods for Engineers, 5ed, TATA McGraw-Hill, 2007
3. Gupta S C and Kapoor V K, Fundamentals of Mathematical Statistics, 9ed, Sultan Chand & Sons, New Delhi, 2002

Reference Books

1. Sastry S S, Introductory method for numerical analysis, 3ed, PHI, 2003.
2. J. Susan Milton, Jesse C. Arnold, Introduction to Probability and Statistics: Principles and Applications for Engineering and the Computing Sciences, 4^{th} Ed, TATA McGraw-Hill Edition 2007.

← BACK TO SEMESTER V

Program: Bachelor of Engineering		**Semester: V**
Course Title: Design of Machine Elements		**Course Code: 23EMEC301**
L-T-P: 3-0-0	**Credits: 3**	**Contact Hours: 3 Hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 3 Hrs**	

Unit I

Chapter 1: Spur Gears 8 Hrs

Mechanical Drives, Gear Drives, Classification of Gears, Selection of Type of Gears, Terminology of Spur Gear, Standard Systems of Gear Tooth, Force Analysis, Gear Tooth Failures, Selection of Material, Number of Teeth, Face Width, Beam Strength of Gear Tooth, Permissible Bending Stress, Effective Load on Gear Tooth, Estimation of Module Based on Beam Strength, Wear Strength of Gear Tooth, Estimation of Module Based on Wear Strength

Chapter 2: Helical and Bevel Gears 7 Hrs

Helical Gears, Terminology of Helical Gears, Virtual Number of Teeth, Tooth Proportions, Force Analysis, Beam Strength of Helical Gears, Effective Load on Gear Tooth, Wear Strength of Helical Gears. Bevel Gears, Terminology of Bevel Gears, Force Analysis, Beam Strength of Bevel Gears, Wear Strength of Bevel Gears, Effective Load on Gear Tooth.

Unit II

Chapter 3: Springs 8 Hrs

Types of springs, Terminology of Helical spring, styles of end, stress and deflection equations, series and parallel connections, spring materials, Design of helical springs, spring design –trial and error method, design against fluctuating load, optimum design of helical spring, surge in spring, multi-leaf springs, nipping of leaf springs.

Chapter 4: Friction Clutches and Brakes 7 Hrs

Clutches, Torque Transmitting Capacity, Multi-disk Clutches, Friction Materials, Breaks, Block Brake with short shoe and Band Brakes

Unit III

Chapter 5: Rolling Contact Bearings 5 Hrs

Bearings, Types of Rolling Contact Bearings, Selection of Bearing Type, Static Load Carrying Capacity, Dynamic Load Carrying Capacity, Equivalent Bearing Load, Load-Life Relationship, Selection of Bearing Life, Load Factor, Selection of Bearing From Manufacturer's Catalogue, Bearing failure – Causes and Remedies.

Chapter 6: Sliding Contact Bearings 5 Hrs

Basic Modes of Lubrication, Viscosity, Measurement of Viscosity, Viscosity Index, Petroff's Equation, Mckee's Investigation, Bearing Design- Selection of Parameters, Comparison of Rolling and sliding Contact Bearings, Bearing failure – Causes and Remedies

Text Books

1. Machine Design, An Integrated Approach, Robert L. Norton, Pearson Education, 2004
2. Design of Machine Elements: V.B. Bhandari, Tata McGraw., New Delhi, 2nd Edition 2007.

Reference Books

1. Machine Design: Hall, Holowenko, Laughlin (Schaum's Outlines series) Adapted by S.K. Somani, Tata McGraw Hill Publishing Company Ltd., New Delhi, Special Indian Edition, 2008.
2. Design of Machine Elements- K Ganesh Babu and K Srithar, MGH Education (I), Chennai, 2009
3. K. Mahadevan and Balaveera Reddy, Design Data Hand Book, CBS Publication, Fourth Edition. 2016.

Program: Bachelor of Engineering		**Semester:** V
Course Title: Programming Industrial Automation Systems		**Course Code:** 24EMEC302
L-T-P: 2-0-2	**Credits:** 4	**Contact Hours:** 6 hrs/week
ISA Marks: 50	**ESA Marks:** 50	**Total Marks:** 100
Teaching Hours: 26 + 48	**Examination Duration:** 2 hrs	

Unit-I

Chapter 1. Introduction: 2 Hrs

Advantages and Disadvantages of Automation, Automation in Production System, Principles and Strategies of Automation, Basic Elements of an Automated System, Levels of Automation and Manufacturing environment.

Chapter 2. Programmable logic controllers (PLC) & its building blocks: 5 Hrs

Internal architecture of Programmable Logic Controllers systems, Input/ Output devices, Memory Organization, I/O processing, Signal conditioning, Remote connections, Networks, Processor Scan cycle, Error Checking, and Diagnostics, Boolean algebra in PLC.

Chapter 03. PLC Standards (IEC61131-3, IEC 61499) and Attributes: 5 Hrs

IEC 61131-3: Building Blocks, benefits, Programming Languages of IEC 61131-3, Ladder diagrams, Analogy with Boolean Algebra and Binary Logic, Function blocks, Instruction lists, Sequential function charts, State chart modeling, Structured text programming with example programs for each.

Unit-II

Chapter 4. Advanced PLC functions: 4 Hrs

PLC Sequencer, Shift registers, Program / Flow Control Instructions, Arithmetic Instructions, Data handling Instructions like FIFO, FAL, ONS, Data Transfer Instructions PLC MOVE, Network Communication Instructions, and Analog PLC operation.

Chapter 05. Designing systems, PLC Start-up & Maintenance: 6 Hrs

PLC Core application development, Development Cycle, Safe systems, Commissioning, Fault finding, PLC System Layout, Safety Standards like NEMA & NEC, Electrical wiring diagrams, PLC Start-Up and Checking Procedures. Building applications (CNC machine, Filling station, Sorting station, Inspection station etc) and Debugging the errors of ladder logic diagrams/electric wiring diagrams of different applications.

Chapter 06. PC based Automation using SCADA and HMI: 4 Hrs

Technologies and advantages of PC based Automation, Programmable Automation Controller systems (PACs) for Industrial control, SCADA Introduction, SCADA Systems, SCADA Functions, Human Machine Interface (HMI), Distributed Control Systems (DCS). Concepts on developing HMI and SCADA systems for industrial applications.

Sl. No	Experiments	No of Sessions
1.	Introduction and Demo on AND, OR, NOT, NAND and NOR logic gates	**2**
2.	Write a program that will activate output D under the following conditions: • When both switch A and B are closed • When switch C is closed	**1**
3.	Motor Forward/Reverse Create a motor controller with two buttons, one for forward and one for reverse. The motor will operate in forward or reverse mode only when one of the buttons is pressed. If both buttons are pressed simultaneously, the motor will not function	**1**
4.	Car Safety System Create a ladder logic program for a car safety system that prevents the application of ignition power when the car door is open and the seatbelt is not fastened. The engine will start only when it is safe, i.e., the car door is closed, the seatbelt is fastened, and the key is turned.	**1**

5.	Exercises involving ALU, Counter and timing functions	**1**
6.	Exercises on Boolean Expressions	**1**
7.	Motor Control A PLC motor controller has two START buttons and two STOP buttons. The motor is to run if two RUN buttons depressed simultaneously. The motor should run when the buttons are released. Motor stops by depressing any STOP button stops. Construct a LAD for this motor control task.	**1**
8.	Sequential Logic Control - Traffic Light Controller	**1**
9.	Conveyor Control Conveyor has to start after pressing PB, and it should travel for 5 secs and it should, halt for a period of 5 seconds and then resume the motion. Construct a LLD for this scenario.	**1**
10.	Develop a ladder logic diagram for the automatic door opening of the room.	**1**
11.	Develop a ladder logic diagram for the automatic operation of the air conditioning unit.	**1**
12.	PLC Programming using Functional block, structured text, and instruction list	**4**
13.	Exercises on SCADA and HMI I. SCADA a. Development of an assembly line b. Development of multi-stage water treatment plant II. HMI a. Virtual development of HMI to control the machining parameters of a CNC machine.	**4**
14.	Open Ended – Develop an HMI/SCADA system to control the processes of i. Food production systems and ii. Manufacturing plant systems.	**2**

Text Books:

1. W. Bolton, Programmable Logic Controllers – 6th Edition, Elsevier, 2015.
2. Frank Lamb, Industrial Automation Hands-On, McGraw Hill Publication, 2013.

References:

1. Frank D. Petruzella, Programmable Logic Controllers, 5th Edition, McGraw Hill Publication, 2019.
2. Tiess Chiu Chang & Richard A. Wysk, An Introduction to Automated Process Planning Systems.
3. Laboratory manual developed by in-house faculty (For Laboratory experiments)

Program: Bachelor of Engineering		Semester: V
Course Title: Finite Element Methods		Course Code: 23EMEC303
L-T-P: 3-0-0	Credits: 3	Contact Hours: 3 Hrs/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 40	Examination Duration: 3 Hrs	

Unit I

Chapter 1. Introduction to FEM: 8 Hrs

Methods to solve Engineering Problems, Brief Introduction to Different Numerical Methods-Finite Element Methods(FEM), Boundary Element Method(BEM), Finite Volume Method (FVM), Finite Difference Method (FDM), General steps of the finite element method, Engineering applications of finite element method, Advantages of the Finite Element Method, Strain- displacement relations, Stress-strain relations, Plain stress and Plain strain conditions, principle of minimum potential energy and virtual work, Rayleigh Ritz method, Galerkin's method, Types of elements: 1D, 2D and 3D, Node numbering, Location of nodes.

Chapter 2. Interpolation functions and stiffness (Displacement) matrix of One-dimensional elements: 7 Hrs

Introduction, Derivation of stiffness matrix for a spring element, Assembly the total stiffness matrix by superposition, shape function, convergent criteria, Pascal's Triangle, One-Dimensional Elements-Analysis of Bars, Linear interpolation polynomials in terms of local coordinate's for1D, elements. Higher order interpolation functions for 1D quadratic and cubic elements in natural coordinates, Lagrange interpolation functions, Numerical Problems: Solution for displacement, stress and strain in 1D straight bars, stepped bars and tapered bars using elimination approach and penalty approach.

Unit II

Chapter 3. Interpolation functions of two- and three-dimensional elements: 8 Hrs

Constant strain triangle, Four-Nodded Tetrahedral Element (TET 4), Eight-Nodded Hexahedral Element, 2D iso-parametric element, 8 noded and 20 noded brick element,

Numerical integration: Gaussian quadrature one point, two-point formulae, 2D integrals,

Numerical Problems: Solution for displacement, temperature using interpolation for 2D elements. Analysis of Trusses and numerical problems.

Chapter 4. Analysis of Beams and Dynamic Considerations: 7 Hrs

Boundary conditions, Load vector, Hermite shape functions, Beam stiffness matrix based on Euler-Bernoulli beam theory, Examples on cantilever beams, propped cantilever beams, Numerical problems on simply supported, fixed straight beams using direct stiffness method with concentrated and uniformly distributed load.

Formulation for point mass and distributed masses, Consistent element and Lumped mass matrix of one-dimensional bar element, Evaluation of eigen values and eigen vectors applied to bars, and stepped bars.

Unit III

Chapter 5. Heat Transfer: 5 Hrs

Finite element formulation of an 1D Heat conduction, Conductivity matrix, Heat conduction with different end conditions, Heat transfer through composite wall, Numerical Problems

Chapter 6. Post processing Techniques: 5 Hrs

Validate and interpret the results, Average and Un-average stresses, Special tricks for post processing, Design modification, CAE Reports.

Text Books

1. T. R. Chandraputala and A. D. Belegundu, Introduction to Finite Elements in Engineering, Third Edition, Prentice Hall of India, 2004.
2. Nitin Ghokale, S.S. Deshpande, S.V. Bedekar and A.N. Thiee, Practical finite element analysis, Finite to infinite, 2008

3. S. S. Rao, Finite Element Method in Engineering, Fourth Edition, Elsevier Publishing, 2007

Reference Books

1. David Hutton, Fundamentals of Finite Element Analysis, Tata McGraw Hill, 2005.
2. S. M. Murigendrappa, Fundamentals of Finite Element Methods, Interline Publication, 2nd Edition 2009.

Program: Bachelor of Engineering		**Semester: V**
Course Title: CAD modelling and PLM Lab		**Course Code: 24EMEP301**
L-T-P: 2-0-2	**Credits: 4**	**Contact Hours: 15 Hrs/week**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hours: 180	**Examination Duration: 2 Hrs**	

1. Sketcher: 24 Hrs

Brief introduction on Sketcher work bench environment

Structure of users and saving of files. Exercises on Sketch Tools, Profile Tool bar and Constraint Tool bar: Generate the following 2D sketches and make them ISO-constrained

2. Part Design: 54 Hrs

Exercise on 3d models using pad, slot, shaft, groove, hole, rib and stiffener commands, cut revolve, Dress up commands like chamfer, fillets etc. *(*Multi-Sections Solid and Removed Multi-Sections Solid Commands)

3. Generative shape design (GSD): 48 Hrs

Exercises using GSD to generate complicated surfaces using sub tool bars: Extrude-Revolution, Offset Variable and Sweep Extrude, Revolve, Trim, Transformation and Fillet tools

Exercises on Surfaces and Operations Tool bar: (Conversion of Surface model into Solid model)

4. Assembly Design: 21 Hrs

Introduction to Assembly Design Work bench; Bottom-Up and Top-Down assembly approaches Invoking existing components into assembly work. Exercise to demonstrate Top-Down assembly approach.

5. Drafting: 18 Hrs

Converting existing 3D models into 2d drawings with all relevant details, sectional views, sheet selection, indicating GD&T symbols and dimensioning.

6. Enovia: 15 Hrs

Introduction to CATIA 3D experience PLM Import the existing CATIA 3D experience data and store in Search and identify the data located in 3D experience database Modify the data in any PLM process Sharing information with users Analyze and Identify impacts of modifications Save the modifications into database

Reference Books

1. Training material of EDS on 3D experience

Program: Bachelor of Engineering		**Semester:** V
Course Title: Automation Lab		**Course Code:** 25EMEP302
L-T-P: 0-0-2	**Credits:** 2	**Contact Hours:** 4 Hrs/week
ISA Marks: 80	**ESA Marks:** 20	**Total Marks:** 100
Teaching Hours: 48	**Examination Duration:** 2 Hrs	

Unit I

Chapter1. Automation Using Hydraulic Systems: 8 Hrs

Introduction to Fluid Power, Advantages and application of Fluid Power, Types of Fluid Power System, Properties and Types of Fluids. Pascal's Law, Continuity Equations, Structure of Hydraulic Control System. **The Source of Hydraulic Power:** Pumps Pumping Theory, Pump Classification, Gear Pumps, Vane Pumps, Piston Pumps, Pump Selection, Hydraulic Actuators and Motors.

Control Components In Hydraulic Systems: Symbolic representation as per ISO 1219 and ISO 5599. Directional Control Valves – Symbolic representation, Constructional features, pressure control valves, flow control valves. S**ervo valves, proportional valves and counter balancing valves.**

Hydraulic Circuit Design (Simulation of circuits in Automation studio): Control of single and double – acting Hydraulic Cylinder, regenerative circuit, pump unloading circuit, Double pump Hydraulic system, Counter Balance Valve application, Hydraulic cylinder sequencing circuits, cylinder synchronizing circuits, speed control of hydraulic cylinder, accumulator circuits.

Chapter2. Automation using Pneumatic Systems: 5 Hrs

Choice of working medium, characteristics of compressed air. Structure of Pneumatic control system. **Linear cylinders, Simple Pneumatic Control:** Direct and indirect actuation pneumatic cylinders, use of memory valve. Flow control valves and speed control of cylinders supply air throttling and exhaust air throttling, use of quick exhaust valve. **Fluid logic control systems.**

Unit II

Chapter 3. Automation Using Electronic Systems: 5 Hrs

Introduction to PLC, types of PLC, components of PLC, structure of PLC and Control of linear actuators using PLC.

Chapter 4. Automation Software and Robot Programming: 5 Hrs

Introduction to Automation Studio software, basics and simulation of circuits. Robotics – Basics, Anatomy and simulation of robotic program (pick and place, welding task etc.)

Sl. No	Name of Experiments	Duration (in hrs)
1	Characteristic Curve of Variable Displacement Hydraulic Pump	0.5
2	Pressure intensification of a single-rod cylinder	0.5
3	Meter-in and Meter-out circuits using Single-rod cylinder and 4/2 DCV	0.5
4	Center Configuration of 4/3 DCV	0.5
5	Application of Regenerative Circuit	1
6	Application of Hydraulic Accumulator	1
7	Hydraulic Motor with 4/3 DCV	1
8	Direct and indirect control of Single Acting Cylinder	0.5
9	Direct and indirect control of Double Acting Cylinder	0.5
10	Speed Control of Single-Acting Cylinder	0.5
11	Position Dependent Control of a Double Acting Cylinder with Mechanical Limit Switches	0.5
12	Design of PLC system to control single-acting cylinder, double-acting cylinder, meter-in, meter-out and regenerative action, clamping and punching operation.	1
13	To control extension/retraction with or without delay using ladder logic	1

14	To build and simulate arc/spot welding process in robotic environment	1
15	To build and simulate pick and place mechanism in robotic environment	1
16	Structured Enquiry example Design a hydraulic circuit for tailstock operation (CNC Machine) i. Piston should move in a set fee for supporting action ii. Piston should retract in rapid mode action	2
17	Open Ended Experiment	2

Text Books:

1. Mikell.O. Groover, Automation, Production system and Computer Integrated Manufacturing, 2nd , PHI, 2002
2. Anthony Esposito, Fluid power with applications, 5th, Pearson Ed, 2000
3. Mikell P. Groover& Mitchell Weiss, Industrial Robotics, 2nd, Mc Graw H, 2003
4. William Bolton, Programmable Logic Controllers, 4th, Newnes, 2006

Reference Books:

1. S R Majumdar, Hydraulic systems, Principles and Maintenance, 5th , TMH, 2002
2. S R Majumdar, Pneumatic Systems, 2nd , TMH, 1995
3. Laboratory manual prepared by in-house team

Program: Bachelor of Engineering		**Semester: V**
Course Title: Finite Element Methods Lab		**Course Code: 23EMEP301**
L-T-P: 0-0-1	**Credits: 1**	**Contact Hours: 2Hrs/week**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hours: 24	**Examination Duration: 2Hrs**	

Category: Demonstration		**No. of Lab. Sessions**
1	Scientific Research Exposure (Research Education): Methods to search/extract Journal papers (Reputed journal paper), Referring papers, Drafting a paper. Introduction to ANSYS Workbench and familiarity. Real time Current/future field issues: Problem Identification	03
Category: Exercises		
Expt./ Job No	Experiment/job Details	No. of Lab. Sessions
1	Static Structural analysis a. Uniform bar, b. Bracket, c. Machine Components	01
2	Linear Buckling a. Columns & Struts (Different Boundary Conditions) b. Machine component	01
3	Non-Linear Structural Analysis a. Geometric Nonlinearity b. Material Nonlinearity c. Contact Nonlinearity	02
4	Dynamic Analysis (Modal/Harmonic/Transient Analysis) a. Beam (Different Boundary Conditions) b. Machine components	01
5	Thermal Analysis a. Fins b. Heat Exchangers c. Machine component	01
6	Drop Test & Impact Analysis a) Mobile drop test b) TV, Refrigerator etc.	01
7	Optimization	01
8	Model Test	01

Category: Structured Enquiry

Execute all the FEM Analysis modules which are dealt under the lab exercise.

Identify the component (Sub-assembly need have Minimum 3 to 4 components)
Start from scratch

- Measure the dimensions of component
- Generate the Solid Modeling of components with overall assembly (In any of the CAD Software)
- Import the model in neutral form to ANSYS Workbench
- Collection of data relevant to Material Properties
- Understand the physics of the problem (Working Principle with load's and boundary conditions)

➢ Interpretation of Results with conclusion.
Category: Open ended
1. Identify field issue pertaining to any component/product in today's industry. 2. Collect the information/literature on earlier worked project through external/internal search a. (Journal Paper/Patent/reports) 3. Comprehend the physics of the problem with working principle. 4. Prepare the abstract and apply to a national/international conference 5. Identify material properties, boundary conditions and load steps. 6. Carryout the analysis as per the FEA steps. 7. Provide engineering solutions to the identified sub assembly (deformation and stresses, material change, weight reduction, increasing load bearing capacity, fatigue life calculation, prediction of endurance limit of component and damage factor). 8. Prepare the draft on the worked-out problem and apply to a national/international conference
Materials and Resources Required: 1. Books/References: Nitin Ghokale, Practical finite element analysis 2. Manuals: Sham Tickoo, ANSYS for Engineers and Designers

← BACK TO SEMESTER V

Program: Bachelor of Engineering		**Semester: V**
Course Title: Mini Project		**Course Code: 15EMEW301**
L-T-P: 0-0-3	**Credits: 3**	**Contact Hours: 3 Hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 36	**Examination Duration: 3 Hrs**	

The mini project is designed to help students develop practical ability and knowledge in reverse engineering. Every batch of 5 students are required to select an equipment such as Table fan, toy car, pump, bicycle etc. They have to dismantle the complete assembly and take measurements using various measuring instruments such as vernier calipers, micrometer, profile projector,3D imager, portable CMM etc. Good sketches are to be made and converted into 3D part using 3D -Experience software. From then on, the complete assembly in 3D, 2D assembly and BOM have to be prepared.

The students will have to develop proficiency in 2D and 3D modeling, Special emphasis is given on incorporating Geometrical dimensioning & tolerancing on the 2D manufacturing drawings. He/she should be well versed in material selection based on applications and develop assembly and part drawings as per industry standard, in addition students have to include one innovative idea in their project. And incorporate the same in the design.
Individual team has to prepare final model in 2D and 3D with proper documentation for the entire project. Progress of the project work will be presented by student's periodically to the panel of reviewers

Phases of mini Project Work:

- Students in batches will first select a product to carry out reverse engineering.
- Dismantle the assembly into individual parts.
- Take dimensions and make good legible sketches.
- Carry out 3D models of all the parts in 3D experience software (Catia).
- Assemble the parts in software to see a complete assembly.
- Render the product and show it in an actual environment.
- Convert it into 2d assembly with ballooning and BOM.
- Part drawings to be converted into 2D manufacturing parts as per industry standards, with GD&T symbols wherever necessary.
- Students have to include an Innovative idea and incorporate the same in their project.
- Prepare a final detailed report explaining the various stages and give a presentation as a team.

Program: Bachelor of Engineering		**Semester: V**
Course Title: Mechanical Vibrations		**Course Code: 15EMEE301**
L-T-P: 3-0-0	**Credits: 3**	**Contact Hours: 3 Hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 3 Hrs**	

Unit I

1. Undamped Free Vibrations 6 Hrs

Introduction, Importance of vibration and its physical significance, Types of vibrations, Mechanical system components, Equivalent stiffness of spring combinations, Derivation of differential equation and Natural frequency for undamped free vibrations of single degree freedom systems, Newton's method and Energy method, Torsional vibrations, Transverse vibrations of beams.

2. Damped Free Vibrations 5 Hrs

Introduction, types of damping, study of response of single degree freedom viscous damped systems for cases of under damping, critical damping and over damping, Logarithmic decrement, Torsional system with viscous damping.

3. Whirling of Shafts 5 Hrs

Introduction, Whirling of shafts with and without damping, Discussion of speeds above and below critical speeds, Introduction to Noise.

Unit II

4. Forced Vibrations 7 Hrs

Introduction, Forced vibrations of single degree freedom viscous damped system due to harmonic excitation, Response of a rotating and reciprocating unbalance system, Support excitation, Vibration isolation and transmissibility.

5. Two Degree of Freedom Systems 7 Hrs

Introduction, Principal modes and Normal modes of vibration, Vibrations of undamped systems, Torsional vibrations, Forced harmonic vibration, Systems with damping, Co-ordinate coupling; applications in vehicle suspension, Dynamic vibration absorber.

Unit III

6. Multi Degree of Freedom Systems 5 Hrs

Introduction, Influence coefficients, Maxwell reciprocal theorem, Orthogonality principle, Matrix iteration method to determine all the natural frequencies of multi degree freedom systems, Dunkerley's method, Rayleigh's method.

7. Vibration Measurement and Condition Monitoring 5 Hrs

Introduction, Vibrometer and accelerometer, Frequency measuring instruments. Signal analysis: Spectrum analyzers, Dynamic testing of machines and structures, Experimental modal analysis, Machine maintenance techniques, Machine condition monitoring techniques, Vibration monitoring techniques.

Text Books

1. Singiresu S. Rao, Mechanical Vibrations, 6th Edition, Pearson Education, 2018.
2. W.T. Thomson and Marie Dillon Dahleh, Theory of Vibrations with Applications, 5th Edn., Pearson Education, 2014.

Reference Books

1. S. Graham Kelly, Mechanical Vibrations: Theory and Applications, Cengage Learning, SI Edn, 2012.
2. M. L. Munjal, Noise and Vibration Control, World Scientific Publishing Co, Pvt. Ltd., 2013

← BACK TO SEMESTER V

Program: Bachelor of Engineering		**Semester: V**
Course Title: Product Innovation		**Course Code: 24EMEE305**
L-T-P: 2-1-0	**Credits: 3**	**Contact Hours: 4Hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hrs: 24 Tutorial Hrs:16	**Examination Duration: 3 Hrs**	

Unit I

1. Technological Innovation: 8 Hrs

Introduction, Sources of Innovation, Types and Patterns of Innovation, drivers for innovation, Innovation enablers, Innovation culture, Innovation Metrics, Challenges for Innovation, innovation Success stories, New product Innovation Process, Innovation progression, growth through Innovation, Idea generation, Idea Screening, Proof of Concept, team formation, Reality check.

2.Customer Analysis: 6 Hrs

Customer Needs Analysis, Big Problem, W's of Customers, Target Customer Segments, Consumer customer segmentation, Customer Value realization, Capture Customer Needs, Classification of needs, Standards Battles and Design dominance, Timing of entry

Unit II

3.Market Analysis: 9 Hrs

Innovation Opportunity, Environmental Analysis, Fore-sighting, S-curve for technology and consumer, Porters 5 forces, market Capacity, Evaluation of opportunity, Volume for casting, Competition Analysis: W's of Competition, Tools to compare products, sources for Competitive information.

4.Tools for Innovation: 7 Hrs

5 Phases, Divergent and Convergent thinking, demographics, Contextual maps, Progression curve, Janus Cone, Generational arcs, Go to Market With innovation

Unit III

5.Innovation Processes and Methods: 10 Hrs

TRIZ – Theory of innovative problem solving, ToC – Theory of Constraints, 8 Steps of Innovation

Reference Books

1. Playbook for strategic foresight and Innovation – Stanford University
2. 8 Steps of Innovation – R. T. Krishnan and V. Dabholkar
3. TRIZ and ToC – Handouts
4. A Unified Innovation Process Model for Engineering Designers and Managers (In Design Thinking) Skogstad, P., Leifer, L. edited by Meinel, C., Leifer, L., Plattner, H. Springer Berlin Heidelberg. 2011: 19–43

Program: Bachelor of Engineering		**Semester: V**
Course Title: Advanced Machining Processes		**Course Code: 15EMEE305**
L-T-P: 3-0-0	**Credits: 3**	**Contact Hours: 3 Hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 3 Hrs**	

Unit I

1: Introduction to Advanced Machining Processes 3 Hrs

Introduction to new methods of production; Need and Capability analysis of various processes, Classification and Selection of Non-Traditional Machining Technologies, Hybrid Processes, Cases.

2: Mechanical Advanced Machining Processes 12 Hrs

Abrasive Jet Machining (AJM): Machining setup, parametric analysis, Process capabilities. Ultrasonic machining (USM): Machining setup, Mechanics of Cutting - Model Proposed by Shaw, Parametric analysis, Process capabilities, Abrasive Flow Machining, Magnetic Abrasive Finishing. Water jet cutting (WJC).

Unit II

3: Thermal Advanced Machining Processes 8 Hrs

Plasma Arc Machining (PAM): Working System, Elements of PAM, Process Performance, PAM Parameters, Process Characteristics, Safety Precautions, Electric Discharge Machining (EDM): Working Principle, Analysis, Process Variables, Process Characteristics, Applications

4: Thermo-electric Advanced Machining Processes 7 Hrs

Electron Beam Machining (EBM): Working Principle, Process Parameters, Characteristics of The Process, Application of EBM, Laser Beam Machining (LBM): Working Principle, Types of Laser, Process Characteristics, Applications, Ion Beam Machining (IBM): Working Principle, Process Parameters, Applications

Unit III

5: Chemical Machining Processes 5Hrs

Chemical Machining: Elements of process, Process Characteristics of CHM. Electro Chemical Machining: Elements and Characteristics and Theory of ECM

6: Hybrid Processes 5 Hrs

Electro chemical grinding (ECG), Electrochemical spark machining (ECSM), electrochemical arc machining (ECAM) and electro discharge abrasive grinding (EDAG).

Text Books

1. Jain V. K. “Advanced Machining Processes”, Allied Publishers, Private Limited.
2. Pandey P. C. and Shan H. S., “Modern Machining Processes”, TATA McGraw Hill Publishing Company Limited, New Delhi.

Reference Books

1. HMT, “Production Technology”, TATA McGraw Hill.
2. Adithan M, “Modern Machining Methods”, S. Chand & Company, New Delhi.

Program: Bachelor of Engineering		**Semester: V**
Course Title: Advanced Welding Technology		**Course Code:** 25EMEE308
L-T-P: 3-0-0	**Credits:** 3	**Contact Hours:** 3 Hrs/week
ISA Marks: 50	**ESA Marks:** 50	**Total Marks:** 100
Teaching Hours: 40	**Examination Duration:** 3 Hrs	

Unit I

Chapter 1. Introduction: 10 Hrs

Introduction to consolidation processes, Classification of welding processes, some common concerns, types of fusion welds and types of joints, Design considerations, Heat effects, weldability and joinability. Welding terms and definitions, welding positions, elements of and construction of welding symbols. Checks prior to weld joint preparation, joint preparation checks, preheating and inter-pass heating, post weld heating, heating processes, post heat treatments, insulation of heated joints.

Chapter 2. Arc Welding Processes: 05 Hrs

a) Consumable electrode arc welding: Shielded metal arc welding (SMAW), flux cored arc welding (FCAW), gas metal arc welding or MIG welding (GMAW),Submerged Arc welding(SAW),Plasma arc welding (PAW),Flux cored arc welding (FCAW),Carbon arc welding and Arc stud welding.
b) Non-consumable electrode welding processes

Gas tungsten arc welding or TIG welding (GTAW), gas tungsten arc spot welding (TIG) and plasma arc welding (PAW).

Unit II

Chapter 3. Resistance and Solid State Welding Processes: 03 Hrs

Theory of resistance welding Heating, pressure, current and current control, power supply.
Resistance spot welding, resistance seam welding, Projection welding, Flash welding, upset welding, percussion welding, Advantages and limitations of resistance welding.

Chapter 4. Other Fusion welding processes: 03 Hrs

Oxy-fuel gas welding processes (OFW), Thermit welding, Electro-slag welding, Electron beam welding, Laser beam welding, and Flash welding.

Chapter 5. Friction welding: 03 Hrs

Introduction, Types of friction welding-Friction stir welding (FSW),Friction stir spot welding(FSSW),Linear friction welding(LFW),Rotary friction welding(RFW),advantages and disadvantages of the same.

Chapter 6. Heat affected zone and weld metal: 02 Hrs

Transformations in HAZ of steel, factors affecting changes in microstructure and mechanical properties of HAZ, reactions in weld pool- gas metal reaction, slag metal reaction.

Chapter 7. Metallurgical issue in weld joint: 04 Hrs

Mechanisms, causes and remedy of cold cracking, solidification cracking, non-metallic inclusions, lamellar tearing, hydrogen damage, banding, segregation.

Unit III

Chapter 8. Weldments Inspection and Testing Codes Governing Welding Inspection: 04 Hrs

Structural welding code; ASME boiler and pressure vessel code, spot examination of welded joints, duties of the inspector, ASTM standards, API standards.

Chapter 9. Magnetic particle and Radiographic inspection: 02 Hrs

Magnetic particle inspection, types of magnetizing currents, demagnetization, interpretation of patterns, on-relevant indications, radiographic sources, detectable discontinuities.

Chapter 10. Chemical, Metallurgical, and Mechanical testing of weldments: 02 Hrs

Comparison of destructive and non-destructive tests, chemical tests, forms of corrosion, testing for corrosion resistance, and metallographic tests.

Chapter 11. Visual and liquid penetrant inspection: 02 Hrs

Selection of NDT method, relationship of welding processes, discontinuities and inspection methods, visual inspection prior to, during and after welding, liquid penetrant test.
Practical Demonstrations Arc welding – Butt joint, lap joint on Mild steel MIG welding –a non coted electrode on mild steel/stainless steel TIG welding – on aluminium sheets. Gas welding –on non ferrous material Spot welding – on thin sheets metal. Friction welding – Joining of two steel bars on lathe . Brazing and soldering- for low temperatures below 300 °C
Reference Books: 1) William A Bowditch, Welding Technology Fundamentals 2) O P khanna, A text book of Welding Technology

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Program: Bachelor of Engineering		**Semester: V**
Course Title: Smart Manufacturing Systems		**Course Code: 25EMEE304**
L-T-P: 2-1-0	**Credits: 3**	**Contact Hours: 4 Hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 28 + 24	**Examination Duration: 2 Hrs**	

Unit I

Chapter 1. Introduction to Smart Manufacturing : 04 Hrs

Introduction to Smart Manufacturing, Smart Manufacturing Ecosystem, Product Development Lifecycle, Production Systems Lifecycle, Business Cycle, Manufacturing Pyramid, Integration, Production Planning and Control, Examples, Standards

Chapter 2. Supply Chain Management :05 Hrs

Introduction to Supply Chain, SCOR model, Virtual/Extended Enterprise, Delivery Channel, Decision Phases in a Supply Chain, Production Approaches, Supply Chain Process, Push & Pull Production Systems, Push-Pull Boundary, Lack of Coordination and Bullwhip Effect, Order-to-Cash Process, Procure-to-Pay Process, Call-off, Replenishment, Sourcing, Uncertainties, Responsiveness vs Cost, Supply Chain Performance Drivers –Facilities, Inventory, Transportation, Information, Sourcing, and Pricing

Chapter 3. Enterprise Resource Planning : 05 Hrs

Business Processes, Process Modeling and Data Modeling, Business Process Reengineering, Event Process Chains (EPC), ERP Functionalities, Financial Accounting, Cost Accounting and Managerial Accounting, Cost Assignment Techniques, Cost Drivers, Purchasing, Receiving, Inventory Management, Warehouse Management, Shipping and Transportation, Billing, Material Requirement Planning (MRP),Manufacturing Resource Planning (MRP II)

Unit II

Chapter 4. Product Development Lifecycle: 05 Hrs

Product Development Lifecycle, Digital Thread, PLM Overview, Background for PLM, Scope, PLM Grid, PLM Paradigm - Concepts, Business Process in the PLM Environment, Product Data in the PLM Environment, Information Systems in the PLM Environment, Organization Change Management in the PLM Environment, CAD, CAE, CAM, CAPP, Simulations, Introduction to Digital Twin, Standards

Chapter 5. Production System Lifecycle : 05 Hrs

Production System Lifecycle, Revisit Production Planning and Control, Manufacturing Pyramid, Manufacturing Execution Systems (MES), MES Functionalities, MES Models, Functional Control Model, MES in Discrete Industry, MES in Process Industry, Data Collection, Traceability, Performance Measurement and Management, Real-Time Enterprise, Revisit Digital Twin, Standards

Chapter 6. Industry 4.0 & Future Trends: 04 Hrs

Industry 4.0 and Smart Factory Architecture, Case Studies of Adoption & Scaling of Smart Manufacturing, Business & Economic Aspects of Smart Manufacturing, Future of Industry 5.0 and Human-Centric Manufacturing

Hands-on activities and case studies: 24 Hrs

- **Develop a visual representation of a smart manufacturing ecosystem. (XMind)**
- **Analyse an ERP system and document its key functionalities for inventory management and procurement. (SAP B1)**
- **Map the product lifecycle stages of a real-world industrial product. (ENOVIA PLM)**
- **Siemens Smart Manufacturing: Digital Twin Implementation in Automotive Industry.**
- **Amazon's Push-Pull Supply Chain: Balancing Speed and Cost**
- **SAP ERP Implementation at Nestlé: Challenges and Lessons Learned.**
- **How PLM Helped Harley-Davidson Reduce Time-to-Market.**
- **Siemens Opcenter MES Implementation in Electronics Manufacturing.**

Text Books:

1. Kandasamy, Jayakrishna, KamalakantaMuduli, V. P. Kommula, and Purushottam L. Meena, Smart manufacturing technologies for industry 4.0: integration, benefits, and operational activities. CRC Press, 2022.
2. Ellen Monk, and Bret Wagner, “Concepts in Enterprise Resource Planning,” Fourth Edition, Course Technology CENGAGE Learning, 2009.
3. Stark John, &Product Lifecycle Management: 21st Century Paradigm for Product Realization, Springer, Third Edition, 2015.
4. Soroush, Masoud, Michael Baldea, and Thomas F. Edgar, Smart manufacturing: concepts and methods. Elsevier, 2020.
5. Elangovan, Uthayan. Smart automation to smart manufacturing: Industrial internet of things. Momentum Press, 2019.
6. Sachin Karadgi, “A Reference Architecture for Real-Time Performance Measurement,” Springer, 2014.

Reference Books:

1. Dhanaraj, Rajesh Kumar, Ali Kashif Bashir, Rajasekar Vani, Balamurugan Balusamy, and Pooja Malik, eds. Digital Twin for Smart Manufacturing. Elsevier, 2023.
2. Leong, WaiYie, ed. Human Machine Collaboration and Interaction for Smart Manufacturing: Automation, Robotics, Sensing, Artificial Intelligence, 5G, IoTs and Blockchain. Institution of Engineering and Technology, 2022.
3. MESA International, Three Functional Dimensions Converge on Smart Manufacturing, Whitepaper #59, 2018.

← BACK TO SEMESTER V

Program: Bachelor of Engineering		**Semester: V**
Course Title: Fundamentals of Robotics		**Course Code:** 25EMEE305
L-T-P: 2-1-0	**Credits:** 3	**Contact Hours:** 4 Hrs/week
ISA Marks: 50	**ESA Marks:** 50	**Total Marks:** 100
Teaching Hours: 28 + 24	**Examination Duration:** 2 Hrs	

Unit I

Chapter 1. Introduction to Robotics: 03 Hrs

Definition & history of robotics, Laws of robotics, Overview of robot components: links, joints, actuators, sensors, Classification of robots: serial, parallel, mobile, humanoid, Industrial and service robots.

Chapter 2. Robot Kinematics: 05 Hrs

Degrees of Freedom (DoF), Forward and inverse kinematics using Denavit-Hartenberg (D-H) representation, Velocity kinematics using the Jacobian matrix, Workspace analysis and singularities.

Chapter 3. Robot Dynamics: 06 Hrs

Newton-Euler and Lagrangian approaches for deriving equations of motion, Dynamic modeling of robotic arms, Understanding force/torque dynamics.

Unit II

Chapter 4. Sensors and Actuators in Robotics: 04 Hrs

Types of actuators: DC motors, stepper motors, servo motors, pneumatic, and hydraulic systems, Sensors: encoders, proximity sensors, LIDAR, vision systems, and force-torque sensors Interfacing sensors and actuators with microcontrollers and PLCs.

Chapter 5. Control Systems in Robotics: 05 Hrs

Open-loop and closed-loop control, PID control for robotic arms, Adaptive and feedback control systems, Introduction to modern control methods (e.g., model predictive control).

Chapter 6. Motion Planning and Trajectory Generation: 05 Hrs

Path planning techniques: straight-line, cubic polynomial, quintic polynomial, Sampling-based algorithms: Rapidly Exploring Random Trees (RRT) and Probabilistic Roadmaps (PRM), Trajectory generation in joint space vs. Cartesian space.

Hands-On Activity: (24 Hours)

- Model and simulate 2-DOF robotic arm using D-H parameters and kinematics
- Newton-Euler dynamic modeling and simulation of a robotic arm
- Interface IR/Ultrasonic sensor and servo motor with Arduino
- Implement PID control for DC motor speed control
- Simulate path planning using RRT or PRM algorithm

Text Books:

1. S.R. Deb, Robotics Technology and Flexible Automation, Tata McGraw-Hill.
2. John Craig, Introduction to Robotics: Mechanics and Control, Pearson.

Reference Books:

1. Richard D. Klafter, Robotics Engineering: An Integrated Approach, Prentice Hall.
2. Fu K. S., Gonzalez R. C., Lee C. S. G., Robotics: Control, Sensing, Vision, and Intelligence, McGraw-Hill.

← BACK TO SEMESTER V

Program: Bachelor of Engineering		Semester: V
Course Title: Additive Manufacturing Processes		Course Code: 22EMEE301
L-T-P: 3-0-0	Credits: 3	Contact Hours: 3Hrs/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 40	Examination Duration: 3 Hrs	

Unit I

Chapter 1: Introduction and Basic principles: 04 hrs

What is AM, benefits of AM, Development of AM technology, generalized AM process chain.

Chapter 2: Vat photo-polymerization processes: 06 hrs

Introduction, materials, UV-curable photopolymers, overview of photopolymer chemistry, resin formulations and reaction mechanisms, reaction rates, Laser scan Vat photo-polymerization, photo-polymerization process modeling, process benefits & drawbacks.

Chapter 3: Powder Bed Fusion Processes: 06 hrs

Introduction, materials (Polymers and Composites, Metals and Composites, Ceramics and Ceramic Composites), Powder Fusion Mechanisms (Solid-State Sintering, Chemically Induced Sintering, LPS and Partial Melting, Full Melting, Part Fabrication), Process benefits and Drawbacks.

Unit II

Chapter 4: Extrusion-Based Systems: 06 hrs

Introduction, Basic Principles (Material Loading, Liquification, Extrusion, Solidification, Bonding, Support Generation), Fused Deposition Modeling.

Chapter 5: Sheet Lamination Processes: 06 hrs

Introduction, Gluing or Adhesive Bonding, Bond-Then-Form Processes, Form-Then-Bond Processes, Material Processing Fundamentals (Thermal Bonding, Sheet Metal Clamping)

Unit III

Chapter 6: Directed Energy Deposition Processes: 06 hrs

Introduction, General DED Process Description, Material Delivery (Powder Feeding, Wire Feeding), DED Systems (Laser Based Metal Deposition Processes, Electron Beam Based Metal Deposition Processes), Typical Materials and Microstructure, DED Benefits and Drawbacks

Chapter 7: Post-processing: 06 hrs

Introduction, Support Material Removal, Surface Texture Improvements, Accuracy Improvements, Aesthetic Improvements, Preparation for Use as a Pattern, Property Enhancements Using Non-thermal Techniques, Property Enhancements Using Thermal Techniques.

Text Books

1. Gibson, I., Rosen, D.W. and Stucker, B., “Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing”, Springer, 2015.

Reference Books

1. Chee kai Chua, Kah Fai Leong, 3D Printing and Additive Manufacturing: Principles and Applications: Fourth edition of Rapid Prototyping, World Scientific Publishers, 2014.
2. Chua C.K., Leong K. F., and Lim C. S., "Rapid Prototyping: Principles and applications", Third Edition, World Scientific Publishers, 2010.

Program: Bachelor of Engineering		**Semester: V**
Course Title: Turbo Machines		**Course Code: 18EMEE303**
L-T-P: 3-0-0	**Credits: 3**	**Contact Hours: 3 Hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 3 Hrs**	

Unit I

1. Principles of Turbo Machinery 5 Hrs

Definition of turbo machine, Comparison with positive displacement machine, Classification; Application of first and second law to turbo-machines, Efficiencies. Dimensionless parameters and their physical significance, Effect of Reynolds number, Specific speed, Illustrative examples on dimensional analysis and model studies.

2.Energy Exchange in Turbo Machine 5 Hrs

Euler Turbine equation, Alternate form of Euler turbine equation-components of energy transfer, Degree of reaction, General Analysis of a turbo machine-effect of blade discharge angle on energy transfer and degree of reaction, General analysis of centrifugal pumps and compressors-effect of blade discharge angle on performance, Theoretical head-capacity relationship.

3. General Analysis of Turbo Machines 6 Hrs

Axial flow compressors and pumps-general expression for degree of reaction, velocity triangles for different values of degree of reaction, General analysis of axial and radial flow turbines-utilization factor and degree of reaction, Condition for maximum utilization factor-optimum blade speed ratio for different types of turbines.

Unit II

4. Compressible Flow Fundamentals 5 Hrs

Energy and momentum equations for compressible fluid flows, various regions of flows, reference velocities, stagnation state, velocity of sound, critical states, Mach number, critical Mach number, types of waves, Mach cone, Mach angle, effect of Mach number on compressibility

5. Centrifugal Compressors6 Hrs

Stage velocity triangles, slip factor, power input factor, Stage work, Pressure developed, stage efficiency and surging, stalling and prewhirl. Expression for pressure ratio developed in a stage, work done factor, efficiencies, Problems.

6. Axial flow Compressors 5 Hrs

Axial Flow Compressors: Basic operations, elementary theory, factors affecting stage pressure ratio, Blockage in the compressor annulus, degree of reaction, three-dimensional flow, design process, blade design, calculation of stage performance, compressibility effects, off-design performance.

Unit III

7. Flow through Variable Area Ducts 4 Hrs

Isentropic flow through variable area ducts, T-s and h-s diagrams for nozzle and diffuser flows, area ratio as a function of Mach number, mass flow rate through nozzles and diffusers, effect of friction in flow through nozzles.

8. Steam Turbines 4 Hrs

Classification, single stage impulse turbine, condition for maximum blade efficiency, stage efficiency. Compounding-need for compounding, method of compounding, impulse staging- condition for maximum utilization factor for multi stage turbine with equiangular blades, effect of blade and nozzle losses, Reaction turbine, Parson's reaction turbine, condition for maximum blade efficiency, reaction staging, Problems on single stage turbines only.

Text Books

1. ShepherdD.G., Principals of Turbo Machinery, Macmillan Publishers,1st Edn.1964

2. Yadav R., (2007) 'Steam & gas turbines and power plant engineering', Central Publishing House Allahabad, Vol. 1,
3. S. M. Yahya, Turbines, Compressors & Fans, Tata McGraw Hill Co. Ltd., 2nd edition, 2002.
4. E Rathakrishnan, Gas Dynamics, PHI- 2nd edition, 2009.

Reference Books

1. Kadambi V. Manohar Prasad, An Introduction to Energy Conversion, Vol-III Turbo Machinery, New Age International, 1st Edn, 2006.
2. Saravanamutto H.I.H, Rogers G.F.C., Cohen H, Gas Turbine Theory, 5th edn., Pearson Education, 2006.

Program: Bachelor of Engineering		**Semester: V**
Course Title: Thermal Management of EV Battery Systems		**Course Code: 22EMEE302**
L-T-P: 3-0-0	**Credits: 3**	**Contact Hours: 3Hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 3 Hrs**	

Unit I

1. **Introductory Aspects of Electric Vehicles: 7 Hrs**

Technology Development and Commercialization, Hybrid Electric Vehicles (HEVs), Fuel Cell Vehicles (FCVs), Plug-In HEVs (or Range-Extended Hybrids), Energy Storage System- Batteries, Ultra capacitors, Grid Connection, Vehicle thermal management,

2. **Electric Vehicle Battery Technologies: 8 Hrs**

Current Battery Technologies, Battery Technologies under Development, Battery Characteristics, Battery Management Systems, Battery Manufacturing and Testing Processes,

Unit II

3. **Phase Change Materials for Passive TMSs: 7 Hrs**

Basic Properties and Types of PCMs, Measurement of Thermal Properties of PCMs, Heat Transfer Enhancements, Cost and Environmental Impact of Phase Change Materials, Applications of PCMs, Heat Exchanger Design and Optimization Model for EV Batteries using PCMs, Melting and Solidification of Paraffin in a Spherical Shell from Forced External Convection

4. Simulation and Experimental Investigation of Battery TMSs: 8Hrs

Numerical Model Development for Cell and Sub-modules, Cell and Module Level Experimentation Set Up and Procedure, Vehicle Level Experimentation Set Up and Procedure, Simulations and Experimentations on the Liquid Battery Thermal Management System Using PCMs,

Unit III

5. **Energy and Exergy Analyses of Battery TMSs: 5Hrs**

TMS Comparison, Thermodynamic Analysis, Modeling of Major TMS Components, Energy and Exergy Analyses, Liquid Battery Thermal Management Systems, Trans-critical CO_2-Based Electric Vehicle BTMS

6. Cost, Environmental Impact and Multi-Objective Optimization of Battery TMSs: 5 Hrs

Exergo-economic Analysis, Exergo-environmental Analysis, Optimization Methodology, Liquid Battery Thermal Management Systems, Experimental and Theoretical Investigation of Temperature Distributions in a Prismatic Lithium-Ion Battery, Thermal Management Solutions for Electric Vehicle Lithium-Ion Batteries based on Vehicle Charge and Discharge Cycles

Text Books

1. Ibrahim Dinçer, Halil S. Hamut, Nader Javani, Thermal Management of Electric Vehicle Battery Management Systems, 1st Edn John Wiley & Sons, 2016
2. John G. Hayes, Goodarzi A.,Electric Power train - Energy Systems, Power electronics and drives for Hybrid, electric and fuel cell vehicles, Wiley Publication

Program: Bachelor of Engineering		**Semester:** V	
Course Title: Advanced CAE - I		**Course Code:** 25EMEE301	
L-T-P: 0-0-3	**Credits:** 3	**Contact Hours:** 6 Hrs/week	
ISA Marks: 80	**ESA Marks:** 20	**Total Marks:** 100	
Teaching Hours: 80	**Examination Duration:** 2Hrs		

1. Introduction to Finite Element Method and Altair Hyper works	4 Hrs
2. Hypermesh workbench Getting started with Hypermesh Interacting with panels	9 Hrs
3. Geometry Clean up - Theory Tools used to geometry clean up (Edge edit, Create Surface and Surface edit, Line and Line Edit, Delete …..) Theory and Demo Exercise – 04 No	12 Hrs
4. 2-D mesh Explanation -Theory Auto mesh and Different types of auto mesh Types of 2 D mesh (Ruled, Spline, Rotate……) Quality Parameters checking. Normal's and Edge Checking and adjusting. Theory and Demo Exercise – 04 No	18 Hrs
5. 3-D mesh Explanation -Theory Volume mesh Creation Types of 3 D mesh (HexaPenta Type, Tetra mesh……) Quality Parameters checking. Normal's and Edge Checking and adjusting. Theory and Demo Exercise - 03 No	18 Hrs
6. 1-D mesh Explanation -Theory Creation of 1 D elements (Bar, Beam Mass….) Creation of Rigid elements (Rbe2 and Rbe3) Creation of Weld elements between two adjacent components Demo Exercise - 03 No	9 Hrs
7. Execute Linear Static Analysis using optistruct solver Theory and Demo Exercise - 01 No, Assignment - 01 No	4 Hrs
8. Perform Buckling Analysis using optistruct solver Theory and Demo Exercise - 01 No	2 Hrs
9. Carryout Modal Analysis using optistruct solver Theory and Demo Exercise - 01 No	2 Hrs
10. Analyze Thermal Analysis using optistruct solver Theory and Demo Exercise - 01 No	2 Hrs

Reference Books:

1. Nitin S Ghokale, Practical Finite Element Analysis, 3rd Edition, Finite to Infinite, 2015.

← BACK TO SEMESTER V

Program: Bachelor of Engineering		**Semester: V**
Course Title: Bionic Design		**Course Code: 22EMEE303**
L-T-P: 1-2-0	**Credits: 3**	**Contact Hours: 3 Hrs/week**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hrs: 30 **Tutorial/ Lab Hrs: 50**	**Examination Duration: 2Hrs**	

1: Introduction and Background 08 Hrs

Introduction to Biomimicry and Systems, Background, Early Attempts at Biomimicry, Sustainability and its role on Engineering Domain, Design thinking and Innovation using Nature inspired design.

2: Bionic Design Methods/ Approach 07 Hrs

Biomimicry 3.8 Taxonomy, Study of Bionic Design methodologies proposed by scientists like: Ask Nature, Bio-Triz, Idea-Inspire, Bio Cards, DANE, Elise 3D, etc,.

3: Case Studies/ Caselet 08 Hrs

Sudy of iconic engineering case studies that demonstrate the nature inspired design that include Travel, Motion, Energy, Colour, Light, Materials, Devices, Sensors, Control, Navigation etc..

4: Selection of Bio-Materials- An overview 07 Hrs

Introduction; Classes of bio materials: metals, polymers, FRPs, fabrics, nanocomposites, bio-resorbable and bioerodable materials, ceramics, glasses.

Text Books

1. Biomimetics: Nature-Inspired Design and Innovation by Sandy B. Primrose, Wiley 2020.
2. Cats' Paws & Catapults –Mechanical Worlds of Nature & People, Steven Vogel, W. W. Norton & Company
3. Biomimitics:, Biologically inspired Technologies, Yoseph Bar-Cohen, Taylor and Francis Publications

Program: Bachelor of Engineering		Semester: V
Course Title: Enterprise Resource Planning-I		**Course Code: 24EMEE301**
L-T-P: 2-0-1	Credits: 3	Contact Hours: 4 Hrs/week
ISA Marks: 80	ESA Marks: 20	Total Marks: 100
Teaching Hours: 30	Examination Duration: 2 Hrs	Semester: 5th

Unit I

Chapter 1. Introduction to ERP: 4 Hrs

Need for ERP, Characteristics, and components of ERP, Suppliers of ERP, Integrated Management Information, Seamless Integration, and Functional information system, Marketing, Accounting, and Financial Management, Supply Chain Management, Resource Management, Integrated Data Model.

Chapter 2. Business Functions and Business Processes: 6 Hrs

Functional Areas of Operation, Business Processes, A process view of business, Functional Areas, and Business process of very small business. Marketing and Sales, Supply Chain Management, Accounting and Finance, Human Resources, Functional Area Information System.

Business Process Reengineering: Need for reengineering, Reengineering Model, BPR Guiding principles, Business process reengineering, and performance improvement, Enablers of BPR in Manufacturing, Collaborative Manufacturing, Intelligent manufacturing, Production Planning, BPR Implementation.

Chapter 3. Financial & Accounting Management: 5 Hrs

Differences between Financial accounting, Cost accounting and Management accounting, Basic finance – Concept of Cost Centre accounting, Cost – Volume – Profit Analysis, Cash Flow Analysis.

Unit II

Chapter 4. Role of ERP in Sales & Purchasing: 5 Hrs

Features of purchase module, ERP Purchase System; Role of ERP in Sales and Distribution, Sub-Modules of the Sales and Distribution Module: Master data management, Order management, Warehouse management, Shipping and transportation, Billing and sales support, foreign trade, Integration of Sales and Distribution Module with Other Modules.

Chapter 5. Inventory Management Perspective: 5 Hrs

ERP inventory management system, Importance of Web ERP in Inventory Management, ERP Inventory Management Module and Sub-Modules of the ERP Inventory Management Module, Bill of Material, Safety stock, Lot number/Batch number, Inventory valuation methods.

Chapter 6. Material Requirement Planning: 5 Hrs

Product structure and Bill of Materials (BOM), MRP concept, MRP calculations, Lot sizing in MRP, capacity requirement planning, MRP-II, MRP Exercises.

Experiments	No. of sessions
1. Introduction to SAP Business One and various functional modules	02
2. Map customer logistics processes in SAP	04
3. Setup master data for standard business processes in logistics	03
4. Utilize controlling tools and company reports	03

Text Books:

1. Ellen Nonk & Bret Wagner, “Concepts in Enterprise Resource Planning”, 4th edition, CENGAGE Learning Custom Publishing, 2013.
2. Vinod Kumar Garg, N. K. Venkitakrishnan, “Enterprise Resource Planning: Concepts and Practice”, 2nd edition, Prentice Hall India Learning Private Limited, 2003.

Reference Books

1. Alexis Leon, “Enterprise Resource Planning”, 4th edition, McGraw Hill Education, 2019.
2. Simha R. Magal & Jeffrey Word, “Integrated Business Processes with ERP Systems”, 1st edition, John Wiley & Sons Inc., 2011.

Program: Bachelor of Engineering		**Semester: V**
Course Title: Fundamentals of Product Lifecycle Management		**Course Code: 24EMEE302**
L-T-P: 2-0-1	**Credits: 3**	**Contact Hours: 4 Hrs/week**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hours: 30	**Examination Duration: 2 Hrs**	

Unit I

Chapter 1. The PLM Environment: 6 Hrs

PLM paradigm, P, L and M of PLM, scope of PLM, benefits of PLM, spread of PLM, issues in traditional environment, product data issues, overcoming problems and enabling opportunities, a complex changing environment, product opportunities, related blogs.

Chapter 2. Business processes in the PLM Environment: 8 Hrs

Relevance of business processes in PLM, action across the product lifecycle, process approach, KPIs for business processes, process reality in a typical company generic issues, generic challenges and a generic vision for business processes in PLM, business processes activities in the PLM initiatives, related blogs.

Unit II

Chapter 3. Product Data in the PLM Environment: 8 Hrs

Product data across the lifecycle, tools to represent product data, vision for product data in PLM, product data related projects, product data improvement, product data migration, top management role with product data, related blogs

Chapter 4. Information System in the PLM Environment: 8 Hrs

The importance of PDM system in PLM, application related projects, software development approaches, PDM system selection and implementation, build and plan PDM system, test and validate PDM system, deploy and use PDM system, review PDM system performance, related blogs.

Experiments	No. of sessions
1. Collaboration and Approvals – 8 Hrs Managing the bookmark workspaces, working with routes, managing assigned tasks, working with subscription, managing issues, working with the common document model, case studies.	04
2. IP Classifications – 8 Hrs Creating a general library, creating general class, managing attribute groups, assigning attribute groups, exporting and importing attribute groups, classifying library objects, case studies.	04
3. Engineering BOM Management Essentials – 8 Hrs Working with parts, creating parts, creating part families, collaborating with CATIA, creating specifications, viewing EBOM of an assembly, authorizing in EBOM, copying and importing an EBOM, adding and replacing parts in EBOM, creating an EBOM, viewing BOM charts, case studies.	04

Reference Books

1. Stark John, "Product Lifecycle Management: 21st Century Paradigm for Product Realization", Springer, Third Edition, 2015
2. Antti Saakasvuori, Anselmi Immonen, “Product Lifecycle Management" - Springer, 1st Edition, 2003.

← BACK TO SEMESTER V

Program: Bachelor of Engineering		**Semester: V**
Course Title: Advanced Statistics and Machine Learning		**Course Code: 19EMEE302**
L-T-P: 0-0-3	**Credits: 3**	**Contact Hours: 3Hrs/week**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hours: 80	**Examination Duration: 2 Hrs**	

Unit I

1. Introduction to Machine Learning 25 Hrs

Introduction to Supervised, Unsupervised, and Reinforcement Learning; Statistics for ML; Exploratory Data Analysis; Use of Python and working with CSV/XLS files.

Python hands on: Installation, Introduction to Python libraries (Pandas, Numpy, matplotlib and so forth)

Unit II

2. Applied Statistics 15 Hrs

Statistics for ML; Data Wrangling; Exploratory Data Analysis; Visualization; Use of Python and working with CSV/DB

Hands on: Pre-processing techniques

3. Machine Learning Methods 18 Hrs

Introduction to ML Life Cycle; Regression – Predictive Modeling; Regularization; Feature Selection; Metrics for Prediction; Visualization;

Unit III

4. ML – Classification 22 Hrs

Introduction to Classification; Logistic Regression; Random Forests; Metrics for Classification; Visualization; Use of Python and DB

Text Books

1. Trevor Hastie, Robert Tibshirani, and Jerome Friedman, “The Elements of Statistical Learning: Data Mining, Inference, and Prediction”, Springer, 2017.
2. Roger D Peng, “R Programming for Data Science”, Learn pub, 2015.

Reference Books

1. Geetha James, Trevor Hastie, Daniela Whitten, Robert Tibshirani, “An Introduction to Statistical Learning with Applications in R”, Springer, 2017.
2. Andrew Ng, “Machine Learning Yearning”, https://www.mlyearning.org/.
3. Michael Nielsen, “Neural Networks and Deep Learning”, http://neuralnetworksanddeeplearning.com/.

Program: Bachelor of Engineering		**Semester: VI**
Course Title: Professional Aptitude & Logical Reasoning		**Course Code: 16EHSC301**
L-T-P: 3-0-0	**Credits: 3**	**Contact Hours: 3Hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 3 Hrs**	

Unit –I - Arithmetical Reasoning and Analytical Thinking

Chapter 1. – Arithmetical Reasoning 10 Hrs
Chapter 2. – Analytical Thinking 4 Hrs
Chapter 3. – Syllogistic Logic 3 Hrs

Unit – II – Verbal and Non – Verbal Logic

Chapter 1. – Verbal Logic 9 Hrs
Chapter 2. – Non-Verbal Logic 6 Hrs

Unit – III - Lateral Thinking

Chapter 1. - Lateral Thinking 8 Hrs

Text Book

1. A Modern Approach to Verbal and Non – Verbal Reasoning – R. S. Aggarwal, Sultan Chand and Sons, New Delhi
2. Quantitative Aptitude – R. S. Aggarwal, Sultan Chand and Sons, New Delhi

References

1. Verbal and Non – Verbal Reasoning – Dr. Ravi Chopra, MacMillan India
2. Lateral Thinking – Dr. Edward De Bono, Penguin Books, New Delhi

Program: Bachelor of Engineering		**Semester: VI**
Course Title: Fluid Mechanics and Hydraulic Machines		**Course Code: 24EMEC301**
L-T-P: 4-0-0	**Credits: 4**	**Contact Hours: 4 Hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 50	**Examination Duration: 3 Hrs**	

Unit I

Chapter 1. Basic Concepts and Fluid properties: 8 Hrs

Introduction, Application Areas of Fluid Mechanics, The No-Slip Condition, Classification of Fluid Flows, Properties of fluids, Viscosity, Surface Tension and Capillary Effect.

Fluid statics: Pressure and its measurements, Hydrostatic forces on surfaces. Nano and Ultrafiltration techniques-Clean water and its importance.

Chapter 2. Fluid Kinematics: 6 Hrs

Lagrangian and Eulerian Descriptions, Fundamentals of Flow Visualization, Streamlines and Stream tubes, Path lines, Streak lines, Timelines, Continuity equation, Velocity and acceleration of fluid flow, Velocity potential function and stream function

Chapter 3. Mass, Bernoulli and Energy Equations: 6 Hrs

Conservation of Mass Principle, Moving or Deforming Control Volumes, Euler's equation of motion along a streamline, Bernoulli's equation, Navier-Stokes equation of motion, The momentum equation,

Unit II

Chapter 4. Flow in Pipes: 8 Hrs

Laminar and Turbulent Flows, Reynolds Number, Boundary Layer, Laminar Flow in Pipes, Pressure Drop and Head Loss, Inclined Pipes, Turbulent Flow in Pipes, Major and Minor Losses, Flow Rate and Velocity Measurement. Sustainable Industrial and domestic fluid system and Environmental Impact Analysis.

Chapter 5. Dimensional analysis: 6 Hrs

Dimensions and Units, Dimensional Homogeneity, Non-dimensionalization of Equations, Dimensional Analysis and Similarity, Rayleigh's method and the Buckingham Pi Theorem, Dimensionless numbers.

Chapter 6. Flow over Bodies: 6 Hrs

Drag and Lift, Friction and Pressure Drag, Reducing Drag by Streamlining, Flow Separation, Drag Coefficients of Common Geometries, Drag Coefficients of Vehicles, Parallel Flow over Flat Plates, Friction Coefficient, Flow over Cylinders and Spheres,

Unit III

Chapter 7. Hydraulic Pumps: 5 Hrs

Centrifugal pumps – Work done, Heads and efficiencies, Priming, specific speed, NPSH, Cavitation, Multistage centrifugal pumps.

Chapter 8. Hydraulic Turbines: 5 Hrs

Classification, Heads and efficiencies of turbines, Pelton, Francis and Kaplan turbines, Velocity triangles and work done, specific speed, Life Cycle Cost Analysis of small, mini and micro hydro turbines

Text Books:

1. Yunus A Cengel, John. M Cimbala: Fluid Mechanics – Fundamentals and Applications 2nd Edition, Mac Graw Hill Publications, 2017

Reference Books

1. White F M: Fluid Mechanics, 8th Edn, McGraw Hill International Publication, 2015.
2. R.K. Bansal: Fluid Mechanics and Hydraulic Machines, 10th Edn, Laxmi Publications, 2018
3. Khandpal T.C.,Garg H.P., Financial Evaluation of Renewable Energy Technologies, Mc-Millan India, 1stEdn, 2013

Program: Bachelor of Engineering		**Semester: VI**
Course Title: Metrology and Quality Engineering		**Course Code: 23EMEC304**
L-T-P: 3-0-0	**Credits: 3**	**Contact Hours: 3 Hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 3 Hrs**	

Unit I

1. Fundamentals of Metrology 6 Hrs

Objectives of Metrology, Standards of physical quantities (mass, length, time, temperature, force, Velocity, density) types of standards, line and end standard, Slip gauges, Angle Gauges, Linear and Angular Measurements, Performance characteristics of measuring instruments, Calibration of instruments, The Process of Measurement, Significance of Measurement process , Methods of measurement, generalized measurement system, errors in measurement, gauges, comparators (mechanical and optical), Numericals.

2. Limits, Fits and Gauges 7 Hrs

Introduction, limits, tolerance, and fits, types of fits, allowance. Hole basis and shaft basis systems, Indian standard system for limits and fits (IS 919-2709), types of gauges, Taylor's principle and gauge design. Numericals.

Introduction to GD&T Terminology, Maximum Material control (MMC) & Least Material Control (LMC), Form and orientation tolerances in detail with application examples, Interpretation of drawings with GD & T and Exercises.

Unit II

3. Advanced Metrology 7 Hrs

CMM(Coordinate Measuring Machine) : Co-ordinate Metrology, CMM configurations, hardware components, Software, Probe sensors, Displacement devices, applications

Laser Metrology: Free electron laser – optical alignment, measurement of distance – interferometry, reversible counting, refractive index correction, reversible counting, refractive index correction, surface topography and optical component testing. Machine Vision System.

4. Quality Engineering 7 Hrs

Quality concepts, Dimensions of quality, Inspection, Objectives of Inspection Difference between Inspection & Quality Control,7 QC tools, Statistical methods for quality control and improvement Basic Principles of Control charts, Control charts for variables, process capability and six sigma.

Unit III

5. Control charts for Attributes and Acceptance sampling 5Hrs

Control chart for fraction non-conforming, variable sample size, Number of defective chart, Control chart for Non conformities (defects) and Control chart for defects Average number of nonconformities. Types of sampling plans, operating characteristic (OC) curves.

6. Introduction to TQM 5 Hrs

Basic approach, TQM framework, TQM principles-Leadership, Employee involvement, Empowerment, Team and Teamwork, Quality circles ,Continuous process improvement – PDCA cycle, 5S, Kaizen – Supplier partnership – Partnering, TQM techniques- Bench marking, FMEA, QFD, TPM.

Text Books

1. Beckwith Marangoni and Lienhard, Mechanical Measurements, 6th Edn., Pearson Education 2007
2. Doeblin E.O., Measurements Systems, Applications and Design, 5th Edition McGraw –Hill,2003
3. Montgomery D. C., Introduction to Statistical Quality Control, 8th Edn. John Wiley & Sons, Inc2019

Reference Books

1. Holman J P, Experimental Methods for Engineers, 8th Edition McGraw-Hill Publications 2011
2. Connie. L. Dotson, Fundamentals of Dimensional Metrology, 6th Edn. Cengage Publications 2015

3. Bosch J A, Giddings and Lewis Dayton, Marcel Dekker, Co-Ordinate Measuring Machines and Systems 2nd Edition CRC press 2015
4. Grant and Leavenworth, Statistical Quality Control, 7th Edition, McGraw-Hill Publications 1996

Program: Bachelor of Engineering		Semester: VI
Course Title: Mechatronic Systems Design		**Course Code: 24EMEP302**
L-T-P: 2-0-2	**Credits: 4**	**Contact Hours: 6 Hrs/week**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 3 Hrs**	

Unit I

Chapter No. 1. Mechatronic Systems Design, Engineering & Modeling 10 Hrs

Introduction to mechatronics system design, a) structure of mechatronic systems (b) Traditional approach to mechatronic systems design (c) Systems engineering approach to mechatronic systems design (d) A systematic methodology to engineering design -- VDI2221 (e) Mechatronics design methodology (V-model)– VDI 2206 (f) Combination of V-model and systematic design methodology, Domain specific design, Verification, Validation & Testing , Mathematical modeling of dynamic systems, Bond graph approach to modeling State charts, UML & Sys ML , Case studies.

Chapter No. 2. Design of Mechatronic control systems in State space 10 Hrs

Controller Design, Alternative Approaches to Controller Design, Observer Design, Alternative Approaches to Observer Design, Steady-State Error Design Via Integral Control, Robust Control System Design, The z-Transform: Transfer Functions, Block Diagram Reduction, Stability, Steady-State Errors, Transient Response on the z-Plane, Gain Design on the z-Plane, Cascade Compensation via the s-Plane, Implementing the Digital Compensator.

Unit II

Chapter No.3. Mechanisms for motion transmission 6 Hrs

Characteristics of motion transmission mechanism, rotary to rotary motion transmission mechanisms, rotary to translational motion mechanisms, cyclic motion transmission mechanisms, shaft misalignments and flexible couplings, actuator sizing.

Chapter No. 4: Motion control systems 6 Hrs

Design Methodology for Programmable motion control Systems, Motion Controller Hardware and Software, Basic Single-Axis Motions, Coordinated Motion Control Methods, Point-to-point Synchronized Motion, Electronic Gearing Coordinated Motion, CAM Profile and Contouring Coordinated Motion, Sensor Based Real-time Coordinated Motion, Coordinated Motion Applications.

Chapter No. 5 : Sensors 6 Hrs

Principles & characteristics of measurement devices, signal conditioning, sensor characterization, , relations between physical quantities, sensor classification, specifications, error reduction techniques, loading errors, Wheatstone bridge circuit, Sensors for position, velocity , acceleration , strain, force, torque, pressure , temperature, flow rate, humidity , vision systems, Sensor fusion.

Unit III

Chapter No.6. Actuators 6 Hrs

Principle and characteristics of electric motors, Solenoids, DC motors & drives, AC induction motors & drives, Step motors, Linear motors.

Chapter No.7. Real Time Interfacing 6 Hrs

Data conversion devices, Filters, Signal sampling and aliasing, Sampling theorem, Quantization, Encoding, Digital to analog conversion methods, Analog to digital conversion methods, Sample & Hold circuit, Flash ADC, Successive approximation ADC, Dual slope ADC, Sigma Delta ADC, Multiplexers.

Text Books

1. Devdas Shetty, Richard A. Kolk, Mechatronics System Design, Second, 2010
2. Sabri Centikunt, Mechatronics with experiments, Second, Wiley, 2015
3. Norman S. Nise, “Control Systems Engineering”, John Wiley & Sons, Inc, Sixth edition – 2011.

Program: Bachelor of Engineering		**Semester:** VI
Course Title: Metrology and Quality Engineering Lab		**Course Code:** 25EMEP301
L-T-P: 0-0-1	**Credits:** 1	**Contact Hours:** 2 Hrs/week
ISA Marks: 80	**ESA Marks:** 20	**Total Marks:** 100
Teaching Hours: 24	**Examination Duration:** 2 Hrs	

Expt. No	Brief description about the Experiments	No. of Lab Slots
1	Introduction to the Laboratory-Standards of measurement for Linear and angular dimensions.	1
2	Analysis of performance characteristics of measuring instruments using Hypothesis testing.	1
3	Analysis of Repeatability and Reproducibility using gauge R& R test.	1
4	Measurement of Screw thread and Gear parameters, surface roughness	1
5	Measurement of Dimensions and GD&T parameters of given components using CMM (Coordinate Measuring Machine).	2
6	Reverse engineering of the given component by extraction of 2-Dimensions of the given part using 3D scanner.	1
7	Testing the goodness of fit for the given quality characteristics by Chi- Square test.	1
8	Construction of control chart for variables and Analysis of process capability for the different components manufacturing.	1
9	Construction and Analysis of control charts for defectives.	1
10	Acceptance Sampling Testing Using Go and No Go Gauges	1
11	Open Ended experiment- Error analysis, Gauge Design	1

Reference Books:

1. Montgomery D. C., Introduction to Statistical Quality Control, 8th Edn. John Wiley & Sons, Inc 2019
2. Hume K.J. & Sharp G.H, Practical metrology , 1st Edition ELBS &Macdonald 1970
3. Juran J.M. & F.M. Gryna, Quality Planning & Analysis, 3rd Re edition TMH Publications 1993

Program: Bachelor of Engineering		**Semester: VI**
Course Title: Minor Project		**Course Code: 24EMEW301**
L-T-P: 0-0-6	**Credits: 6**	**Contact Hours: 6Hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 36	**Examination Duration: 3 Hrs**	

The minor project is offered as a 6 credit course to sixth semester students as studio mode project course. Course is conducted in studio mode where students work in team of 6 each. The course highlights the significance of Engineering Design and Product Design is Engineering. Also, students develop the proficiency of understanding the end users, their requirements and needs by conducting brief field and literature survey followed by product benchmarking which helps them to understand the insights of the problem. Further students develop the conceptual designs to best fit the constraints; one best design is evaluated and expanded to detailed 3D design and 2D drawing that fetches the bill of materials and recognizing suitable raw materials for prototyping. Students then move to Maker Space to develop the prototypes for the finalized design. Students master the skills of prototyping like use of hand tools, machining tools, and 3D printing wherever required. Most of the projects involves using of circuits, actuators, motors and other electrical components that help them to learn the basics of mechatronics. The final prototype is functional and demonstrates the conceptual design requirements. Efforts are put to make sure that these prototypes are innovative and involve newer functions. The entire course is reviewed in three timely reviews to evaluate Design, Build and Control aspects of the project work.

Phases of mini Project Work:

- Students in batches will first select a product to carry out reverse engineering.
- Dismantle the assembly into individual parts.
- Take dimensions and make good legible sketches.
- Carry out 3D models of all the parts in 3D experience software (Catia).
- Assemble the parts in software to see a complete assembly.
- Render the product and show it in an actual environment.
- Convert it into 2d assembly with ballooning and BOM.
- Part drawings to be converted into 2D manufacturing parts as per industry standards, with GD&T symbols wherever necessary.
- Students have to include an Innovative idea and incorporate the same in their project.
- Prepare a final detailed report explaining the various stages and give a presentation as a team.

Program: Bachelor of Engineering		**Semester: VI**
Course Title: Industry Readiness & Leadership Skills		**Course Code: 22EHSH302**
L-T-P: 0.5-0-0	**Credits: 0.5**	**Contact Hours: 1Hr/week**
ISA Marks: 100	**ESA Marks: Nil**	**Total Marks: 100**
Teaching Hours: 16	**Examination Duration: NA**	

Chapter No. 1. Written Communication

Successful Job Applications, Résumé Writing, Emails, Letters, Business Communication, Essay, and Paragraph Writing for Recruitment Tests

Chapter No. 2. Interview Handling Skills

Understanding Interviewer Psychology, Common Questions in HR Interviews, Grooming, Interview Etiquette

Chapter No. 3. Lateral & Creative Thinking

Lateral Thinking by Edward de Bono, Fractionation and Brain Storming, Mind Maps, Creativity Enhancement through Activities

Chapter No. 4. Team Building & Leadership Skills

Communication in a Team, Leadership Styles, Playing a Team member, Belbin's team roles, Ethics, Effective Leadership Strategies

References

1. Diana Booher – E Writing, Laxmi Publications
2. Edward de Bono – Lateral Thinking – A Textbook of Creativity, Penguin UK
3. William Strunk, E B White – The Elements of Style, Pearson
4. John Maxwell – The 17 Essential Qualities of a Team Player, HarperCollins Leadership
5. Robin Ryan – 60 Seconds and You're Hired! – Penguin Books

← BACK TO SEMESTER VI

Program: Bachelor of Engineering		**Semester: VI**
Course Title: Failure Analysis in Design		**Course Code: 15EMEE302**
L-T-P: 3-0-0	**Credits: 3**	**Contact Hours: 3 Hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 3 Hrs**	

Unit I

1. Introduction 8 Hrs

Study of Failure criteria and its importance, Role of failure prevention analysis in mechanical design, Modes of mechanical failure, Review of failure theories for ductile and brittle materials including Mohr's theory and modified Mohr's theory, Numerical examples.

2. Surface Failure 7 Hrs

Introduction, Surface geometry, Mating surface, Friction, Adhesive wear, Abrasive wear, Corrosion wear, Surface fatigue spherical contact, Cylindrical contact, General contact, Numerical examples.

Unit II

3. Fatigue of Materials 5 Hrs

History of failure due to fatigue loads and development of fatigue failure, Concepts and terminology, High cycle and low cycle fatigue, Fatigue design models, Fatigue design methods, Fatigue design criteria, Fatigue testing, Fatigue fracture surfaces and macroscopic features, Fatigue mechanisms and microscopic features.

4. Stress-Life (S-N) Approach 6 Hrs

S-N curves, Statistical nature of fatigue test data, General S-N behavior, Different factors influencing S-N behavior, S-N curve representation and approximations, Constant life diagrams, Fatigue life estimation using S-N approach, Case study.

5. Strain-Life (ε-N) approach 5 Hrs

Monotonic stress-strain behavior, Strain controlled test methods, Cyclic stress-strain behavior, Strain based approach to life estimation, Determination of strain life fatigue properties, Mean stress effects, Effect of surface finish, Life estimation by ε-N approach.

Unit III

6. Creep deformation 5 Hrs

The evolution of creep damage, primary, secondary and tertiary creep. Stress dependence of creep – power law dependence. Comparison of creep performance under different conditions – extrapolation and the use of Larson-Miller parameters. Creep-fatigue interactions. Numerical examples.

7. Buckling Analysis of rectangular plates 4 Hrs

Governing differential equation and boundary conditions, plate with all edges simply supported, plates with other boundary conditions, buckling under in-plane shear, post buckling analysis.

Text Books

1. Ralph I. Stephens, Ali Fatemi, "Metal Fatigue in Engineering", John Wiley New York, 2nd edition, 2001.
2. Jack A Collins, Failure of Materials in Mechanical Design John Wiley & Sons, 1993.
3. Gambhir, M.L, Stability Analysis and Design of Structures, Springer-Verlag, 2004.

Reference Books

1. Robert L. Norton, Pearson, "Machine Design- An Integrated Approach", 2nd edition, 2000.

Program: Bachelor of Engineering		**Semester: VI**
Course Title: Product Design & Development		**Course Code: 19EMEE303**
L-T-P: 2-1-0	**Credits: 3**	**Contact Hours: 5Hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 28, Tutorial Hrs: 12	**Examination Duration: 3 Hrs**	

Unit I

1. VoC to Product Specifications 6 Hrs

QFD methods to develop product specification from VoC

Concept development methods – Functional Analysis, Mock-ups, Concept selection methods (Pugh Matrix, Customer Focus Groups, Delphi method), Gap analysis, Rapid prototyping techniques, First Order analysis of concepts.

2. Design Methods 10 Hrs

1. Knowledge based engineering design techniques
2. Design Optimization techniques, Robust design methods overview,
3. Design for Six Sigma (Quality) methodology
4. Design for "X" – (X = Cost, Manufacturability, Assembly, Sustainability)
5. CAE led design techniques
6. Bio-inspired design
7. Value engineering – Function Cost relationship, Value Engineering tools and techniques, VE application in product design

Unit II

3. Product Development Process 3 Hrs

Program Management, Design and functional review methods (DFMEA), Assembly process and virtual builds, Quality goals and control plans

4. Product Verification and Validation 3 Hrs

Load goals and duty cycle definition, Reliability and durability goals, Virtual prototyping techniques, Accelerated product verification methods

Unit III

5. Product family management 3 Hrs

Product lifecycle management; Evolution of product models and families, Modeling of product family lifecycle, Product Strategy, Product market positioning, Product positioning – psychological, Brand, customer segment.

6. Technology management 3 Hrs

Technology management methods, Technology as a competitive tool, Critical Component Development Process, Technology Development Process

Reference Books

1. Karl Ulrich and Steven Eppinge, Product Design and Development
2. Kenneth B. Kahn, The PDMA Handbook of New Product Development, Second Edition
3. Six Sigma Guide

Program: Bachelor of Engineering		**Semester: VI**
Course Title: Computer Integrated Manufacturing		**Course Code: 15EMEE306**
L-T-P: 3-0-0	**Credits: 3**	**Contact Hours: 3 Hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 3 Hrs**	

Unit I

1: Manufacturing operations: 8 Hrs

Production system facilities, manufacturing support systems, automation in production systems, manual labor in production systems. Automation principles and strategies, manufacturing industries and products, product/production relationships, production concepts and mathematical models, costs of manufacturing operations

2: Manufacturing systems: 7Hrs

Components, classification, manufacturing process functions, single station manufacturing cells, applications. Group Technology Part families, classification and coding, production flow analysis

Unit II

3: Cellular Manufacturing, Flexible Manufacturing Systems: 5Hrs

Cellular manufacturing quantitative analysis in cellular manufacturing, FMS components, planning and implementation, quantitative analysis of FMS

4: Material handling and storage: 5 Hrs

Material handling equipment, considerations in material handling system design, principles of material handling, material transport systems: storage systems: automated storage systems, automatic data capture, automatic identification methods

5: PLM and IIoT: 5Hrs

Areas of Product Life cycle Management (PLM), phases of product life cycle and technologies, benefits of PLM.

Definition of Industrial Internet of Things (IIoT), Evolution, Enablers for IIoT platform, drivers, Benefits, protocols, challenges, future

Unit III

6: Robot fundamentals: 5 Hrs

Robot anatomy and related attributes, classification, robot control systems, end effectors, sensors in robotics, robot programming

7: Robot kinematics: 5 Hrs

Matrix representation, Homogeneous transformation matrices, Representation of transformations, Inverse transformation matrices, forward and inverse kinematics of robots, D-H representation of forward kinematic equations, degeneracy and dexterity

Text Books

1. Grover M.P., “Automation, Production Systems and Computer Integrated Manufacturing”, PHI,.
2. Chris McMahon & Jimmie Browne, “CAD & CAM Principles”, Practice & Mfg. Mngt.’, Pearson Education.

Reference Books:

1. Radhakrishnan P., “CAD/CAM/CIM”, New Age International Private Limited.
2. Zeid Ibrahim, “CAD/CAM”, McGraw Hill International.
3. Rao P.N., ‘CAD/CAM Principles and Applications’, Tata McGraw-Hill.
4. Vajpayee S. K., “Principles of CIM”, Prentice Hall of India.
5. Saeed B. Niku, “Introduction to Robotics”, Prentice Hall of India.

Program: Bachelor of Engineering		**Semester: VI**
Course Title: Noise, Vibration and Harshness (NVH)		**Course Code: 23EMEE301**
L-T-P: 2-1-0	**Credits: 3**	**Contact Hours: 4Hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 30	**Examination Duration: 3 Hrs**	

Unit I

1. NVH Fundamentals and Standards 06Hrs

Review of fundamentals of vibrations, Significance of NVH study, Advantages, Application areas of NVH, Severity of machine and human beings to vibrations, Common machinery faults requiring diagnosis, Ride comfort analysis of railroad vehicles, Standards for vibrations of buildings and machinery, Vibration transducers and considerations, Data acquisition and processing, Vibration data collection errors, Experimental modal testing and important aspects, Modal parameters from Bode and Nyquist plots,

2. Transient Vibrations 06Hrs

Introduction, Response of linear mechanical systems to vibrations, Response under a nonperiodic force, Convolution integral, Response of mechanical systems to an impulse, general forcing condition and base excitation, Response spectrum, Design under a shock environment, Numericals.

Unit II

3. Vibration Control 06Hrs

Introduction, Vibration Nomo graph and vibration criteria; Reduction of vibration at the source, Control of vibration; Control of natural frequencies, Introduction of damping, Vibration isolation for different types of foundation, Shock isolation, Active vibration control, Numericals.

4. Finite Element Method for Vibration Problems 06Hrs

Introduction, Equations of motion of an element, Mass matrix, stiffness matrix, and force vector, Transformation of element matrices and vectors, Equations of motion of the complete system of finite elements, Incorporation of boundary conditions, Consistent and lumped mass matrices, Numericals.

Unit III

7. Fundamentals of Acoustics 03Hrs

Introduction, Human perception of sound, Noise limits in India, Permissible noise exposure for industrial workers, Sound wave propagation in 1-D, Acoustic quantities, Acoustic transducers, Parameters for choice of microphones, Types of microphones: Electro-dynamic and Piezoelectric microphone.

8. Measurements in Acoustics 03Hrs

Introduction, Sound level measurement, Sound power measurement, Sound pressure level measurement, Sound intensity measurement, Radiation fields of a sound source, Standards for sound measurement, Noise measurement case studies.

Text Books

1. C. Sujatha, Vibration and Acoustics, Tata McGraw-Hill Education, 2010
2. Singiresu S. Rao, Mechanical Vibrations, Pearson Education Ltd., 6th Edition, 2018.
3. M. L. Munjal, Noise and Vibration Control, World Scientific Publishing Co, Pvt. 2013

Hands-on Sessions Using Simulation Software

Sl. No.	NVH Analysis	No of Sessions
01	Analysis of cantilevered thin and thick square plate (Free-Free and Forced-Fixed condition).	01
02	Analysis cantilevered thin and thick square plate with changes in design to increase the natural frequency.	01
03	Normal mode analysis of cylinder: Axi-Symmetric case	01

04	Normal mode analysis of a Bracket with design changes (Free- Free and Forced-Fixed).	01
05	Modal frequency response analysis of i) Thick square plate. ii) Frame assembly	01
06	Modal frequency response analysis of an automotive chassis.	01
07	Harmonic forced vibration response analysis of simply-supported thick square plate	01
08	Transient forced vibration response of i) Simply-supported thick square plate ii) Monocoque chassis.	01
09	Acoustic analysis of brake squeal and half car model	01
10	Optimize the rectangular box model for panel thicknesses to reduce the vibration level using what-if studies and optimization process	01

Program: Bachelor of Engineering		**Semester: VI**
Course Title: Smart Manufacturing Technologies		**Course Code:** 25EMEE306
L-T-P: 2-1-0	**Credits:** 3	**Contact Hours:** 4 Hrs/week
ISA Marks: 50	**ESA Marks:** 50	**Total Marks:** 100
Teaching Hours: 28 + 24	**Examination Duration:** 2 Hrs	

Unit I

Chapter 1. Data-Driven Manufacturing : 07 Hrs

Basics of Data Collection & Processing in Manufacturing, Introduction to Data Warehousing, Architecture of a Smart Manufacturing Data Warehouse, Applications of Data Warehousing in Manufacturing; Industrial Cybersecurity Challenges, Securing IoT Devices & Data Privacy

Chapter 2. AI/ML& Robotics in Manufacturing: 07 Hrs

Basics of AI: Machine Learning vs. Deep Learning, Robotics and AI Integration in Industry 4.0 & 5.0, Key AI and Robotics Applications in Manufacturing; Fundamentals of Machine Learning: Supervised, Unsupervised, Reinforcement Learning, AI in Quality Control and Defect Detection; Augmented Reality (AR) & Virtual Reality (VR) in Smart Factories, AR-based Training & Maintenance Applications, Virtual Manufacturing Simulations

Unit II

Chapter 3. Automation and Robotics in Smart Manufacturing : 07 Hrs

Industrial Robots & Collaborative Robots, AMRs vs. AGVs: Differences and Applications,Automated Material Handling Systems, Automated Guided Vehicles (AGVs): Design & Control, Automated Storage & Retrieval Systems (AS/RS), AI-driven Supply Chain & Smart Warehousing, Role of Reinforcement Learning in AMR Navigation

Chapter 4. Evolutionary Computing:07 Hrs

Introduction to Evolutionary Computing, Applications and Implementation of Evolutionary Algorithms in Smart Manufacturing, Evolutionary Algorithms for Process Optimization, Production Scheduling and Resource Allocation, Emerging Trends in Evolutionary Computing for Manufacturing

Hands-on activities: 24 Hrs

- Build a real-time manufacturing analytics dashboard. (Power BI or Tableau)
- Train an AI model to predict failures in industrial application. (Python)
- Build an interactive AR maintenance training for factory equipment. (Unity3D)
- Simulate an AMR navigating a warehouse using AI-based path planning. (ROS)
- Use evolutionary optimization techniques for a real-world manufacturing problem. (MATLAB)

Text Books:

1. Kandasamy, Jayakrishna, KamalakantaMuduli, V. P. Kommula, and Purushottam L. Meena, eds. Smart manufacturing technologies for industry 4.0: integration, benefits, and operational activities.
2. Soroush, Masoud, Michael Baldea, and Thomas F. Edgar, eds. Smart manufacturing: concepts and methods. Elsevier, 2020.
3. Elangovan, Uthayan. Smart automation to smart manufacturing: Industrial internet of things. Momentum Press, 2019.

Reference Books:

1. Dhanaraj, Rajesh Kumar, Ali Kashif Bashir, Rajasekar Vani, BalamuruganBalusamy, and Pooja Malik, eds. Digital Twin for Smart Manufacturing. Elsevier, 2023.
2. Leong, Wai Yie, ed. Human Machine Collaboration and Interaction for Smart Manufacturing: Automation, Robotics, Sensing, Artificial Intelligence, 5G, IoTs and Blockchain. Institution of Engineering and Technology, 2022.
3. Gilchrist, Alasdair. Industry 4.0: the industrial internet of things. Apress, 2016.

Program: Bachelor of Engineering		**Semester: VI**
Course Title: Mobile Robotic Systems		**Course Code:** 25EMEE307
L-T-P: 2-1-0	**Credits:** 3	**Contact Hours:** 4 Hrs/week
ISA Marks: 50	**ESA Marks:** 50	**Total Marks:** 100
Teaching Hours: 28 + 24	**Examination Duration:** 2 Hrs	

Unit I

Chapter 1. Introduction to Mobile robots (4 Hours)

Intelligence and embodiment, A roboticist's problem, challenges of mobile autonomous robots, Locomotion, static and dynamic stability, degrees of freedom. Coordinate systems and frames of reference, forward kinematics, inverse kinematics, inverse kinematics using feedback control.

Chapter 2. Path Planning (5 Hours)

Map representations, path planning algorithms, sampling based path planning, path smoothing, planning at different length scales. Uncertainty and error propagation in robotics, probabilistic robotics, basic concepts in probability.

Chapter 3. Recursive State Estimation (5 Hours)

Robot environment interaction, Bayes filter, representation and computation. Gaussian filters, Kalman filter, extended kalman filter, information filter, histogram filter, particle filter

Unit II

Chapter 4. Robot Motion and Perception (5 Hours)

Kinematic configuration, probabilistic kinematics, velocity motion model, odometry motion model. Maps, Beam models of range finders, likelihood fields for range finders, correlation-based sensor models, feature-based sensor models.

Chapter 5.Mobile Robot Localization: Markov and Gaussian (5 Hours)

Mobile robot localization, Markov localization, EKF localization, Estimating correspondences, multi-hypothesis tracking, grid localization, Monte Carlo localization.

Chapter 6. Occupancy Grid Mapping (4 Hours)

Occupancy grid mapping, Simultaneous localization and mapping, RGB-D SLAM.

Hands-On Activity: (24 Hours)

- Simulate forward and inverse kinematics of a 2-wheeled mobile robot
- Implement and visualize sampling-based planning
- Code and simulate Kalman Filter for 1D/2D state estimation of a moving robot
- Simulate laser/ultrasonic range detection with noisy models and beam likelihood
- Implement particle filter for 2D mobile robot localization on a map

Text Books:

1. Sebastian Thrun, Wolfram Burgard& Dieter Fox, " Probabilistic Robotics", The MIT Press.
2. Alonzo Kelly, "Mobile Robotics: Mathematics, Models, and Methods", Cambridge University

Reference Books:

1. Eugene Kagan, NirShvalb&Irad Ben-Gal, "Autonomous Mobile Robots and Multi-Robot Systems ", First Edition, John Wiley & Sons Ltd, 2020.
2. NikolausCorrell, Introduction to Autonomous Robots, 1st edition.

← BACK TO SEMESTER VI

Program: Bachelor of Engineering		**Semester: VI**
Course Title: Design for Additive Manufacturing (DfAM) Lab		**Course Code: 22EMEE305**
L-T-P: 1-0-2	**Credits: 3**	**Contact Hours: 5Hrs/week**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hours: 80	**Examination Duration: 2 Hrs**	

Experiment	Sessions
1. Introduction, Motivation, Design for Manufacturing and Assembly, AM Unique Capabilities (Shape Complexity, Hierarchical Complexity, Functional Complexity, Material Complexity), Core DFAM Concepts and Objectives, Exploring Design Freedoms	02
2. Reverse Engineering methods and Techniques	03
3. Generation of CAD models using software	03
4. Generating STL files from the CAD models & working on STL files	02
5. Modifying STL files using open source software	02
6. Optimization techniques & Topology optimization using software	06
7. Processing optimized data using open source software	04
8. Sending the tool path data for fabricating the physical part on 3D printer	03
9. Support removal and post processing of 3D printed parts	02
10. Evaluation of the quality of fabricated parts for surface finish, dimensional accuracy and suitability for given application.	01

* REVERSE ENGINEERING SOFTWARE:
  1. Faro 3D Imager 2. Hand Scanner software
* TOPOLOGY OPTIMIZATION SOFTWARE:
  1. Autodesk Fusion 360 with Netfabb 2. nTopology
  3. 3D Experience Functional Generative Design 4. Solidworks
* PRINTER SIMULATION SOFTWARE:
  1. CURA 2. CubePro

Program: Bachelor of Engineering		**Semester: VI**
Course Title: Green Hydrogen		**Course Code: 22EMEE306**
L-T-P: 3-0-0	**Credits: 3**	**Contact Hours: 3Hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 3 Hrs**	

Unit I

1. Introduction: 7 Hrs

Global Warming – Green House Gas Emissions – Introduction to hydrogen – Primary Sources of Hydrogen – Colours of Hydrogen – Water Splitting Reaction. Wide range of applications – Global Hydrogen Demand – Characteristics of Hydrogen

2. Fundamentals of Electrolysis: 8Hrs

Electrochemical water splitting – Electrolyzer or electrolytic cell – Thermodynamics – Thermodynamic functions of state – Water splitting cells: General characteristics – Faraday's law – Faradaic efficiency – Energy efficiency of water electrolysis cells, Classification of Electrolysers

Unit II

3. Fuel Cells:7 Hrs

Working principle of fuel cells, Fuel cell thermodynamics, fuel cell electrochemistry - Nernst equation, Electrochemical kinetics, Butler-Volmer equation, performance evaluation of fuel cells, Types of Fuel Cells: AFC, PAFC, SOFC, MCFC, DMFC, relative merits and demerits. Fuel cell characterization: In-situ and ex-situ characterization techniques, I-V curve, frequency response analyses; Fuel cell system integration

4. Application of Fuel Cells 8Hrs

Fuel Cell usage for domestic power systems, large scale power generation, Automobile, environmental analysis. Future trends in fuel cells, portable fuel cells, laptops, mobiles, submarines.

Unit III

5. Hydrogen storage and safety 6Hrs

Physical and chemical properties, general storage methods, compressed storage-composite cylinders, metal hydride storage, carbon based materials for hydrogen storage. Hydrogen safety aspects, backfire, pre-ignition, hydrogen emission NOx control techniques and strategies, Hydrogen powered vehicles.

6. Future trends in fuel cells: 4Hrs

Need of green hydrogen technology- Solution to overcome Global warming- Efforts to be taken

Text Books

1. Viswanathan, B., M Aulice Scibioh, Fuel Cells – Principles and Applications, Universities Press, 2006.
2. A.J. Bard, L.R.Faulkner, Electrochemical Methods, 2nd Edn.,John Wiley & Sons, 2001.
3. Fuel Cell Handbook, EG&G Technical Services, Inc., 7th Edn., NETL, West Virginia, 2004
4. Ryan O Hayre, Suk-Won Cha Whitney Colella, Fuel Cell Fundamentals, 2nd Edn., John Wiley, 2018.
5. Franno Barbir, PEM Fuel Cells: Theory and Practice, 2nd Ed. Elsevier/Academic Press, 2013.
6. Xianguo Li, Principles of Fuel Cells, Taylor & Francis, 1st Edn., 2005

Program: Bachelor of Engineering		**Semester:** VI
Course Title: Advanced CAE- II		**Course Code:** 25EMEE302
L-T-P: 0-0-3	**Credits:** 3	**Contact Hours:** 6 Hrs/week
ISA Marks: 80	**ESA Marks:** 20	**Total Marks:** 100
Teaching Hours: 80	**Examination Duration**: 2 Hrs	

Experiment wise plan

Serial No.	Details	Details	No. of hours
1	Finite Element Methods: A conceptual introduction, Failure criteria of materials	Demonstration	05
2	**Ansys workbench** ➢ Getting started with Ansys ➢ Interacting with panels	Exercise/Tutorial	06
3	**Case study on** ➢ One dimensional ➢ Two dimensional ➢ Three dimensional components	Exercise/Tutorial	06
4	Convergence study in FEA Quality parameters for 1D/2D/3D elements, Convergence Study of 2D and 3D Solid Elements	Exercise/Tutorial	06
5	Case study on Static structural analysis	Exercise/Tutorial	03
6	**Dynamic analysis Vibration** ➢ Vibration ➢ Stress based Fatigue ➢ Strain based Fatigue/	Exercise/Tutorial	09
7	**Non-linear analysis** ➢ Geometry ➢ Material ➢ Contact analysis	Exercise/Tutorial	09
8	Buckling and Stress stiffening	Exercise/Tutorial	03
9	**Thermal analysis** ➢ Steady state thermal analysis ➢ Transient thermal analysis	Exercise/Tutorial	03
10	**Case study on Explicit Dynamics** ➢ High-Speed Impact: Bird Crash	Exercise/Tutorial	06
11	**Contact Analysis** ➢ Frictional and Frictionless ➢ No Separation ➢ Bonded ➢ Rough	Exercise/Tutorial	06
12	Multi Body Dynamics (MBD) Analysis	Exercise/Tutorial	06
13	Optimization of machine components	Exercise/Tutorial	03
14	**Analysis of Composite** ➢ Polymer matrix composite ➢ Metal matrix composite	Demo	06

15	**Couple Field Analysis.** ➢ Thermo-Structural Analysis ➢ Electro-Mechanical Analysis	Demo	03

Text Books

1. Nitin Ghokale, Practical finite element analysis, Finite to infinite, 2008.

Reference Books:

1. Chen, Xiaolin_ Liu, Yijun-Finite Element Modeling and Simulation with ANSYS Workbench-CRC Press (2014)
2. Erdogan Madenci, Ibrahim Guven (auth.)-The Finite Element Method and Applications in Engineering Using ANSYS®-Springer US (2015)
3. Barbero, Ever J.-Finite Element Analysis of Composite Materials Using ANSYS®-CRC Press (2013)

Program: Bachelor of Engineering		**Semester: VI**
Course Title: Biomechanics		**Course Code: 22EMEE307**
L-T-P: 0-0-3	**Credits: 3**	**Contact Hours: 6Hrs/week**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hours: 80	**Examination Duration: 3Hrs**	

1. Introduction and Fundamentals 14 Hrs

What are Biomechanics? Anatomical Concepts in Biomechanics, free-body diagrams and equilibrium; linear and angular kinematics, kinetic equation of motion, work and energy method, application to biological systems: stress, strain, Modulus, strain energy, tension, compression, torsion, bending, buckling.

2. Tissues 14 Hrs

Animal tissues and plant tissues. Classification of animal tissues-hard tissue, soft tissue, properties of plant and animal tissues according to mechanics view point, Structure, Function, composition, material properties and modeling of tissues, Plant tissues – vascular bundles – xylem and phloem. Continuum Mechanics Concepts in Modeling of large deformation, Finite Element Modeling.

3. Joints and Movements 5 Hrs

Classification of joints, forces and stresses, biomechanical analysis joints, Gait, Joint replacement and reasons, Finite Element Modelling.

4. Bio-fluid mechanics 5 Hrs

Flow properties of blood and others, Fluid flow in plants, Dynamics of fluid flow in the biological system – modeling and experimental approaches, Measurement/Estimation of In-vivo elasticity of fluid transporting vessels.

Content – Practical (Hands-on) 42 Hrs

The below mentioned parameters are executed in experimental/analytical/simulation form. Tools used: Rhino 7, ANSYS Workbench, Material Studio or J-Octa.

To determine the -

1. Tensile properties of a material (root or bones or plants or others).
2. Bending properties of a material (root or bones or plants or others).
3. Hardness properties of a material.
4. Torsional/shear properties of a material
5. Buckling properties of a material
6. Energy absorbed and toughness of a material
7. Wear properties of material and different combination of material
8. Ground reaction forces during normal walking or running
9. Finite Element Modeling and analysis of hard tissue and soft tissue (examples: Bone, ligaments or muscles)
10. Fluid flow through the cardiovascular system: Simple modeling and analysis

Text Books

1. Basic Biomechanics of the Musculoskeletal System. M. Nordin and V. H. Frankel, publisher-Lippincott Williams and Wilkins, 2012.
2. Biomechanics: Mechanical Properties of Living Tissues. Y. C. Fung, Springer, Second edition, 2007

Reference Books

1. Plant Biomechanics: An engineering approach to plant form and function, K. J. Niklas, University of Chicago Press, 1992.
2. Fundamentals of Biomechanics: Equilibrium, Motion and Deformation, Ozkaya, Nordin, Goldsheyder and Leger. Third edition, Springer, 2014.
3. Fundamentals of Biomechanics, R. L. Huston, CRC Press, 2013.

← BACK TO SEMESTER VI

Program: Bachelor of Engineering		**Semester: VI**
Course Title: Enterprise Resource Planning-II		**Course Code: 24EMEE303**
L-T-P: 2-0-1	Credits: 3	Contact Hours: 4 Hrs/week
ISA Marks: 80	ESA Marks: 20	Total Marks: 100
Teaching Hours: 30	Examination Duration: 2 Hrs	Semester: 6th

Unit I

Chapter 1. ERP Implementation basics: 5 Hrs

Master Data Management – Item Master, Vendor Master, COA, Customer Master, Machine Master, etc. Vendors- Role of Vendor; Consultants: Types of consultants; Role of a Consultant, Employees; Role of employees; Resistance by employees; Dealing with employee resistance, Role of Top Management, Role of Implementation Partner.

Chapter 2. ERP implementation Life cycle: 10 Hrs

Objectives of ERP implementation, Different phases of ERP implementation. Consultants, vendor and employees.

ERP Projects: Project types, Implementation methodology, Project Preparation, Business Blueprinting, Gap Analysis, Realization, Final Preparation, Go Live and Support, User Training.

ERP Post Implementation: Maintenance of ERP- Organizational and Industrial impact; Success and Failure factors and ERP Implementation - Case studies.

Unit II

Chapter 3. ERP and e-Business: 5 Hrs

Introduction ERP and e-business process model, components of e-Business supply chain ERP/ e-business integration ERP to ERP II –Bringing ERP to the Entire Enterprise.

Chapter 4. Future Directions in ERP: 5 Hrs

Faster Implementation Methodologies; Business Modules and BAPIs; Convergence on Windows NT; Application Platform; New Business Segments; More Features; Web Enabling; Market Snapshot.

Chapter 5. Other Related Technologies of SCM: 5 Hrs

Relation to ERP; E-Procurement; E-Logistics; Internet Auctions; E-markets; Electronic Business Process Optimization; Business Objects in SCM; E-commerce.

Experiments	**No. of sessions**
5. Perform the steps in the production processes in SAP	04
6. Point out essential settings for advanced financial accounting functions	03
7. Customize the UI as per requirement	03
8. Generation of company reports and query generation	02

Text Books

1. Ellen Nonk & Bret Wagner, “Concepts in Enterprise Resource Planning”, 4th edition, CENGAGE Learning Custom Publishing, 2013.
2. Vinod Kumar Garg, N. K. Venkitakrishnan, “Enterprise Resource Planning: Concepts and Practice”, 2nd edition, Prentice Hall India Learning Private Limited, 2003.

Reference Books

1. Alexis Leon, “Enterprise Resource Planning”, 4th edition, McGraw Hill Education, 2019.
2. Simha R. Magal & Jeffrey Word, “Integrated Business Processes with ERP Systems”, 1st edition, John Wiley & Sons Inc., 2011.

Program: Bachelor of Engineering		**Semester: VI**
Course Title: Advanced Product Lifecycle Management		**Course Code: 24EMEE304**
L-T-P: 2-0-1	**Credits: 3**	**Contact Hours: 4 Hrs/week**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hours: 30	**Examination Duration: 2 Hrs**	

Unit I

Chapter 1. Organizational Change Management in the PLM Environment: 6 Hrs

Organizational change management (OCM), benefits of OCM, incremental change, transformational change, resistance to change, pre-requisites for organizational change, KPI's for organizational change, special features of OCM, results of ignoring OCM, participants in change, related blogs.

Chapter 2. Project Management in the PLM Environment: 8 Hrs

Characteristics of a project, project phases, project management (PM) knowledge areas, PM tools and templates, KPI's for PM, importance of PM in PLM, generic issues with projects, interaction with other activities, PM activities in PLM initiatives, top management role with project management, related blogs.

Unit II

Chapter 3. The PLM Initiative: 8 Hrs

5 pilers to the initiative, middle managers and executives, company dilemma, personal dilemma, approaches to a PLM initiative, pitfalls for the PLM initiatives, examples of the PLM dilemma, results of use of the ten-step approach, common features of PLM initiation, related blogs.

Chapter 4. Deployment of the PLM System: 8 Hrs

Different stages of deployment, leading a PLM project, PLM maturity model, choosing a system, realization stage of the project, challenges in deployment of PLM in the industries, related blogs.

Experiments	**No. of sessions**
1. Change Management Essentials – 8 Hrs Creating change request, creating change orders, adding and modifying proposed change, adding change actions, tracking changes in an EBOM, creating impact analysis, releasing parts, part revisions and effectivities, releasing an EBOM, generating a change request summary report, generating different types of reports, case studies.	04
2. Project Management Essentials – 8 Hrs Creating programs and projects, creating schedule and assigning members, creating experiments, project issues and baselines, creating bookmarks and defining rights, creating routes and completing tasks, monitoring the status of projects and programs, managing risks, managing resources, working with budgets and benefits, working with calendars, assessing and tracking projects, case studies	04
3. Variant Management Essentials – 8 Hrs Variant management overview, define product line, project phase and milestones, product portfolio, requirements, variant dictionary, marketing rules, product configurations, product architecture, generate GBOM and define effectivity, release the logical features, generate BOMs for a product configuration, case studies.	04

Reference Books

1. Stark John, "Product Lifecycle Management: 21st Century Paradigm for Product Realization", Springer, Third Edition, 2015
2. Antti Saakasvuori, Anselmi Immonen, "Product Lifecycle Management" - Springer, 1st Edition, 2003.

Program: Bachelor of Engineering		**Semester: VI**
Course Title: Vehicle Structure and Design Optimization		**Course Code: 19EMEE301**
L-T-P: 0-0-3	**Credits: 3**	**Contact Hours: 3Hrs/week**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hours: 80	**Examination Duration: 2 Hrs**	

Sl. No	Content	Teaching Hours
1	Brief explanation of different types of Loads and its effect; Different types of stresses- Static and Thermal, Different types of beams, Struts and Columns, thick and thin cylinders;	02
2	Understanding vehicle structure based on application; (e.g: 3box, load body and chassis)	04
3	Choices for Preparation of Virtual Model (1D, 2D, 3D representation);	03
4	Importance of Joinery;	02
5	Common performance measures for vehicle structures; (Stiffness, Modal, Durability)	03
6	Understanding Data and Assumptions; (e.g. nominal and tolerance, etc.)	02
7	Baseline data; (Initial collection of data which serves as a basis for comparison with the subsequently acquired data.)	02
8	Quality control in virtual environment;	03
9	Example case of static stiffness of BIW, Chassis; (BIW (short for Body in White) is a stage in automotive design and manufacturing. BIW refers to the body shell design of an automotive product such as cars. It is just a sheet metal welded structure. BIW will not have doors, engines, chassis or any other moving parts.)	05
10	Understanding effect of thermal loads on structure;	02
11	Understanding how to compute life based on stress results;	02
	Hands on Session	
1	Demonstrate importance of geometric parameters on performance of structure	05
2	Demonstrate importance of cross members on performance of structure	05
	PART B (Design Optimization)	
1	Optimization in the Design Process, Engineering Design Practice, Characteristics of Different Industries, CAE and the Design Cycle, The impact of optimization on CAE, What is an Optimum Design? Optimization terminology in a nutshell, Finding an Optimum, Formulation of an Optimization problem;	02
2	What is optimization in the context of EV structure;	02
3	Different types of design optimization;	02
4	How to plan and approach giving design guidance;	02
5	What is concept level design guidance (generative designs);	03
6	How to handle design guidance at a detailed design stage;	03
7	Examples - design guidance for stiffness attribute;	04
8	Examples - design guidance for durability attribute;	04
9	What is MDO, its application;	02

	(Medium density overlay-MDO is produced with a high-quality thermosetting resin-impregnated fiber surface bonded to one or both sides under heat and pressure to create an exterior-grade plywood panel.)	
10	Watch-outs during design guidance process;	02
11	Examples - design guidance for NV & crash attribute;	04
12	**Hands on Session**	
13	Optimize front control arm of a vehicle for all its performance criteria. FAW up by 10%	05
14	Optimize B-Pillar for roof crush if GVW goes up by 20% due to electrification Effect of wheel base increase on chassis stiffness and how to bring it back, Section optimization using morphing.	05

Text Books

1. Dr. N.K. Giri, Automotive Mechanics, 8th Edition, 2008, Khanna Publication, New Delhi.
2. Practical Aspects of Structural Optimization, Altair University, 3rd Edition.
3. Robin Hardy, Iqbal Husain, "Electric and Hybrid Vehicles". CRC Press, ISBN 0-8493-1466-6.
4. Ron Hodkinson and John Fenton, "Lightweight Electric/ Hybrid Vehicle Design". SAE International
5. John M. Miller, Propulsion Systems for Hybrid Vehicles" Institute of Electrical Engineers, London, ISBN0 863413366.
6. Automobile Electrical and Electronic systems, Tom Denton, Third Edition, 2004, SAE International, SAE ISBN 0 7680 147 2, Society of Automotive Engineers. Inc 400 common wealth Drive, Warrendale, PA 15096-0001 USA.

Projects:

Part A

Objective: To carry out Baseline Performance, Virtual Testing and Design Countermeasures

Sl. No.	Content
01	Battery case for EV;
02	Motor compartment / Passenger compartment - improve performance;

Part B

Objective: To Provide design guidance

Sl. No.	**Content**
01	Battery case for EV (Metal vs Composite);
02	Motor compartment / Passenger compartment - improve performance;

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Program: Bachelor of Engineering		**Semester: VI**
Course Title: Machine Learning Applications		**Course Code: 19EMEE307**
L-T-P: 0-0-3	**Credits: 3**	**Contact Hours: 3Hrs/week**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hours: 80	**Examination Duration: 2 Hrs**	

Unit I

1. Unsupervised Learning 27 Hrs

Refresher week, Introduction to Unsupervised Learning, Clustering Analysis: K-Means, K-Medoid, DBSCAN, Hierarchical Clustering.

Unit II

2. Introduction to Deep Learning Frame-Work 18 Hrs

Introduction to DL, Exploring the popular DL frameworks, Getting started with Tensor Flow, Introduction to Keras, Setting up the environment.

3. Introduction to Deep Neural Network (DNN) 21 Hrs

Introduction- What is Deep Learning, Why Deep Learning and Why now, Mathematical building blocks of NN, Examples on Regression, Classification.

Unit III

4. Deep Learning in practice 14 Hrs

Introduction to Convolution network, Understanding Recurrent NN, Examples

Text Books

1. Deep Learning, Ian Goodfellow, Yoshua Bengio et.al
2. Trevor Hastie, Robert Tibshirani, and Jerome Friedman, “The Elements of Statistical Learning: Data Mining, Inference, and Prediction”, Springer, 2017
3. Deep Learning with Python, Francois Chollet

Reference Books

1. Andrew Ng, “Machine Learning Yearning”, https://www.mlyearning.org/.
2. Michael Nielsen, “Neural Networks and Deep Learning”, http://neuralnetworksanddeeplearning.com/.

Program: Bachelor of Engineering		**Semester: VII**
Course Title: Heat and Mass Transfer		**Course Code: 24EMEC401**
L-T-P: 3-0-0	**Credits: 3**	**Contact Hours: 3 Hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 3 Hrs**	

Unit I

Chapter 1. Introductory concepts and Definitions: 5 Hrs

Modes of heat transfer: Basic laws governing conduction, convection, and radiation heat transfer; Thermal conductivity; convective heat transfer coefficient; radiation heat transfer combined heat transfer mechanism, Mass transfer; Definition and terms used in mass transfer analysis, Fick's first law of diffusion. Boundary conditions of 1^{st},2^{nd} and 3^{rd} kind Conduction. Sustainability Aspects in heat transfer devices-Global Reporting Initiative (GRI) Standards

Chapter 2. One dimensional Steady State Conduction: 5 Hrs

Heat flow and temperature distribution in plane wall. Critical thickness of insulation, Thermal resistance concept. Steady state conduction in slab, cylinder and spheres with heat generation. Heat transfer in extended surfaces of uniform cross-section without heat generation [No Derivations] Fin efficiency and effectiveness. Numericals

Chapter 3. One-dimensional transient conduction: 5 Hrs

Conduction in solids with negligible internal temperature gradient (Lumped system analysis), Use of Transient temperature charts (Heisler's charts) for transient conduction in slab, long cylinder and sphere Numerical Problems.

Unit II

Chapter 4. Boundary layer flow and Forced convection: 6 Hrs

Flow over a body velocity boundary layer, general expressions for drag coefficient and drag force, thermal boundary layer. General expression for local heat transfer coefficient; Average heat transfer coefficient; Reynolds, Prandtl, Nusselt and Stanton numbers, Flow inside a duct, Correlations for flow over flat plate, cylinder and sphere Numerical problems based on empirical relation.

Chapter 5. Free or Natural Convection: 4 Hrs

significance of Grasshoff number, correlations for free convection over vertical, horizontal and inclined flat plates, vertical/ horizontal cylinders and spheres

Chapter 6. Heat Exchangers: 5 Hrs

Classification, overall heat transfer coefficient, fouling and fouling factor; LMTD, Effectiveness-NTU methods of analysis of heat exchangers. Sustainability issues in Heat Recovery Wheel for waste heat utilization

Unit III

Chapter 7. Condensation and Boiling: 5 Hrs

Types of condensation (discussion only) Nusselt's theory for laminar condensation on a vertical flat surface [No Derivation]. use of correlations for condensation. Regimes of pool boiling pool boiling correlations [Theory]

Chapter 8. Radiation heat transfer: 5 Hrs

Thermal radiation; definitions of various terms used in radiation heat transfer; Stefan-Boltzman law, Kirchoff's law, Planck's law and Wein's displacement law. Solar Radiation geometry. Numerical problems

Text Books:

1. Nicati Ozisik, Heat transfer-A basic approach, 1, Tata Mc Graw Hill, 2002
2. M.Tirumaleshwar, Fundamentals of Heat and Mass Transfer, 4, Pearson education, 2009

←BACK TO SEMESTER VII

Program: Bachelor of Engineering		**Semester:** VII
Course Title: I C Engines		**Course Code:** 25EMEC401
L-T-P: 2-0-0	**Credits:** 2	**Contact Hours:** 2 Hrs/week
ISA Marks: 50	**ESA Marks:** 50	**Total Marks:** 100
Teaching Hours: 30	**Examination Duration:** 2 Hrs	

Unit I

Chapter 1. Combustion in Spark Ignition Engines: 8 Hrs

Introduction: IC Engine Classification, Operating Cycles, SI and CI Engines.

Ignition limits, Normal combustion, Thermodynamic analysis of SI Engine combustion- stages, ignition lag, and effect of engine variables on ignition lag, Causes of Cycle-by- Cycle and Cylinder-to-Cylinder variations and flame propagation phase, detonation, Abnormal Combustion: Knock fundamentals and fuel factors, Factors affecting knock.SI engine combustion chambers.

Chapter 2. Combustion in Compression Ignition Engines: 7 Hrs

Types of Diesel Combustion Systems, Direct and Indirect-Injection Systems, Comparison, Combustion efficiency, Normal combustion–stages, delay period, variables affecting delay period. Diesel knock, comparison between diesel and petrol engine knocks.CI engine combustion chambers, Fuel spray behaviour. HRR analysis.

Unit II

Chapter 3. Engine Exhaust Emissions and Control Systems: 5 Hrs

Formation of NO_X, HC/CO mechanism, Smoke and Particulate emissions, Green House effect, Methods of controlling emissions, Three-way catalytic converter and Particulate trap, Emission (HC, CO, NO and NO_X) measuring equipment, Smoke and Particulate measurement, Indian Driving cycles and emission norms.

Chapter 4. IC Engine Performance Testing: 5 Hrs

Operating variables that affect SI Engine performance, efficiency and emissions: Spark timing, Mixture composition, Load and Speed, Compression ratio. Variables that affect CI Engine performance, efficiency, and emissions: Load and Speed, Fuel-Injection parameters.

Chapter 5. Recent Trends in IC Engines: 5 Hrs

Dual fuel Engine, Common Rail Direct Injection Diesel Engine (CRDI), Homogeneous Charge Compression Ignition Engine (HCCI), Reactivity controlled compression ignition engine (RCCI) Lean Burn Engine, Surface Ignition alcohol CI Engine, VVT engines, Gasoline Direct Injection Engine.

Text Books:

1. John B Heywood, “Internal Combustion Engine Fundamentals”, Tata McGraw-Hill, 1988
2. Heinz Heisler, “Advanced Engine Technology”, SAE International Publications, USA, 1998
3. Patterson D.J. and Henein N.A, “Emissions from combustion engines and their control”, Ann Arbor Science, publishers Inc, USA, 1978

Reference Books:

1. Ganesan V. “Internal Combustion Engines”, Third Edition, Tata Mcgraw-Hill, 2007.
2. Gupta H.N, “Fundamentals of Internal Combustion Engines”, Prentice Hall of India, 2006.
3. Ultrich Adler, “Automotive Electric / Electronic Systems”, Published by Robert Bosh GmbH, 1995.

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Program: Bachelor of Engineering		**Semester: VII**
Course Title: Thermal Engineering Lab		**Course Code: 19EMEP401**
L-T-P: 0-0-1	**Credits: 1**	**Contact Hours: 2 Hrs/week**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hours: 24	**Examination Duration: 2 Hrs**	

1. Fluid Mechanics and hydraulic machines

a. To obtain the performance characteristics of centrifugal blower
b. To study the effect of speed on the performance of centrifugal pump
c. To study the effect of speed / gate opening on the performance of Pelton turbine
d. To study the effect of speed / gate opening on the performance of Francis turbine
e. To determine the performance of nozzle and water flow meters

2. **Heat Transfer**

a. To determine the emissivity of given surface
b. To study the performance of pinfin
c. To determine thermal conductivity of insulating materials
d. To study the performance of vapour compression refrigeration (VCR) system

3**. I C Engines**

a. To study the performance of two stroke engine
b. To obtain the performance characteristics of multi-cylinder engine using Morse test
c. To study the effect of engine operating variables (Injection pressure/ injection timing/ compression ratio)

Materials and Resources Required

1. White, F.M., Fluid Mechanics, 5ed., McGraw Hill International, 2003
2. Nicati Ozisik - Heat transfer-A basic approach, Tata Mc Graw Hill, 2002
3. Yunus A. Cengel - Heat transfer, a practical approach, Tata Mc Graw Hill, 4th Edn, 2011
4. John B. Heywood, Fundamentals of Internal Combustion Engines, McGrawHill, Singapore.
5. Ganesan.V, Internal Combustion Engines, Tata McGraw Hill, 2nd Edition, 2003
6. Manuals: Lab manual prepared by the Department

←BACK TO SEMESTER VII

Program: Bachelor of Engineering		**Semester: VII**
Course Title: Senior Design Project		**Course Code: 20EMEW401**
L-T-P: 0-0-6	**Credits: 6**	**Contact Hours: 6 Hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 3 Hrs**	

About the Course:
Senior Design project course uses User experience design (UX) approach to solve complex engineering problems. In this course students are challenged to solve frontier complex engineering problems in the field of smart manufacturing, green engineering, and Design engineering and advanced materials. The objective of the course is to infuse lifelong qualities in students such as research, design thinking, innovation and entrepreneurial qualities. After this course students are capable to convert customer pain points into business solution.

Program: Bachelor of Engineering		Semester: VII
Course Title: CIPE & EVS		Course Code: 15EHSA401
L-T-P: Audit	Credits: Audit	Contact Hours: 32 Hrs/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 32	Examination Duration: 3 Hrs	

Unit – 1

Chapter 1 Features of Indian Constitution: 4 Hrs

Features of Indian Constitution, Preamble to the constitution of India, Fundamental rights under Part III – details of Exercise of rights, Limitations & Important cases. Berubari Union and Exchange of Enclaves, KesavanandBharati vs. UOI, Maneka Gandhi vs. UOI, Air India Ltd. vs. Nargees Meerza, T.M.A. Pai Foundation v. St. of Karnataka, M.C. Mehta vs. UOI etc.,

Chapter 2 Relevance of Directive principles of State Policy: 3 Hrs

Relevance of Directive principles of State Policy under Part IV, Fundamental duties & their significance. Sarla Mudgal v. UOI

Chapter. 3 Union: 4 Hrs

Union – President, Vice President, Union Council of Ministers, Prime Minister, Parliament & the Supreme Court of India.

Chapter 4 State: 2 Hrs

State – Governors, State Council of Ministers, Chief Minister, State Legislature and Judiciary.

Chapter 5 Constitutional Provisions for Scheduled Castes & Tribes 2 Hrs

Constitutional Provisions for Scheduled Castes & Tribes, Women &Children & Backward classes, Emergency Provisions.

Chapter 6 Electoral process: 2 Hrs

Electoral process, Amendment procedure, 42nd, 44th and 86th Constitutional amendments.

Unit – 2

Chapter 7 Scope & Aims of Engineering Ethics: 5 Hrs

Scope & Aims of Engineering Ethics: Meaning and purpose of Engineering Ethics, Responsibility of Engineers, Impediments to responsibility, Honesty, Integrity and reliability, risks, safety & liability in engineering. Bhopal Gas Tragedy, Titanic case.

Chapter 8 Intellectual Property Rights: 3 Hrs

Intellectual Property Rights (IPRs)- Patents, Copyright and Designs

Chapter 9 Ethical perspectives of professional bodies: 3 Hrs

Ethical perspectives of professional bodies- IEEE, ASME, NSPE and ABET, ASCE etc.

Unit – 3

Chapter 10 Effects of human activities on environment: 2 Hrs

Effects of human activities on environment - Agriculture, Housing, Industry, Mining, and Transportation activities, Environmental Impact Assessment, Sustainability and Sustainable Development.

Chapter 11 Environmental Protection: 2 Hrs

Environmental Protection – Constitutional Provisions and Environmental Laws in India.

Text Books (List of books as mentioned in the approved syllabus)

1. Dr. J. N. Pandey, “Constitutional Law of India”, Central Law Agency, 2005
2. Dr. M.K. Bhandari, “Law relating to Intellectual Property Rights”, Central Law Publications, Allahabad, 2010.
3. Charles E. Harris and others, “Engineering Ethics: Concepts and Cases”, Thomson Wadsworth, 2003

References

1. Durga Das Basu, “Introduction to the Constitution of India”, Prentice-hall EEE, 2001
2. Mike Martin and Ronald Schinzinger, “Ethics in Engineering”, Tata McGraw-Hill Publications.

Program: Bachelor of Engineering		**Semester: VII**
Course Title: Operations Research		**Course Code: 24EMEE401**
L-T-P: 3-0-0	**Credits: 3**	**Contact Hours: 3 Hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 3 Hrs**	

Unit I

Chapter 1. Introduction to Operations Research: 3 Hrs

System orientation, Use of interdisciplinary teams in OR, Necessity of OR in business and industry, Scope of OR in modern management, OR and Decision making

Chapter 2. Linear Programming: 12 Hrs

Formulation, Identification of decision variables, Constructing Objective Functions and Constraints, Assumptions, Practical Examples, Methods of Solution, Graphical Method, Simplex method (Big M and 2-phase methods), By computer, Examples

Unit II

Chapter 3. Duality Theory and Sensitivity Analysis: 7 Hrs

Duality theory, Existence of Dual of a LP problem, Economic interpretation of duality Primal Dual relationships in formulation and their solutions, Sensitivity Analysis or Post Optimality Analysis, Dual Simplex Method, Changes affecting feasibility, Changes affecting optimality, Examples

Chapter 4. Transportation Models: 8 Hrs

The transportation algorithm, Formulation as a LP problem, Determination of initial solution, Stepwise improvement to obtain optimal solution, Special cases such as multiple, unbalanced, degeneracy etc. The assignment model, Formulation as a LP problem, The Hungarian method of solution, Examples

Unit III

Chapter 5. Network Models: 5 Hrs

The maximal flow problems, The shortest route problem, The minimal spanning tree problem, Critical Path Method (CPM) and Program Evaluation & Review Technique, Network representation of simple projects, Critical path Crashing of project duration, Examples

Chapter 6. Game Theory: 5 Hrs

Formulation of games, Two-person zero sum game, Dominance property, Games with and without saddle point, Graphical solutions (2 x n, m x 2 game)

Text Books

1. F.S. Hillier and G.J. Lieberman, Introduction to Operations Research, 9th Edn., MGH, India, 2017.
2. H.A. Taha, Operations Research: An Introduction, 10th Edition, Pearson India, 2017.

Reference Books

1. Vohra N. D, Quantitative Techniques in Management, 5th Edition, Mcgraw Higher Ed.,2017
2. R. Panneerselvam, Operations Research, 2nd Edition, Phi Learning Pvt. Ltd, 2009.

Program: Bachelor of Engineering		**Semester: VII**
Course Title: Design of Thermal Systems		**Course Code: 24EMEE402**
L-T-P: 3-0-0	**Credits: 3**	**Contact Hours: 3 Hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 3 Hrs**	

Unit I

Chapter 1. Heat exchangers Classification and Selection: 5 Hrs

Introduction, Recuperation and Regeneration, Transfer process, Geometry and Construction, - Tubular Heat Exchanger, Plate Heat Exchanger, Extended Surface heat exchanger, Heat Transfer Mechanisms, Flow arrangements, Applications and Selection of Heat Exchangers.

Chapter 2. Design of Shell and Tube heat exchanger: 10 Hrs

Construction of shell and tube exchanger, specifications and classification of S&T Heat Exchanger, some Typical operating limits for heat exchangers of S&T Type, Design of Shell and Tube Heat Exchangers.

Unit II

Chapter 3. Condensers: 5 Hrs

Classification of condensers, various types of condensers and their applications, Shell and tube condensers: Analysis and design, special consideration in Reflux Condensers: Flooding, Condensers for mixtures, Waste heat recovery, Sources and Quality of waste heat, Approach to waste Heat Recovery, Charge preheating, Preheating of combustion air, waste Gases, Heat recovery devices, heat pump.

Chapter 4. Modeling of Thermal Equipment: 6 Hrs

Counter flow heat exchanger, Evaporators and Condensers, Heat exchanger effectiveness, Effectiveness of a counter flow heat exchanger, NTU, Pressure drop and pumping power, Numerical Problems.

Chapter 5. Optimization: 4 Hrs

Mathematical representation of optimization problems, A water chilling system, Optimization procedure, Setting up the mathematical statement of the optimization problem.

Unit III

Chapter 6. Lagrange Multipliers: 5 Hrs

The Lagrange multiplier equations, unconstrained optimization, Constrained optimization.

Chapter 7. Dynamic Programming: 5 Hrs

Characteristic of the Dynamic programming solution, Apparently constrained problem, Application of Dynamic programming to energy system problems.

Text Books

1. W.F. Stoecker, Design of Thermal Systems, 3 ed., MGH, 1989.
2. Sarit K. Das., Process heat transfer, Narosa Publishing House 1st Edition, 2005
3. Sadik Kakac, Hongtan Liu, Heat Exchanger Selection, Rating and Thermal Design, 2 ed., CRC, 2002.
4. Robert Goldstick, Albert Thumann, Principles of Waste Heat Recovery, Fairmont Press, 1986,

Reference Books

1. Yogesh Jaluria, Design and Optimisation of Thermal Systems, 2nd ed., CRC Press,2008
2. Hodge B.K., Analysis and Design of Thermal Systems, 1 ed., PHI, 1990.

←BACK TO SEMESTER VII

Program: Bachelor of Engineering		**Semester:** VII
Course Title: Mechanics of Composite Materials		**Course Code:** 25EMEE401
L-T-P: 3-0-0	**Credits:** 3	**Contact Hours:** 3 Hrs/week
ISA Marks: 50	**ESA Marks:** 50	**Total Marks:** 100
Teaching Hours: 40	**Examination Duration:** 3 Hrs	

Unit I

Chapter 1 Introduction to Composite Materials: 5 Hrs

Overview of Composite Materials, basic concept of composite materials, Comparison with conventional materials (metals, ceramics, polymers), Historical development and evolution of composite materials, Need and advantages of composites in modern engineering applications, Matrix materials-polymers, metals and ceramics; Reinforcements, Interfaces-wettability, interactions at the interface, types of bonding at the interface, optimum interfacial bond strength.

Chapter 2 Polymer Matrix Composites: 5 Hrs

Types, characteristics, processing of PMCs, Layup and curing, fabricating process, open and closed mould process, hand layup techniques; structural laminate bag molding, production procedures for bag molding; filament winding, pultrusion, pulforming, thermo-forming, injection molding, blow molding.

Chapter 3 Metal and Ceramic Matrix Composites: 5 Hrs

Types of MMCs, base metals selection; important metallic matrices; processing-liquid state and solid state processes; interfaces in MMCs; Need for production of MMC's and its applications; Types of CMCs, processing of CMCs-cold pressing and sintering, hot pressing, reaction bonding processes, liquid infiltration, directed oxidation, in-situ chemical reaction techniques, sol-gel and polymer pyrolysis, applications of CMCs.

Unit II

Chapter 4 Macro Mechanics of a Lamina: 8 Hrs

Introduction to Lamina and Laminate Theory, Definition of lamina and laminate, Significance of analyzing a single lamina (macro level), Stress-strain behavior in composite lamina, Assumptions in macromechanics analysis, Stress-Strain Relationships in a Lamina, Transformation of Stress, Strain, and Material Properties, Strength Analysis of a Lamina, Failure modes in a lamina (fiber breakage, matrix cracking, delamination), Maximum stress theory, Maximum strain theory, Tsai-Hill failure criterion, Tsai-Wu failure criterion, Design considerations under environmental conditions, Case studies: Behavior of lamina in real-world applications.

Chapter 5 Micro Mechanics of a Lamina: 7 Hrs

Introduction to Micromechanics of Composites, Importance of micromechanics in composite analysis, Scope: Bridging constituent material properties to lamina behavior, Concept of Representative Volume Element (RVE), Geometry and Structure of a Lamina, Mechanical Behavior of Constituents, Elastic behavior of fibers and matrix, Assumptions in micromechanical models (perfect bonding, linear elasticity, etc.), Stress-strain relationships for isotropic vs anisotropic constituents, Longitudinal and Transverse Properties of a Lamina, Strength Properties of a Lamina, Numerical problems.

Unit III

Chapter 6 Macro Mechanics of Laminate: 5 Hrs

Macro Mechanics of Laminate: Introduction, Laminate code, Stress–Strain Relations for a Laminate, Classical Lamination theory, assumptions of CLT, Stress- Strain equation and variation in a laminate, force and moment resultants related to midplane strains and curvatures, Numerical problems.

Chapter 7 Applications: 5 Hrs

Applications in aerospace, automotive, marine, sports, biomedical, and construction, Sustainability aspects and recycling of composites Limitations and challenges in design, manufacturing, and repair, Future trends and innovations in composite materials.

Text Books:

1. Krishan K. Chawla, Composite Materials - Science and Engineering, 3rd Edition, Springer, 2012.

2. Robert M. Jones, Mechanics of Composite Materials, 2nd Edition, Tailor & Francis Inc. 1999.

Reference Books:

1. D. Hull and T. W. Clyne, an Introduction to Composite Materials (Cambridge Solid State Science Series), 2nd Edition, Cambridge University Press, 1996.
2. Autar K. Kaw, Mechanics of Composite Materials, 2nd Edition, CRC Press, Taylor and Francis, 2006.

Program: Bachelor of Engineering		**Semester: VII**
Course Title: Design of Automotive Power Train		**Course Code: 15EMEE402**
L-T-P: 3-0-0	**Credits: 3**	**Contact Hours: 3 Hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 3 Hrs**	

Unit I

Chapter 1 Vehicle Performance Parameters: 5 Hrs

Vehicle drag, power for propulsion, resistances to vehicle motion, traction and tractive effort, relation between engine revolutions and vehicle speed, road performance curves(acceleration, grade ability and drawbar pull), numericals.

Chapter 2 General Considerations in Engine Design: 5 Hrs

General Design Consideration, Selection of type: Process, Cycle, Number of Cylinders, Arrangement of Cylinders, Single and Double acting, Engine Speed, Piston Speed, Stroke to Bore Ratio.

Chapter 3 Cylinder, Cylinder Head and Piston: 5 Hrs

Function, construction, materials and design of cylinder, cylinder head and piston, piston pin and piston rings.

Unit II

Chapter 4 Connecting Rod and Crankshaft: 5 Hrs

Function, construction, materials and design of connecting rod, design of crankshaft and its types.

Chapter 5 Flywheel: 5 Hrs

Function, construction, material, types. Stresses in flywheel rim and arms. Design of flywheel.

Chapter 6 Power Transmission- Manual Gearbox: 5 Hrs

Necessity of gear box, Sliding mesh gear box, Constant mesh gear box, Synchromesh gearbox, gear synchronization and engagement.

Unit III

Chapter 7 Power Transmission- Automatic Gearbox: 5 Hrs

Architecture, fundamental design and operation principles of Torque convertors, Epicyclic gear trains and Dual Clutch Transmission.

Chapter 8 Power Transmission- Drive Shaft, Final Drive and Differential: 5 Hrs

Construction & types of propeller/drive shafts, Final drive, Differential-principle, open and non-slip differentials, differential lock. Electronic limited slip differential. Four wheel drive arrangements.

Text Books

1. Dr. N.K. Giri, Automotive Mechanics, 8th Edition, Khanna Publication, New Delhi, 2008.
2. Sharma and Aggarwal, Machine Design, 12th Edition, S.K. Kataria & Sons, New Delhi, 2012.

Reference Books

1. Heinz Heisler, Advanced Vehicle Technology, 2nd Edition, Butterworth Heinemann, 2002.
2. Heywood, John B. Internal Combustion Engine Fundamentals, McGraw-Hill, New York 1988.

Program: Bachelor of Engineering		**Semester:** VII
Course Title: Design and Analysis of Experiments		**Course Code:** 25EMEE403
L-T-P: 2-1-0	**Credits:** 3	**Contact Hours:** 4 Hrs/week
ISA Marks: 50	**ESA Marks:** 50	**Total Marks:** 100
Teaching Hours: 30 + 24	**Examination Duration:** 2 Hrs	

Unit I

Chapter 1. Introduction to DAE 5 Hrs

Need for Research, Need for Design of Experiments, Experimental Design Techniques, Applications of Experimental Design.

Chapter 2. Taguchi's approach to quality 5 Hrs

Taguchi's Approach to Quality and Quality loss function, Noise Factors and Average Quality Loss, Exploiting Non Linearity, Classification of Parameters, Exercises.

Chapter 3. Analysis of Variance 5 Hrs

Test of Hypothesis using t-test, Z –test, Chi square and F-tests, No-Way and One-Way ANOVA, Exercises.

Unit II

Chapter 4. Full Factorial Design of Experiments 5Hrs

Two-Factor Complete Factorial Experiments, Complete Factorial experiment with Three Factors and 2^n Factorial Experiments Exercises.

Chapter 5. Fractional Factorial Designs 5 Hrs

Half Fraction of 2^2 Factorial Experiments, Half Fraction of 2^3 Factorial Experiments, Half Fraction of 2^4 Factorial experiments, Exercises, Central Composite Design and Box-Behnken Design, Case Studies.

Chapter 6. Robust Design 5 Hrs

Control Factors and their Levels, Matrix Experiment and Data Analysis Plan; Conducting the Experiment using Orthogonal Array and Data analysis, Relationship between Signal to Noise Ratio and quality loss after adjustment, Signal to Noise Ratios for static problems, Signal to Noise Ratios for dynamic problems.

Experiments	No. of sessions
1. Introduction to Minitab and problem solving using Minitab.	02
2. One Way ANOVA, Two Way ANOVA and constructing factorial designs in Minitab.	04
3. Analyzing Factorial designs, Yate's algorithms and construction of statistical plots.	03
4. Case studies on Robust design, S/N ratios for product/process optimization.	03

Text Books

1. D.C.Montgomery, Design and Analysis of Experiments- John Wiley and Sons.
2. Madhav S. Phadke, Quality Engineering using Robust Design- Prentice Hall PTR, Englewood Cliffs,
3. R Panneerselvam, Design and Analysis of Experiments- PHI Learning Private Limited,New Delhi.

Reference Books:

1. Robert H. Lochner and Joseph E. Matar, Designing for Quality- an Introduction Best of Taghuchi and Western Methods or Statistical Experimental Design- Chapman and Hall.
3. P.J.Ross, Taghuchi Techniques for Quality Engineering- McGraw Hill, New York.

←BACK TO SEMESTER VII

Program: Bachelor of Engineering		**Semester: VII**
Course Title: Dynamics & Durability of Vehicles		**Course Code: 19EMEE401**
L-T-P: 0-0-3	**Credits: 3**	**Contact Hours: 6 Hrs/week**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hours: 80	**Examination Duration: 2 Hrs**	

	PART A (Dynamics of Vehicles)	
Sl. No	**Content**	**Teaching Hours**
1	Introduction - Kinematics & Compliance in vehicles;	02
2	Introduction to Roads and Loads;	02
3	Introduction to Durability in industry;	02
4	Data and Assumptions for multi-body systems - quality control;	03
5	Loads mapping for downstream use with examples;	03
6	Example applications using Multi-Body Dynamic Systems;	03
7	Introduction - Flex Body;	02
8	Durability example with and without Flex body;	03
9	Control systems in Multi-Body;	04
	Hands on Session	
1	Build a 2/3-wheeler suspension system to carry out K&C	08
2	Build a 3-wheeler suspension system to carry out loads extraction for durability	08
	PART B (Durability of Vehicles)	
1	Conduction, Convection, Steady state, Transient flows, Turbulence and its significance	03
2	Importance of BTMS, Current state of thermal management in EV	03
3	Types of battery packs for xEV	02
4	Heat load calculation for battery packs	02
5	How to approach design assessment of power pack for thermal management	02
6	Importance of data & assumptions (includes baselining)	02
7	Example case of using AcuSolve to assess a design	03
8	How to improve the thermal performance of a power pack design	02
9	Importance of Drag co-eff for vehicles moving at high speeds	02
10	Fast assessment of A-Surface design for drag using VWT	02
11	Introduction to thermal management in electronic circuits	03
	Hands on Session	
1	Assume 2 different designs and compare the thermal performance	07
2	Prepare 2 vehicle designs (external surface) and compute drag	07

Text Books

1. Dr. N.K. Giri, Automotive Mechanics, 8thEdition,2008, Khanna Publication, New Delhi.
2. Nitin Ghokale, Practical finite element analysis, Finite to infinite, 2008.
3. Practical Aspects of Structural Optimization, Altair University, 3rd Edition.
4. Robin Hardy, Iqbal Husain, "Electric and Hybrid Vehicles". CRC Press, ISBN 0-8493-1466-6.
5. Ron Hodkinson and John Fenton, "Lightweight Electric/ Hybrid Vehicle Design". SAE International
6. John M. Miller, Propulsion Systems for Hybrid Vehicles" Institute of Electrical Engineers, London, ISBN0 863413366.

<table>
<tr><td colspan="2">7. Automobile Electrical and Electronic systems, Tom Denton, Third Edition, 2004, SAE International, SAE ISBN 0 7680 147 2, Society of Automotive Engineers. Inc 400 common wealth Drive, Warrendale, PA 15096-0001 USA.</td></tr>
<tr><td colspan="2">Reference Books:</td></tr>
<tr><td colspan="2">PROJECTS:</td></tr>
<tr><td colspan="2">Part A</td></tr>
<tr><td colspan="2">Objective: To carry out Dynamic and Durability of different chassis</td></tr>
<tr><td>Sl. No.</td><td>Content</td></tr>
<tr><td>01</td><td>Compare durability of conventional ICE chassis with Electric version</td></tr>
<tr><td colspan="2">Part B</td></tr>
<tr><td colspan="2">Objective: To carry out to analyze the heat produced during EV operation and streamline external airflow</td></tr>
<tr><td>Sl. No.</td><td>Content</td></tr>
<tr><td>01</td><td>Compute Delta T for a chosen EV battery pack</td></tr>
<tr><td>02</td><td>Improve drag performance of a chosen external vehicle element</td></tr>
</table>

Program: Bachelor of Engineering		Semester: VII
Course Title: Operations Management		Course Code: 15EMEE405
L-T-P: 3-0-0	Credits: 3	Contact Hours: 3 Hrs/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 40	Examination Duration: 3 Hrs	

Unit I

Chapter 1. Operations management & operations decision making: 8 Hrs

Introduction, importance of operations management in manufacturing and service industries, Competitiveness, Strategy, Productivity, Factors affecting productivity. The environment of operations, Location Planning and Analysis, Characteristics of decisions, framework for decision-making, decision methodology, decision support systems, economic models and statistical models. Numericals

Chapter 2. Forecasting: 4 Hrs

Forecasting objectives and uses, steps in forecasting process, opinion and judgmental methods, time series methods, exponential smoothing, regression and correlation methods, application and control of forecasts. Numericals

Chapter 3. Aggregate planning and master scheduling: 4 Hrs

Introduction- Planning and scheduling, objectives of aggregate planning and Aggregate planning methods, master scheduling objectives, master scheduling methods, Numericals

Unit II

Chapter 4. MRP and ERP: 4 Hrs

Overview: MRP and CRP, MRP: Underlying concepts, System parameters, Benefits and requirements of MRP, MRP logic, MRP Processing, Capacity management, and CRP activities. MRP, MRP-II and ERP,Numericals

Chapter 5. Scheduling, single machine scheduling & flow –shop & Job shop scheduling: 12 Hrs

Production activities, PAC objectives and data requirements, concept, measures of performance, SPT rule, Weighted MFT, EDD rule, minimizing the number of tardy jobs. Numerical problems, Johnson's rule for 'n' jobs on 2 and 3 machines. Numericals.

Job-shop scheduling: Types of schedules, heuristic procedure, scheduling 2 jobs on 'm' machines. Numericals

Unit III

Chapter 6. Lean manufacturing: 4 Hrs

Introduction, Japanese concept of continuous improvement (Kaizen), innovation concept of improvement, need for continuous improvement, steps in implementing continuous improvement, 5S principles, Lean Tools, Lean Services, Lean manufacturing history.

Chapter 7. Just in time- an introduction: 4 Hrs

Spread of JIT movement, the new production system research association of Japan, core Japanese practices of JIT, creating continuous manufacture, Enabling JIT to occur, basic element of JIT, benefits of JIT.

Text Books

1. William J Stevenson "Operations Management" Mc Graw Hill,2018,12th Edition
2. Krajewski E. J. and Ritzman, 'Operations Management', Strategy and Analysis, Pearson Education, 2018.

Reference Books

1. Monks, J.G., Operations Management, McGraw-Hill International Edition, 1987.
2. Pannerselvam. R., Production and Operations Management, Prentice Hall India, 2003
3. Chary, S.N., 'Production and Operations Management', Tata-McGraw Hill, 2004
4. Nicholas J. Aquilano, 'Fundamental of Operations Management', Irwin/McGraw-Hill; 4th edition.

Program: Bachelor of Engineering		Semester: VII
Course Title: Supply Chain Management		Course Code: 15EMEE406
L-T-P: 3-0-0	Credits: 3	Contact Hours: 3 Hrs/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 40	Examination Duration: 3 Hrs	

Unit I

Chapter 1. Understanding Supply Chain: 5 Hrs

Meaning of SCM, Supply chain stages, Decision phases in supply chain (SC), Process view of SC, Examples of supply chain, Competitive and supply chain strategies, Achieving Strategic Fit and Expanding Strategic Scope.

Chapter 2. Supply Chain Drivers and Metrics: 5 Hrs

Drivers of SC performance, framework for structuring drivers, Facilities, Transportation, Information, Inventory, Obstacles to achieve Strategic Fit.

Chapter 3. Designing the Supply Chain Network: 5 Hrs

Role of distribution in SC, Factors influencing distribution network design, Design options for a distribution network, Role of network design in SC, Factors influencing network design decisions.

Unit II

Chapter 4. Sourcing in Supply Chain: 5 Hrs

Role of sourcing in SC, Supplier scoring and assessment, Supplier selection and assessment, Design collaboration.

Chapter 5. Transportation in Supply Chain: 5 Hrs

Role of transportation in SC & factors affecting transportation decisions, Modes of transportation and their performance characteristics, Design options for a transportation network, Trade-offs in transportation design, Tailored transportation.

Chapter 6. Co-ordination in Supply Chain: 5 Hrs

Lack of SC Co-ordination & the Bullwhip Effect, Effect of lack of co-ordination on performance, Obstacles to co-ordination in the SC, Managerial levers to achieve co-ordination, Building a strategic partnership & trust within a supply chain and spot customers.

Unit III

Chapter 7. Role of Technology in Supply Chain: 5 Hrs

Role of IT in supply chain, Supply chain IT framework, Customer Relationship Management, Internal SCM, SRM.

Chapter 8. Emerging Concepts in Supply Chain: 5 Hrs

Role of E-Business in SC, E-Business frame work, Reverse Logistics; Reasons, Activities, Role, RFID Systems; Components, applications, implementation.

Text Books

1. Sunil Chopra and Peter Meindl'Supply Chain Management – Strategy, Planning and Operation, II ed 2003, Pearson Education Inc. ISBN: 81-297-0172-3.
2. Douglas Lambert and James Stock, Strategic Logistics Management", ', IV Ed, Irwin MGH ISBN: 0-07-118122-9.

Reference Books

1. Michael Hugos, 'Essentials of Supply Chain Management, ', Ed 2003, John Wiley and Sons.
2. Robert B. Handfield and Ernest L. Nichols, Supply Chain Redesign-Transforming Supply Chain into Integrated Value Systems, ed 2002, Pearson Education Inc. ISBN: 81- 297-0113-8.
3. Jeremy F. Shapiro and Duxbury, Modeling the Supply Chain", Ed 2002, Thomson Learning. ISBN: 0-534-37363.
4. Kapoor, Marketing Logistics: A Supply Chain Approach", Pearson Education Pvt Ltd. ISBN-8129702444.

Program: Bachelor of Engineering		**Semester: VII**
Course Title: Modern Trends in Manufacturing		**Course Code: 15EMEE417**
L-T-P: 3-0-0	**Credits: 3**	**Contact Hours: 3 Hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 3 Hrs**	

Unit I

Chapter 1. Systematic Approach for Manufacturing Strategy: 4 Hrs

Seven Losses Regarding Productivity and Profitability, Feasibility Study of Productivity Improvement, Four Levels of Manufacturing Strategy.

Chapter 2. Management and Productivity in Engineering: 8 Hrs

Definition of Engineering, Management and Management Engineering, Industrial Engineering and Productivity, Necessity of Facts and Work Measurement.

Productivity, Purpose of Productivity Improvement, Engineering Approach for Productivity, Three Levels of Improvement, Points of Successful Productivity, Relationship of Methods, Performance, and Utilization to Standard Time.

Chapter 3. Concurrent Engineering: 3 Hrs

Introduction, importance of CE, building blocks of CE, Important factors in concurrent engineering process, communication models, benefits and its tools.

Unit II

Chapter 4. Continuous Process Improvement: 8 Hrs

Introduction, Japanese concept of continuous improvement (kaizen), innovation concept of improvement, need for continuous improvement, tools for continuous improvement, steps in implementing continuous improvement, three pillars of continuous improvement, standardization, quality circles, suggestion systems, kaizen and management, kaizen umbrella, TPM, Six sigma, FMEA and discussion of few case studies.

Chapter 5. Pull Production Systems: 7 Hrs

Introduction to TPS, KANBAN system, difference between pull and push system, other types of kanban, kanban rules, adapting to fluctuation in demand through kanban, a detailed kanban system example, supplier kanban and sequence schedule for kanban.

Unit III

Chapter 6. Quality Management Systems: 5 Hrs

Need for ISO 9000 and Other Quality Systems, ISO 9000:2000 Quality System – Elements, Implementation of Quality System, Documentation, Quality Auditing, QS 9000, ISO 14000 –Concept, Requirements and Benefits. Occupational Health & Safety Management (OSHAS -18001) standards, Environmental Management Certification (ISO 14001) and its benefits to stakeholders.

Chapter 7. Six sigma: 5 Hrs

Principles of Six sigma, project selection for six sigma, six sigma problem solving, design for six sigma, six sigma in service and small organization, six sigma and lean production, statistical thinking and application, statistical foundation, statistical methodology, design of experiments, analysis of variances

Text Books

1. Masaki Imai, ‘KAIZEN’, McGraw Hill International.
2. Shigeyasu Sakamoto, "Beyond World-Class Productivity", Springer-Verlag London Limited 2010.
3. Dale H. Besterfield, "Total Quality Management", Pearson Education, Asia.

Reference Books

1. Richard J. Schonberger, ‘Japanese Manufacturing Techniques’, the Free Press – Macmillan Publication.
2. James R. Evans and William M. Lindsay, ‘The Management and Control of Quality’.

Program: Bachelor of Engineering		**Semester: VII**
Course Title: Computational Heat Transfer and Fluid Flow		**Course Code: 15EMEE407**
L-T-P: 3-0-0	**Credits: 3**	**Contact Hours: 3 Hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 3 Hrs**	

Unit I

Chapter 1. Computational Fluid Dynamics (CFD) Solution Procedure: 7 Hrs

CFD applications in Research and Design, CFD Problem set-up-Creation of geometry, Mesh generation, Specification of boundary conditions. CFD Solver- Initialization and Convergence monitoring. Post Processor-Plots, data reports and Animation

Chapter 2. Governing Equations for CFD: 8 Hrs

Continuity Equation, Momentum Equation, Energy Equation- Physical Interpretation and comments. The additional equations for turbulent flow, Generic form of Governing equations, Physical Boundary conditions

Unit II

Chapter 3. CFD Techniques: 7 Hrs

Discretization of Governing Equations- Finite difference method, Finite volume method, Converting governing equations into algebraic equations, Direct and Iterative solutions, Pressure- velocity coupling- SIMPLE scheme

Chapter 4. CFD Solution Analysis: 8 Hrs

Consistency, Stability, Convergence, Accuracy and Efficiency of CFD solutions. Accelerating convergence, controlling solution errors, verification and Validation. Case studies related to fluid flow through channel and pipe bend

Unit III

Chapter 5. Practical Guidelines for CFD Simulation and Analysis: 5 Hrs

Grid generation- Guidelines on grid quality and grid design, Local refinement and solution adaption. Guidelines on Boundary conditions– Setting inlet, outlet and wall boundary conditions. Symmetric and Periodic Boundary conditions. Turbulence Modelling- Approaches, selection strategies, Case study: modeling of hydrofoil flows

Chapter 6. Advanced Topics in CFD: 5 Hrs

Advances in Numerical methods and Techniques- Moving grids, Multigrids, Parallel Computing and Immersed boundary methods. Advances in computational models- Direct numerical Simulation (DNS), Large Eddy Simulation (LES), RANS-LES, Lattice Boltzmann method, Monte-Carlo method, Particle methods

Text Books

1. Jiyuan Tu, Guan Heng Yeoh, Chaoqun, Computational Fluid Dynamics, Butterworth- Heinemann, 1st Edition 2008
2. Dale A. Anderson, John C. Tannehill and Richard H. Platcher. Computational Fluid Mechanics and Heat Transfer; McGraw Hill Book Company, 2001

Reference Books

1. Suhas V. Patankar, Numerical Fluid flow and Heat transfer, Hemisphere Series on Computational Methods in Mechanics and Thermal Science, 2nd Edn. 2000
2. Joel H. Ferziger and Milovan Peric, Computational Methods for Fluid Dynamics, 3rd Edition, Springer-Verlag, Berlin, 2001
3. Anderson J D, Computational Fluid Dynamics- The Basics with Applications, MGH, 2nd Ed. 2001

Program: Bachelor of Engineering		**Semester: VII**
Course Title: Fundamentals of Gas Turbines		**Course Code: 15EMEE408**
L-T-P: 3-0-0	**Credits: 3**	**Contact Hours: 3 Hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 3 Hrs**	

Unit I

Chapter 1. Principles of Gas Turbine and Applications: 4 Hrs

Introduction to turbo machines, history of gas turbines, gas turbine cycles and applications – (Land, Water/Marine and Air/Aero) Components of Gas Turbines (Compressors, Combustors, Turbines, Exhaust systems). Working of Gas Turbines.

Chapter 2. Compressor: 7 Hrs

Types of compressors, (Centrifugal and Axial), relative merits and demerits, Criteria for selecting type of compressors.

Centrifugal Compressors: Principle of operation, work done and pressure rise diffuser, compressibility effects, compressor characteristics and design procedures.

Axial Flow Compressor: Basic operations, elementary theory, factors affecting stage pressure ratio, Blockage in the compressor annulus, effect of compressibility, pre-whirl, supersonic flow, degree of reaction, design process, blade design, calculation of stage performance, off-design performance.

Chapter 3. Fuel System: 4 Hrs

Fuel specifications, Properties, Manual and automatic control, Fuel control systems, Fuel spray nozzles, Fuel heating, Effect of a change of fuel, Gas turbine fuels, Fuel requirements, Vapor locking and boiling, Fuel contamination control.

Unit II

Chapter 4. Combustion System: 5 Hrs

Introduction, Combustion process, Enthalpy of formation, Fuel supply, Types of combustion chamber, Can-annular combustion chamber, Tube-annular combustion chamber, Annular combustion chamber, Combustion chamber performance, Combustion intensity, Combustion efficiency, Combustion stability Emissions, Materials.

Chapter 5. Axial Flow Turbines: 5 Hrs

Types of Turbines, spool shafts in aero engines, Advantages and disadvantages, Turbine geometry, Thermodynamic and Aerodynamic theory, velocity diagrams, Impulse turbine, turbine blade cooling. Exhaust System: Introduction, Exhaust gas flow, environmental considerations, construction and materials.

Chapter 6. Prediction of Performance of Simple Gas Turbines: 5 Hrs

Component characteristics, off design operation of the single shaft gas turbine, off-design operation of free turbine engine.

Unit III

Chapter 7. Cooling, Seals and Lubrication System: 5 Hrs

The cooled turbine, methods of blade cooling, Seals: Non contacting seals - labyrinth seals, ring seals, Mechanical seals, Seal system, and dry gas seals, attrition coatings. Lubrication Systems: Basic oil system, lubrication management program, selection, oil contamination, filter selection, cleaning and flushing, oil sampling and testing

Chapter 8. Materials of Gas turbine and Maintenance: 5 Hrs

Introduction, Super alloys-Nickel based iron-nickel, Cobalt, Thermal barrier coating for jet engine alloys, advanced materials for jet engines. Maintenance: Introduction, On-wing maintenance, Scheduled maintenance, Unscheduled maintenance, Condition monitoring, Flight deck indicators, In-flight recorders, Ground indicators, Maintenance precautions, Trouble shooting, Adjustments, Ground testing.

Text Books:

1. Rolls Royce - “The Jet Engine” 5th edition, ISBN 0 902121 2 35,© Rolls-Royce plc 1986
2. Saravanamutto H.I.H, Rogers G.F.C., Cohen H, Gas Turbine Theory, 5th Edn., Pearson 2006

Reference Books

1. Meherwan P. Boyce “Aircraft Propulsion and Gas Turbine Engines”, CRC press, Taylor and Francis Group, London New York.ISBN 978-0-8493-9196-5
2. Meherwan P. Boyce “Gas Turbine Engineering Handbook (Fourth Edition)”, 2012, Elesevier, ISBN-978-0-12-383842-1

←BACK TO SEMESTER VII

Program: Bachelor of Engineering		**Semester: VII**
Course Title: Optimization Methods		**Course Code: 24EMEE408**
L-T-P: 1-0-2	**Credits: 3**	**Contact Hours: 5 Hrs/week**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hours: 65	**Examination Duration: 2 Hrs**	

Chapter 1. Introduction to Optimization: 10 Hrs

Introduction, Engineering Applications of Optimization, Optimization Techniques, Classification of Optimization Problems, Tool.

Chapter 2. Analysis, Connection definition, Model Simplification: 8 Hrs

Chapter 3. Topology Optimization: 8 Hrs

Introduction to Topology Optimization, Design Space, Shape Controls, Displacement Constraints

Run Optimization –Topology, Shape Explorer –Topology, Maximize Stiffness Results, Minimize Mass Results

Chapter 4. Topography Optimization: 8 Hrs

Introduction to Topography Optimization, Topography Optimization Setup, Shape Controls, Bead Patterns

Run Optimization –Topography, Exporting Topography Results, Analysing & Comparing Topography Results

Chapter 5. Gauge Optimization: 4 Hrs

Introduction to Gauge Optimization, Run Optimization –Gauge, Analysing & Comparing Gauge Results

Chapter 6. Fastener Optimization, Lattice Optimization: 8 Hrs

Introduction to Fastener Optimization, Introduction to Lattice Optimization

Run Optimization –Lattice, Lattice Properties , Lattice Diameter Result Type, Smooth Lattice ,Lattice Results

Chapter 7. Motion Analysis Introduction : 14 Hrs

Inspire Motion Overview , Workflow, Geometry handling, Moving and ground parts, Rigid Groups , Joints, Actuators ,Motors, Using Table Data as input, Springs /Dampers, Gravity, Using Inspire Structures Features with motion, Analyze motion Animating results, Plotting results , Tracers , Running Optimization from motion loads and results, Exporting to Motion View

Chapter 8. Manufacturing Analysis Introduction: 5 Hrs

Introduction to Manufacture, Casting and stamping simulation

Reference Books

1. Engineering Optimization Theory and Practice, Fourth edition, S. S. Rao, by John Wiley & Sons, Inc.
2. Practical_ Aspects_ of_ Optimization_ with_ Altair_ OptiStruct by Altair Engineering
3. Simulation_ Driven_ Design_ with_ Inspire by Altair Engineering

←BACK TO SEMESTER VII

Program: Bachelor of Engineering		**Semester: VII**
Course Title: HVAC Systems		**Course Code: 24EMEE405**
L-T-P: 3-0-0	**Credits: 3**	**Contact Hours: 3 Hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 3 Hrs**	

Unit I

Chapter 1. Introduction to HVAC Systems and Psychrometry: 8 Hrs

Purpose, applications, definition and components of air conditioning - Need and methods of ventilation. Evolution of air properties and psychrometric chart - Basic processes such as sensible heating/cooling, humidification/dehumidification and their combinations, steam and adiabatic humidification, adiabatic mixing, etc. - Bypass factor and Sensible heat ratio, Numerical problems.

Chapter 2. Human Comfort & Indoor Air Quality: 4 Hrs

Heat transfer from body, convection, radiation, conduction, evaporation, clothing resistance, activity level - Concept of human comfort - Thermal response - comfort factors - Environmental indices - Indoor air quality.

Chapter 3. Summer and Winter AC Systems and Equipment: 4 Hrs

Simple summer AC process, Room sensible heat factor, Coil sensible heat factor, ADP - Precision AC - Winter AC. Classification of air conditioning systems, Filters, types, efficiency – Fan laws, cooling coils and heating coils, sizing and off design performance - Cooling and dehumidifying coil, dry and wet, sizing, performance.

Unit II

Chapter 4. Heat Transfer: 3 hrs

Heat transfer in wall and roof, sol-air temperature, insulation, cooling load temperature difference - Fenestration, types of glass, sun shade, shading coefficient, maximum radiation, cooling load factor

Chapter 5. Cooling load and heating load estimation: 7 hrs

Thermodynamics of human body and mathematical model, Human comfort chart, Design conditions, outdoor, indoor - External load, wall, roof, glass - Internal load, occupancy, lighting, equipments - Ventilation, air quantity, loads - Load estimation methods. Vapour transfer in wall, vapour barrier, load estimation basics.

Introduction to AutoCAD REVIT software

Chapter 6. Air distribution, diffusion and Ventilation: 6 hrs

Ducts, types, energy equation for pipe flow, friction chart, methods of sizing, air distribution systems, ADPI, outlet/inlet selection.

Need, threshold limits of contaminants, estimation of ventilation rates, decay equation, air flow round buildings, Natural, wind effect, stack effect, combined effect - Mechanical, forced, exhaust, combined - Displacement ventilation

Unit III

Chapter 7. Ventilation system design: 4 hrs

Exhaust ducts, filters, blowers, hoods, chimney, etc.

Chapter 8. Industrial ventilation: 4 hrs

Steel plants, car parks, plant rooms, mines, etc.

Text Books

1. Faye C. McQuiston, Jerald D. Parker, Jeffrey D. Spitler, Heating, Ventilating and Air Conditioning: Analysis and Design, 6th Edition, July 2004,
2. W P Jones, Air Conditioning Engineering ELBS 3rd edn Edward Arnold (Publishers) ltd. London.

Reference Books

1. Harris, Modern Air Conditioning Practice 3nd Edn McGraw Hill Book Company
2. S. N. Sapali, Refrigeration and air conditioning 2nd Edn, PHI learning pvt ltd, Delhi 2016
3. C P Arora, Refrigeration and air conditioning 3rd edn

Program: Bachelor of Engineering		**Semester: VII**
Course Title: Design of Jigs, Fixtures and Press Tools		**Course Code: 24EMEE404**
L-T-P: 2-0-1	**Credits: 3**	**Contact Hours: 4 Hrs/week**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hours: 30	**Examination Duration: 3 Hrs**	

Unit I

Chapter 1. Principles of Jigs & Fixtures: 04 Hrs

Objectives of tool design, Function and advantages of Jigs and fixtures, Basic elements - principles of location, Locating methods and devices, Redundant Location, Principles of clamping, Mechanical actuation – pneumatic and hydraulic actuation, Standard parts – Drill bushes and Jig buttons, Tolerances and materials used.

Chapter 2. Design and development of jigs and fixtures: 08 Hrs

Types of Jigs – Post, Turnover, Channel, latch, box, pot, angular post jigs, Indexing jigs, General principles of milling, Lathe, boring, broaching and grinding fixtures, Assembly, Inspection and Welding fixtures, Modular fixturing systems, Quick change fixtures.

Unit II

Chapter 3. Press Working Terminologies and Elements of Cutting Dies: 06 Hrs

Press Working Terminologies – operations, Types of presses – press accessories, Computation of press capacity, Strip layout, Material Utilization, Shearing action, Clearances, Press Work Materials, Center of pressure, Design of various elements of dies, Die Block – Punch holder, Die set, guide plates, Stops – Strippers – Pilots, Selection of Standard parts, Design and preparation of four standard views of simple blanking, piercing, compound and progressive dies.

Chapter 4. Bending and Drawing Dies: 06 Hrs

Difference between bending and drawing – Blank development for above operations, Types of Bending dies, Press capacity, Spring back – knockouts – direct and indirect – pressure pads, Ejectors, Variables affecting Metal flow in drawing operations – draw die inserts – draw beads ironing, Design and development of bending, forming, drawing, reverse redrawing and combination dies, Blank development for axisymmetric, rectangular and elliptic parts, Single and double action dies.

Unit III

Chapter 5. Other Forming Techniques: 06 Hrs

Bulging, Swaging, Embossing, coining, curling, hole flanging, shaving and sizing, assembly, fine Blanking dies – recent trends in tool design, Computer aids for sheet metal forming analysis – basic introduction - tooling for numerically controlled machines- setup reduction for work holding, Single minute exchange of dies – Poka Yoke.

Hands-on activities	**No. of sessions**
1. Design the different types of jigs (channel jig, leaf jig, etc.) for a given application.	04
2. Design various fixtures (milling, welding, etc.) for a given component.	04
3. Design press tools for the given component.	04

Text Books

1. Joshi P. H., “Jigs and Fixtures”, 3rd edition, McGraw Hill Education, 2017.
2. Joshi P. H., “Press Tools Design and Construction”, 23rd edition, S Chand & Company, 2017.

Reference Books

1. John Nee, “Fundamentals of Tool Design”, 6th edition, Society of Manufacturing Engineers, 2010.
2. Frank W. Wilson, “Fundamentals of Tool Design”, Prentice Hall, 1962.
3. K. Venkataraman, “Design of Jigs, Fixtures and Press Tools”, John Wiley & Sons Ltd., 2015.

Program: Bachelor of Engineering		**Semester: VII**
Course Title: Facets of Project Analysis		**Course Code: 24EMEE407**
L-T-P: 2-0-1	**Credits: 3**	**Contact Hours: 4 Hrs/week**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hours: 30	**Examination Duration: 2 Hrs**	

Unit I

Chapter 1. Planning Overview and Resource Allocation:6 Hrs

Phases of capital investments, levels of decision making, facets of project analysis, concept of strategy, diversification debate, portfolio strategy, generation and screening of project ideas, related blogs.

Chapter 2. Market and Demand Analysis: 8 Hrs

Situational analysis and specification of objectives, collection of secondary information, conduct of market survey, characterization of market, demand forecasting, marketing plan, related blogs.

Unit II

Chapter 3. Technical Analysis: 8 Hrs

Manufacturing process/technology, technical arrangements, material inputs and utilities, product mix, plant capacity, location and site, machineries and equipment, structures and civil works, environmental aspects, project charts and layouts, related blogs.

Chapter 4. Financial and Related Analysis: 8 Hrs

Costs of project, means of finance, estimates of sales and production, cost of production, projected cash flow statements, time value of money, project risk analysis, economic and ecological analysis, related blogs.

Experiments	No. of sessions
1. Collaborations for a Turnkey Project using PLM Approach – 10 Hrs Managing workspace for a feasibility study, routes for portfolio strategies, issue management and common document model approach during market and demand analysis, case studies.	05
2. Managing Technical Analysis using PLM approach – 10 Hrs Create and manage libraries, class and groups for a chosen project, generate and track changes, work on issues and baselines, monitor the projects, execute project, case studies	05
3. Managing Financial Analysis using PLM approach – 4 Hrs Risk management, managing resources, budgets and benefits using advanced project management, case studies.	02

Reference Books

1. Prasanna Chandra, "Projects: Planning, Analysis, Financing, Implementation and Review", CFM – MHE Professional Series, McGraw Hill Education, 8th Edition, 2014
2. Stark John, "Product Lifecycle Management: 21st Century Paradigm for Product Realization", Springer, Third Edition, 2015
3. Kerzner, Harold. *Project management: a systems approach to planning, scheduling, and controlling*. John Wiley & Sons, 2017.

← BACK TO SEMESTER VIII

Program: Bachelor of Engineering		**Semester: VIII**
Course Title: Internship – Training		**Course Code: 18EMEI493**
L-T-P: 0-0-6	**Credits: 6**	**Contact Hours: ---**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hours: ---	**Examination Duration: 3 Hrs**	

Internships are educational and career development opportunities, providing practical experience in a field or discipline. They are structured, short-term, supervised placements often focused around particular tasks or projects with defined timescales.

An internship may be compensated, non-compensated or some time may be paid. The internship has to be meaningful and mutually beneficial to the intern and the organization. It is important that the objectives and the activities of the internship program are clearly defined and understood. Following are the intended objectives of internship training:

- Will expose Technical students to the industrial environment, which cannot be simulated in the classroom and hence creating competent professionals for the industry.
- Provide possible opportunities to learn, understand and sharpen the real time technical / managerial skills required at the job.
- Exposure to the current technological developments relevant to the subject area of training.
- Experience gained from the 'Industrial Internship' in classroom will be used in classroom discussions.
- Create conditions conducive to quest for knowledge and its applicability on the job.

Program: Bachelor of Engineering		**Semester: VIII**
Course Title: Capstone Project		**Course Code: 20EMEW402**
L-T-P: 0-0-11	**Credits: 11**	**Contact Hours:**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: ---	**Examination Duration: 3 Hrs**	

An academic capstone project is a comprehensive project that culminates a student's academic and intellectual experience. Most commonly, capstone projects are carried out during their final year of school or during the end of an academic program.

The purpose of this project is to prepare students for future career challenges. Even the topics students are assigned (or even choose for yourself) are designed to help students analyze real-life problems and come up with suitable solutions to them, thus contributing to their wisdom, knowledge, and problem-solving abilities. In the process of researching a solution to the problem students intend to solve for their capstone project, students will also gain insight into the latest trends in their field.

←BACK TO SEMESTER VIII

Program: Bachelor of Engineering		**Semester: VIII**
Course Title: Internship - Project		**Course Code: 20EMEW494**
L-T-P: 0-0-11	**Credits: 11**	**Contact Hours: ---**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: ---	**Examination Duration: 3 Hrs**	

An internship is an experiential academic experience in which a student has intentional learning goals/objectives with measurable outcomes. These learning goals/objectives may include:

- *Academic Learning:* the student may apply and test knowledge learned in the classroom to a professional work environment.
- *Career Development:* the student may explore a specific field of interest, expand his or her professional network and gain and understanding of the qualifications and duties involved in a specific profession or career field.
- *Skill Development:* the student gains an understanding of the transferable skills and knowledge required for success in a professional work environment and integrates those skills in their academic learning.
- *Personal Development:* the student gains decision-making skills, self-confidence, business savvy, ethics, and teamwork required for success in a professional work environment.

An internship is designed as an exchange. The student agrees to complete work that will benefit the host organization and in return is offered the opportunity to learn new skills, expand his or her knowledge of a particular field and explore career options. Employers offer internships for many reasons. They see student interns as fruitful and economical resources with which they can accomplish projects not otherwise possible. They believe interns bring enthusiasm and new ideas into work settings and make strong employees. Just as importantly, employers feel an increasing commitment to education and want to help train students to assume responsible roles in society.

←BACK TO SEMESTER VIII

Program: Bachelor of Engineering		**Semester: VIII**
Course Title: Aircraft Systems and Design		**Course Code: 15EMEE413**
L-T-P: 3-0-0	**Credits: 3**	**Contact Hours: 3 Hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 3 Hrs**	

Unit I

Chapter 1. Aircraft industry overview: 3 Hrs

Evolution and History of Flight, Types Of Aerospace Industry, Key Players in Aerospace Industry, Aerospace Manufacturing, Airline deregulation, Structure of the industry, Airline economics, Aircraft design process, Aerospace Industry Trends.

Chapter 2. Introduction to Aircrafts: 5 Hrs

Basic components of an Aircraft, Structural members, Aircraft Axis System, Aircraft Motions, Control surfaces and High lift Devices. Types of Aircrafts - Lighter than Air/Heavier than Air Aircrafts Conventional Design Configurations based on Power Plant Location, Wing vertical location, intake location, Tail Unit Arrangements, Landing Gear Arrangements. Unconventional Configurations-Biplane, Variable Sweep, Canard Layout, Twin Boom Layouts, Span loaders, Blended Body Wing Layout, STOL and STOVL Aircraft, Stealth Aircraft. Advantages and disadvantages of these Configurations.

Chapter 3. Introduction to Aircraft Mechanical Systems: 8 Hrs

Types of Aircraft Systems, Mechanical Systems: Environmental control systems (ECS), Pneumatic systems, Hydraulic systems, Fuel systems, Landing gear systems, Engine Control Systems, Ice and rain protection systems, Cabin Pressurization and Air Conditioning Systems, Steering and Brakes Systems Auxiliary Power Unit.

Unit II

Chapter 4. Basic Principles of Flight: 7 Hrs

Significance of speed of Sound, Air speed and Ground Speed, Properties of Atmosphere, Bernoulli's Equation, Forces on the airplane, Airflow over wing section, Pressure Distribution over a wing section, Generation of Lift, Drag, Pitching moments, Types of Drag, Lift curve, Drag Curve, Lift/Drag Ratio Curve, Factors affecting Lift and Drag, Center of Pressure and its effects. Aero foil Nomenclature, Types of Aero foil, Wing Section- Aerodynamic Center, Aspect Ratio, Effects of lift, Drag, speed, Air density on drag,

Chapter 5. Overview of the Aircraft Design Process: 6 Hrs

Introduction, Phases of aircraft Design, Aircraft conceptual Design Process, Conceptual stage, Preliminary Design, Detailed Design, Design Methodologies. Aerodynamic loads, Inertial loads, Loads due to engine, Actuator loads, maneuver loads, VN diagrams, Gust loads, Ground loads, Ground conditions, Miscellaneous loads. Sample problems.

Chapter 6. Aircraft materials: 3 Hrs

Introduction, Basic construction, material forms- Metallic materials and forms. Alloy designations, Mechanical properties- strength, static, stress strain curves, fatigue properties, crack growth.

Unit III

Chapter 7. Analysis of plates: 4 Hrs

Theory of plates- Analysis of plates for bending, stresses due to bending, plate deflection under different conditions, Plate buckling, Compression buckling, shear buckling and buckling due to in plane bending moments. Sample exercises.

Chapter 8.Analysis of Beams: 4 Hrs

Theory of beams- Symmetric beams in pure bending, deflection of beams, Unsymmetrical beams in bending. Sample exercises. Torsion in closed section beams, torsion in open section beams, multi cell sections. Sample exercises.

Program: Bachelor of Engineering		Semester: VIII
Course Title: Industrial Engineering Methods and Practices		**Course Code: 15EMEE414**
L-T-P: 3-0-0	**Credits: 3**	**Contact Hours: 3 Hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 3 Hrs**	

Unit I

Chapter 1. Industrial engineering and productivity: 6 Hrs

Evolution of industrial engineering, industrial engineering functions, recent advances in industrial engineering, productivity of materials, land, buildings, machines and manpower, measurement of productivity, factors affecting the productivity.

Chapter 2. Methods engineering: 4 Hrs

Objective and scope of work-study and method-study, human factor in work-study, work-study and management, work-study and supervisor, work-study and worker.

Chapter 3. Methods analysis techniques: 6 Hrs

Types of recording techniques, process chart symbols, construction of charts (operation process chart, flow process chart, two hand process chart, multiple activity chart, travel chart, string diagram etc.), applications of various charts with examples.

Unit II

Chapter 4. Micro motion study: 5 Hrs

Purpose of micro motion study, fundamental hand motions, therbligs, micro motion study equipments, cycle graph and chronocyclegraph, simo-chart construction, memo motion study.

Chapter 5. Work measurement & time Study practice: 6 Hrs

Concept of human work, terminology used in work measurement, theory of work measurement, work measurement techniques, definition of time study , time study equipments, basic time study procedure, conducting the time study

Chapter 6. Performance rating & computing standard time: 5 Hrs

Necessity of performance rating, factors influencing rating, rating systems and their details, allowances and their details, problems in time study and time standards, standard time computation with examples.

Unit III

Chapter 7. Ergonomics: 4 Hrs

Areas of study under ergonomics, system approach to ergonomics model, man-machine system, work capabilities of industrial worker, general principles for carrying out physical activities.

Chapter 8. Design of man-machine system interface: 4 Hrs

Concept of fatigue in industrial worker, relationship between controls and displays, design of work place and effect of environment (influence of climate on human efficiency, influence of noise, vibrations and lighting system).

Text Books:

1. Jhamb L. C, Work Study & Ergonomics, 16th Edition Everest Publishing House 2009

Reference Books

1. ILO, Introduction to Work Study, 4th Revised Edition International Labour Office 1992
2. Suresh Dalela and Sourabh, Work Study and Ergonomics, 6th edition Standard Publishers Distributors 2017
3. Vijay Sheth, Industrial Engineering Methods and Practices, 5th Edition 2012 Penram International Publishing (India) Pvt.Ltd.

Program: Bachelor of Engineering		Semester: VIII
Course Title: Advanced Energy Technology		Course Code: 15EMEE415
L-T-P: 3-0-0	Credits: 3	Contact Hours: 3 Hrs/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 40	Examination Duration: 3 Hrs	

Unit I

Chapter 1. Solar Radiation, Measurement of Solar Radiation, Solar Radiation Geometry: 8 Hrs

Energy source, India's production and reserves of commercial energy sources, need for non-conventional energy sources. Solar Radiation: Extra-Terrestrial radiation, spectral distribution of extra-terrestrial radiation, solar constant, solar radiation at the earth's surface, beam, diffuse and global radiation, solar radiation data. Measurement of Solar Radiation: Pyrometer, shading ring pyrheliometer, sunshine recorder, schematic diagrams and principle of working. Solar Radiation Geometry: Flux on a plane surface, latitude, declination angle, surface azimuth angle, hour angle, zenith angle, solar altitude angle expression for the angle between the incident beam and the normal to a plane surface (No derivation) local apparent time. Apparent motion of sum, day length, numerical examples.

Chapter 2. Radiation Flux on a Tilted Surface, Solar Thermal Conversion: 8 Hrs

Radiation Flux on a Tilted Surface: Beam, diffuse and reflected radiation, expression for flux on a tilted surface (no derivations) numerical example. Solar Thermal Conversion: Collection and storage, thermal collection devices, liquid flat plate collectors, solar air heaters concentrating collectors (cylindrical, parabolic, paraboloid) (Quantitative analysis); sensible heat storage, latent heat storage, application of solar energy water heating. Space heating and cooling, active and passive systems, power generation, refrigeration. Distillation (Qualitative analysis) solar pond, principle of working, operational problems.

Unit II

Chapter 3. Solar Photovoltaic Energy Conversion and PV System Applications: 8 Hrs

Principles - Physics and operation of solar cells. Classification of solar PV systems, Solar cell energy conversion efficiency, I-V characteristics, effect of variation of solar insolation and temperature, losses. Solar PV power plants. Building-integrated photovoltaic units, grid-interacting central power stations, standalone devices for distributed power supply in remote and rural areas, solar cars, aircraft, space solar power satellites. Socio-economic and environmental merits of photovoltaic systems.

Chapter 4. Fuel Cell Technology: 8 Hrs

Fuel cell electrochemistry - Reaction rate - Butler Volmer equation-implications and use of fuel cell polarization curve - Conversion of chemical energy in electricity in a fuel cell. Cogeneration - Fuel cell electric vehicles - Fuel cell vehicles - Motor cycles and bicycles-airplanes - Fueling stations - Fuel cell power plant structure - Fuel processor and fuel cell stack. Advantages and disadvantages. Problems with fuel cells. Research related to fuel cell development in the world and in India.

Unit III

Chapter 5. Energy Storage: 4 Hrs

Introduction, energy demand, energy storage devices, types of battery, basic principle, components, cathode and anode materials, effect of nano-size on energy storage and electrode materials performance, electrochemical energy storage, super-capacitors, advantage of nanotechnology in energy storage devices.

Chapter 6. Energy Policy: 4 Hrs

Energy policy issues - Fossil Fuels, renewable energy, power sector reforms, restructuring of energy supply sector, energy strategy for future. Energy conservation act and National electricity policy and plan.

Reference Books

1. David Merick, Richard Marshall, (2001), Energy, Present and Future Options, Vol. I and II, John Wiley.
2. Twidell, J.W. and Weir, A., Renewable Energy Sources, EFN Spon Ltd., 1986
3. Peter Gevorkian, Sustainable Energy Systems Engineering, McGraw Hill,2007

4. Bagotsky. V.S, “Fuel Cells”, Wiley, 2009.
5. Ibrahim Dincer and Marc A. Rosen, “Thermal Energy Storage Systems and Applications”, 2nd Edition, John Wiley and Sons Ltd., 2011.

Program: Bachelor of Engineering		**Semester: VIII**
Course Title: Thermal Management of Electronic Equipment		**Course Code: 15EMEE416**
L-T-P: 3-0-0	**Credits: 3**	**Contact Hours: 3 Hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 3 Hrs**	

Unit I

Chapter 1. Introduction: 5 Hrs

Semiconductor Technology Trends, Temperature-Dependent Failures, Importance of Heat Transfer in Electronics, Thermal Design Process, Energy and Work, Macroscopic and Microscopic Energies, Energy Transfer and Heat Transfer, Equation of State.

Chapter 2. Thermal Resistance Network: **5 Hrs**

Thermal Resistance Concept, Series Thermal Layers, Parallel Thermal Layers,
General Resistance Network, Thermal Contact Resistance, Thermal Interface Materials, Spreading Thermal Resistance, Thermal Resistance of Printed Circuit Boards (PCBs).

Chapter 3. Thermal Specification of Microelectronic Packages: **5 Hrs**

Importance of Packaging, Packaging Types, Thermal Specifications of Microelectronic Packages, Package Thermal Resistance Network, Parameters Affecting Thermal Characteristics of a Package.

Unit II

Chapter Chapter 4. Cooling methods: 10 **Hrs**

Conduction Cooling, Convection Cooling, Selection Of Fan, Liquid Immersion Cooling, Flow-Through Cooling Of CCAs, Cold wall Cooling, Cold Plates, Jet Impingement Cooling, Synthetic Jet Cooling, Thermoelectric Or Solid State Coolers, Cooling Using Phase Change– Cooling With PCM Materials, Micro/Mini Channel Cooling, Cooling Using Heat Pipes– Working Principle, Selection Of Heat Pipe Working Fluid; Selection Of Cooling Technique– Ranges Of Cooling Rates Of Different Cooling Methods, Selection Criteria.

Chapter 5. Fins and Heat Sinks: 5 Hrs

Fin Equation, Fin Thermal Resistance, Effectiveness, and Efficiency, Fins with Variable Cross Sections, Heat Sink Thermal Resistance, Effectiveness, and Efficiency, Heat Sink Manufacturing Processes.

Unit III

Chapter 6. Experimental Techniques and Thermal Design: 5 Hrs

Flow Rate Measurement Techniques, System Impedance Measurement, Fan and Pump Curve Measurements, Velocity Measurement Methods, Temperature Measurement Techniques, Acoustic Noise Measurements, Importance of Experimental Measurements in Thermal Design.

Chapter 7. Computer Simulations and Thermal Design: 5 Hrs

Heat Transfer and Fluid Flow Equations: A Summary, Fundamentals of Computer Simulation, Turbulent Flows, Solution of Finite-Difference Equations

Commercial Thermal Simulation Tools, Importance of Modeling and Simulation in Thermal Design.

Text Books

1. Younes Shabany, Heat Transfer: Thermal Management of Electronics, CRC Press Inc, 2010.
2. Ravi Kandasamy and Arun S. Mujumdar, Thermal Management of Electronic Components, Lambert Academic Publishing, 2010.

Reference Books

1. Dave S. Steinberg, Cooling Techniques for Electronic Equipment, Wiley, 1991.
2. Sung Jin Kim, Sang Woo Lee, Air Cooling Technology for Electronic Equipment, Taylor & Francis, 996.
3. Rao R. Tummala, Fundamentals of Microsystems Packaging, McGraw-Hill, 2001.
4. Yunus A. Cengel, Heat Transfer: A Practical Approach. McGraw-Hill, 2003.

←BACK TO SEMESTER VIII

Program: Bachelor of Engineering		Semester: VIII
Course Title: Introduction to Nano-science and Nanotechnology		Course Code: 15EMEO401
L-T-P: 3-0-0	Credits: 3	Contact Hours: 3 Hrs/week
ISA Marks: 50	ESA Marks: 50	Total Marks: 100
Teaching Hours: 40	Examination Duration: 3 Hrs	

Unit I

Chapter 1 Introduction: **5Hrs**

Nanotechnology, Frontier of future- an overview

Length scales, Variation of physical properties from bulk to thin films to nanomaterials, - confinement of electron energy states (LDOS) in 0D, 1D,2D and 3D systems (qualitative treatment); Surface, size, shape and assembly effects.

Bonding and crystal structure in solids, colloids and core-shell structures. Chemical and molecular interaction, functionalzation, basis for biological self-assembly and self-organization.

Chapter 2 Synthesis of nano-materials: **6Hrs**

Top-down approach: Lithography and soft processes, Ball milling, chemical stamping.

Bottom-Up approach: Chemical Routes for Synthesis of Nano-materials, Solvo-thermal and Sol-gel synthesis; Micro-emulsions, micelles and reverse micelles; Physical and Chemical Vapour Deposition, Sputtering, Laser ablation, Epitaxy.

Biological Methods: Role of plants and bacteria in metal (magnetic and non-magnetic) nanoparticle synthesis

Chapter 3 Characterization: **5Hrs**

Electron Microscopy (SEM/TEM); Scanning Probes (STM, AFM), X-ray Photoelectron Spectroscopy (XPS), Optical Spectroscopy –IR/UV/VIS, Raman, Photoluminescence, X-ray Diffraction (including Debye-Scherrer method), Particle Size Analyser-light Scattering, Electrical (I-V and C-V), Porosity (BET method), Zeta potential, nano-indentation.

Unit II

Chapter 4 Properties: **6Hrs**

- Electronic and optoelectronic properties: Ballistic transport, Coulomb blockade, Diffusive transport,
- Dielectric properties: Polarisation, Ferroelectric behavior.
- Optical Properties: Photoconductivity, Optical absorption & transmission, Plasmons and Excitons, Luminescence and Phosphorescence.
- Magnetic properties: Nanomagnetism, magneto-resistance; Super Para Magnetism
- Thermal and Mechanical properties: changes in thermal transport, thermal transition temperatures, and interfaces with dissimilar materials. Improved hardness and toughness of metals and alloys
- Biological: Permeability through biological barriers, molecular recognition and biological assemblies.

Chapter 5 General Applications: **5Hrs**

- Electrical, Electronics & Photonics- Switching glasses, Semiconductor devices including LEDs and Solar Cells, Photonic Crystals.
- Computer Science- Storage devices and Quantum computing etc
- Mechanical and Civil: Composites and their properties.
- Environmental and Chemical: Porous materials, Catalysis, tracers etc
- Biotechnology- Interaction between bimolecular and nanoparticle surface, nano-bio assemblies, Nanosensors etc

Unit III

Chapter 6 Specific Applications: **8Hrs**

Part of this can be implemented as a student project that involves: literature-survey, project report and a Seminar (Power-Point) Presentations by groups of two students each (applications and students to be identified by teachers and monitored by one teacher each):

- Carbon and its allotropes: Fullerenes (C_{60}), Carbon nanotubes and Graphene:
- Applications of Carbon Nanotubes: Field emission, Fuel Cells, Display devices, Hydrogen storage.
- Nano-Medicine: Developments and protocols for diagnostics, drug delivery and therapeutics.
- Nanotribology: Friction at nanoscale, Nanotribology and wear-resistance, MEMS and NEMS
- Photo-electronics: Merger of photonics and electronics at nanoscale dimensions
- Single electron devices, molecular circuits
- Nanocomposites (i.e. metal oxide, ceramic, glass and polymer and core-shellbased);
- Biomemitics and Biomaterials, synthetic nanocomposites for bone, teeth replacement, DNA scaffolding.
- Nanosensors: Temperature Sensors, Chemical and gas Sensors, Light and radiation sensors

Chapter 7 Demonstration through experiments: 4Hrs

1. Chemical synthesis of Au and Ag nanoparticles and characterization by Optical spectroscopy of size dependence band-gap
2. Debye Scherrer analysis of XRD data of nanoparticles of different sizes.
3. Surface area and Pore size distribution of the BET data from a nano-porous material.
4. Some experiment to study mechanical strength of nanocomposites (nano-indentation)

Guest lectures from industries and research laboratory personnel: 1Hrs

Societal issues of Nanotechnology: Prospects and Dangers; Commercial aspects, emerging industry and employment opportunities.

Reference Books

1. Nano Materials- A.K. Bandyopadhyay/ New Age Publishers.
2. Nanocrystals: Synthesis, Properties and Applications.
3. C. N. R. Rao, P. John Thomas and G. U. Kulkarni, Springer Series in Materials Science.
4. Nano Essentials- T. Pradeep/TMH.
5. Plenty of Room for Biology at the Bottom-An introduction to bio-nanotechnology, E. Guzit, Imperial College Press

Books Recommended for extra reading:

1. C P Poole & F J Owens, Introduction to Nanotechnology, Wiley, 2003.
2. Understanding Nanotechnology, Scientific American 2002.
3. M Ratner & D Ratner, Nanotechnology, Prentice Hall 2003.
4. M Wildon, K Kannagara G Smith, M Simmons & B Raguse, Nanotechnology, CRC Press Boca Raton 2002.

Apart from the above, in view of the course being of advanced nature, the content of course will be supplemented with course material from the course instructors.

Program: Bachelor of Engineering		**Semester: VIII**
Course Title: Nanotechnology		**Course Code: 15EMEO402**
L-T-P: 3-0-0	**Credits: 3**	**Contact Hours: 3 Hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 3 Hrs**	

Unit I

Chapter 1. An overview of Nanoscience & Nanotechnology: 4 Hrs

Historical background – nature, scope and content of the subject – multidisciplinary aspects – industrial, economic and societal implications

Chapter 2. Experimental Techniques and Methods: 5 Hrs

For investigating and manipulating materials in the nano scale – electron microscope – scanning probe microscope – optical and other microscopes

Chapter 3. Fullerenes: 6Hrs

Discovery, synthesis and purification – chemistry of fullerenes in the condensed phase – orientational ordering – pressure effects – conductivity and superconductivity – ferromagnetism – optical properties. Carbon Nanotubes – synthesis and purification – filling of nanotubes – mechanism of growth – electronic structure – transport properties – mechanical and physical properties – applications

Unit II

Chapter 4. Self-assembled Monolayers: 5 Hrs

Monolayers on gold – growth process – phase transitions – patterning monolayers – mixed monolayers – applications

Chapter 5. Semiconductor Quantum Dots: 5 Hrs

Synthesis – electronic structure of nanocrystals – how quantum dots are studied – correlation of properties with size – uses

Chapter 6. Monolayer-protected Metal Nanoparticles: 5 Hrs

Method of preparation – characterization – functionalized metal nanoparticles –applications – superlattices

Unit III

Chapter 7. Nano biology: 5 Hrs

Interaction between biomolecules and nanoparticle surfaces – materials used for synthesis of hybrid nano-bio assemblies – biological applications – nanoprobes for analytical applications – Nano biotechnology – future perspectives

Chapter 8. Molecular Nano machines: 5 Hrs

Covalent and non-covalent approaches – molecular motors and machines – other molecular devices – single molecular devices – practical problems involved

Text Books

1. T Pradeep, NANO: The Essentials – Understanding Nanoscience and Nanotechnology; TMGH (2007)

Reference Books

1. Richard Booker & Earl Boysen; Nanotechnology: Wiley (2005).
2. Di Ventra, Introduction to Nanoscale Science and Technology [Series: Nanostructure Science and Technology]: et al (Ed); Springer (2004).
3. Demystified: Linda Williams & Wade Adams; Nanotechnology McGraw-Hill (2007)
4. Charles P Poole Jr, Frank J Owens, Introduction to Nanotechnology: Wiley India New Delhi, 2007

Program: Bachelor of Engineering		**Semester: VIII**
Course Title: Design of Experiments		**Course Code: 15EMEO403**
L-T-P: 3-0-0	**Credits: 3**	**Contact Hours: 3 Hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 3 Hrs**	

Unit I

Chapter 1. Introduction: 04 Hrs

Strategy of experimentation, applications of experimental design, basic principles, guidelines for designing the experiments.

Chapter 2. Taguchi's approach to quality: 04 Hrs

Definition of quality, Taguchi's quality philosophy, Quality loss function, off-line and on-line quality control, Signal and Noise Factors.

Chapter 3. Motivation for using ANOVA: 08 Hrs

Introduction to analysis of variance (ANOVA), test of hypothesis, limitations of testing of hypothesis for difference between the means of two samples, testing of hypothesis using chi-square, t-test and F-test, one-way ANOVA examples.

Unit II

Chapter 4. Factorial Experiments: 08 Hrs

Two-Factor Factorial Design, General Factorial Design, 2^2, $2^3$and 2^4 Full Factorial Designs, Exercises

Chapter 5. Fractional Factorial Designs: 04 Hrs

One half fraction of 2^k Design, One quarter fraction of 2^k Design, General 2^{k-p} Fractional Factorial Design, Exercises

Chapter 6. Regression Approach: 04 Hrs

Simple Regression and Multiple regressions, Types of designs, Central composite design and Box-Behnken design, Exercises

Unit III

Chapter 7. Orthogonal Array Experiments: 04 Hrs

Introduction, Design of Orthogonal arrays, ANOVA for Orthogonal Array.

Chapter 8.Robust Parameter Design: 04 Hrs

Introduction, Signal-to-Noise ratio, ANOVA for S/N ratio, Steps of S/N approach.

Text Books

1. Douglas C. Montgomery, "Design and Analysis of Experiments", John Wiley and Sons.
2. Madhav S. Phadke, "Quality Engineering using Robust Design", Prentice Hall PTR, Englewood Cliffs, New Jersey.
3. R. Panneerselvam, "Design and Analysis of Experiments- R PHI Learning Private Limited, New Delhi.

Reference Books

1. Robert H. Lochner and Joseph E. Matar, "Designing for Quality- an Introduction Best of Taguchi and Western Methods or Statistical Experimental Design", Chapman and Hall.
2. Philips.J. Ross, "Taguchi Techniques for Quality Engineering", McGraw Hill, New York.

Program: Bachelor of Engineering		**Semester: VIII**
Course Title: Engine Management Systems		**Course Code: 15EMEO404**
L-T-P: 3-0-0	**Credits: 3**	**Contact Hours: 3 Hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 3 Hrs**	

Unit I

Chapter 1 Basics of Gasoline (SI) Engine: 6Hrs

Introduction, Operating concept, Valve timing, Stages of combustion, Combustion knock, Effect of engine variables on knock, Torque and power, Engine efficiency, Specific fuel consumption, Fuels for spark ignition engines.

Chapter 2 Gasoline engine management : 4Hrs

Technical requirement, Cylinder charge control, Air-charge control, Variable valve timing, controlled charge flow, A/F –mixture formation, Ignition- Battery ignition systems, Electronic ignition system, Inductive ignition system, Ignition coils, Spark plugs.

Chapter 3 Gasoline fuel injection: 5 Hrs

Fuel supply for manifold injection, Operating concept, Electromagnetic fuel injectors, Types of fuel injection, Fuel supply for gasoline direct injection, Operating concept, Rail, High pressure pump, Pressure control valve, High pressure injector, Combustion process, A/F mixture formation, Operating modes, Motronic engine management, ME-Motronic, MED-Motronic.

Unit II

Chapter 4 Basics of Diesel Engine: 5 Hrs

Method of operation, Stages of combustion, Operating statuses, Fuel-injection system, Combustion chambers-Di and IDI, Diesel fuels-properties, Alternative fuels- Alcohols, Vegetable oils.

Cylinder Charge Control - Intake air filters, Swirl flaps, Superchargers & Turbochargers, Exhaust Gas Recirculation.

Chapter 5 Diesel fuel injection: 5 Hrs

Requirements of ideal fuel injection system, Basic Principles of fuel supply - Mixture distribution, Start of fuel injection and delivery, Injected fuel quantity, Injection characteristics, Injection pressure, Injection direction and number of injection jets. Fuel supply system.

Chapter 6 Fuel injection pumps: 5 Hrs

Design and method of operation of in-line fuel injection pump systems, Distributor fuel injection pump systems, Unit injector system and unit pump system, Common rail system.

Nozzles and Nozzle holders - Pintle nozzles, Hole type nozzles, future development.

Unit III

Chapter 7 Engine Exhaust Emission Control: 5 Hrs

Formation of NO_X, HC/CO mechanism, Smoke and Particulate emissions, Methods of controlling emissions- Thermal converter, Catalytic converter and Particulate Trap, Diesel Smoke and its control, Emission (HC, CO, NO and NO_X) measuring equipment, Emission norms.

Chapter 8 Recent Trends in IC Engines: 5 Hrs

Dual fuel Engine, Homogeneous Charge Compression Ignition Engine (HCCI), Reactivity controlled compression ignition engine (RCCI), Lean Burn Engine, VVT engines,

Text Books

1. Robert Bosch Gmbh, 2004, Gasoline Engine Management – 2nd Edition
2. Robert Bosch Gmbh, 2004, Diesel Engine Management " 3rd Edition

Reference Books

1. Mathur and Sharma, Dhanpal Rai & sons, A Course in I.C. Engine –New Delhi
2. John B. Heywood, Internal Combustion Engine Fundamentals –McGraw- Hill