VIT®

Vellore Institute of Technology

(Deemed to be University under section 3 of UGC Act, 1956)

SCHOOL OF MECHANICAL ENGINEERING

B.Tech Mechanical Engineering

(B.Tech BME)

Curriculum

(*2018-2019 admitted students*)

VISION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

Transforming life through excellence in education and research.

MISSION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

World class Education: Excellence in education, grounded in ethics and critical thinking, for improvement of life.

Cutting edge Research: An innovation ecosystem to extend knowledge and solve critical problems.

Impactful People: Happy, accountable, caring and impactful workforce and students.

Rewarding Co-Creations: Active collaboration with national & international industries & universities for productivity and economic development.

Service to Society: Service to the region and world through knowledge and compassion.

VISION STATEMENT OF THE SCHOOL OF MECHANICAL ENGINEERING

To be a leader in imparting world class education in Mechanical Engineering, leading to nurturing of scientists and technologists of highest caliber who would engage in sustainable development of the globe.

MISSION STATEMENT OF THE SCHOOL OF MECHANICAL ENGINEERING

The mission of the school is to create and maintain an environment for Excellence in Instruction, Learning and Applied Research in the area of Mechanical and allied disciplines so as to equip our students with necessary knowledge and skills for higher education / employment and to meet the social demands.

B. Tech Mechanical Engineering

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

1. Graduates will be engineering practitioners and leaders, who would help solve industry's technological problems.

2. Graduates will be engineering professionals, innovators or entrepreneurs engaged in technology development, technology deployment, or engineering system implementation in industry.

3. Graduates will function in their profession with social awareness and responsibility.

4. Graduates will interact with their peers in other disciplines in industry and society and contribute to the economic growth of the country.

5. Graduates will be successful in pursuing higher studies in engineering or management.

6. Graduates will pursue career paths in teaching or research.

PROGRAMME OUTCOMES (POs)

PO_1: Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO_2: Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.

PO_3: Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO_4: Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions for complex problems

PO_5: Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

PO_6: The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO_7: Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO_8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO_9: Individual and Teamwork: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO_10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO_11: Project Management and Finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO_12: Life-long Learning: Recognize the need for and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change.

PROGRAMME SPECIFIC OUTCOMES (PSOs)

On completion of B. Tech. (Mechanical Engineering) programme, graduates will be able to

- PSO1: Model, design and analyse mechanical systems and components taking into account social, economic and environmental implications
- PSO2: Realize components and products using appropriate materials and machine tools
- PSO3: Work professionally in mechanical and related systems

CREDIT STRUCTURE

Category-wise Credit distribution

Category	Credits
University core (UC)	70
Programme core (PC)	60
Programme elective (PE)	38
University elective (UE)	12
Bridge course (BC)	-
Total credits	**180**

B. Tech Mechanical Engineering

DETAILED CURRICULUM

University Core

S. No.	Course Code	Course Title	L	T	P	J	C
1.	CHY1002	Environmental Sciences	3	0	0	0	3
2.	CHY1701	Engineering Chemistry	3	0	2	0	4
3.	CSE1001	Problem Solving and Programming	0	0	6	0	3
4.	CSE1002	Problem Solving and Object Oriented Programming	0	0	6	0	3
5.	ENG1011	English for Engineers	0	0	4	0	2
6.	HUM1021	Ethics and Values	2	0	0	0	2
7.	MAT1011	Calculus for Engineers	3	0	2	0	4
8.	MAT2001	Statistics for Engineers	2	1	2	0	4
9.	MEE3099	Industrial Internship	0	0	0	0	2
10.	MEE3999	Technical Answers for Real World Problems (TARP)	1	0	0	8	3
11.	MEE4098	Comprehensive Examination	0	0	0	0	2
12.	MEE4099	Capstone Project	0	0	0	0	20
13.	MGT1022	Lean Start-up Management	1	0	0	4	2
14.	PHY1701	Engineering Physics	3	0	2	0	4
15.	PHY1999	Introduction to Innovative Projects	1	0	0	4	2
16.	EXC4097	Co-Extra Curricular Basket	0	0	0	0	2
17.	FLC4097	Foreign Language Course Basket	2	0	0	0	2
18.	STS4097	Soft Skills	0	0	0	0	6

Programme Core

S. No.	Course Code	Course Title	L	T	P	J	C
1.	EEE1001	Basic Electrical & Electronics Engineering	2	0	2	0	3
2.	MAT2002	Applications of Differential and Difference Equations	3	0	2	0	4
3.	MAT3003	Complex variables and Partial Differential Equations	3	2	0	0	4
4.	MAT3005	Applied Numerical Methods	3	2	0	0	4
5.	MEE1001	Engineering Drawing	1	0	4	0	3
6.	MEE1002	Engineering Mechanics	2	2	0	0	3
7.	MEE1003	Engineering Thermodynamics	2	2	0	0	3
8.	MEE1004	Fluid Mechanics	2	2	2	0	4
9.	MEE1005	Materials Engineering and Technology	3	0	2	0	4
10.	MEE1007	Manufacturing Processes	2	0	2	0	3
11.	MEE2001	Machine Drawing	1	0	4	0	3
12.	MEE2002	Strength of Materials	2	2	2	0	4
13.	MEE2003	Thermal Engineering Systems	2	2	2	0	4
14.	MEE2004	Mechanics of Machines	2	2	2	0	4
15.	MEE2005	Heat Transfer	2	2	2	0	4
16.	MEE2006	Machining Process and Metrology	2	0	2	0	3
17.	MEE3001	Design of Machine Elements	2	2	0	0	3

Programme Elective

S. No.	Course Code	Course Title	L	T	P	J	C
1.	CHE2006	Fuels and Combustion	3	0	0	0	3
2.	EEE2007	Electronics and Microcontrollers	2	0	0	4	3
3.	EEE3001	Control Systems	3	0	2	0	4
4.	MEE1008	MEMS	3	0	0	0	3
5.	MEE1009	New Product Development	2	0	0	4	3
6.	MEE1011	Renewable Energy sources	2	2	2	0	4
7.	MEE1012	Alternative Fuels	3	0	0	0	3

8.	MEE1014	Industrial Engineering and Management	3	0	0	0	3
9.	MEE1015	Total quality management and Reliability	3	0	0	0	3
10.	MEE1016	Lean Enterprises and New Manufacturing Technology	3	0	0	0	3
11.	MEE1017	New Venture Planning and Management	2	0	0	4	3
12.	MEE1018	Facilities and Process Planning	3	0	0	0	3
13.	MEE1024	Operations Research	2	2	0	0	3
14.	MEE1027	Instrumentation and Control Engineering	3	0	2	0	4
15.	MEE1030	Robotics	2	0	2	0	3
16.	MEE1045	Mechatronics Systems Design	3	0	0	4	4
17.	MEE2007	CAD/CAM	2	0	4	0	4
18.	MEE2008	Product Design for Manufacturing	2	0	0	4	3
19.	MEE2009	Tribology	2	2	0	0	3
20.	MEE2010	Design of Composite Materials	2	2	0	0	3
21.	MEE2011	Welding Engineering	2	0	0	4	3
22.	MEE2012	Manufacturing Automation	3	0	2	0	4
23.	MEE2013	Modelling and simulation of Manufacturing Systems	3	0	0	4	4
24.	MEE2014	Metal Casting Technology	2	0	0	4	3
25.	MEE2015	Non-Destructive Testing	3	0	2	0	4
26.	MEE2016	Rapid Manufacturing Technologies	2	0	0	4	3
27.	MEE2019	Materials Characterization Techniques	2	0	0	4	3
28.	MEE2020	Metal Forming Theory and Practice	3	0	0	0	3
29.	MEE2022	Power Plant Engineering	3	0	0	0	3
30.	MEE2023	Gas dynamics and Jet propulsion	2	2	0	0	3
31.	MEE2025	Fluid Power systems	3	0	2	0	4
32.	MEE2026	Turbo machines	2	2	2	0	4
33.	MEE2067	Computational Multibody Dynamics	3	0	0	4	4
34.	MEE3002	Finite Element Analysis	2	2	2	0	4
35.	MEE3003	Engineering Failure Analysis	3	0	0	4	4
36.	MEE3004	Internal Combustion Engines	3	0	0	0	3
37.	MEE3005	Refrigeration and Air Conditioning	3	2	0	0	4

38.	MEE3006	Automobile Engineering	2	0	2	0	3
39.	MEE3008	Mechanical Vibrations	2	2	2	0	4
40.	MEE3010	Robot Dynamics and Applications	3	0	0	0	3
41.	MEE3501	Product Development and Management	2	0	2	4	4
42.	MEE3502	Design Process Planning and Management	2	0	2	4	4
43.	MEE4001	Tool design	3	0	0	4	4
44.	MEE4002	Advanced Machining Processes	2	0	0	4	3
45.	MEE4003	Micro and Nano Machining	3	0	0	0	3
46.	MEE4005	Surface Engineering	3	0	0	0	3
47.	MEE4006	Computational Fluid Dynamics	2	2	2	0	4
48.	MEE4007	Design of Transmission Systems	2	2	0	4	4

University Elective Baskets

Management courses

Sl.No	**Code**	**Title**	**L**	**T**	**P**	**J**	**C**
1	MGT1001	Basic Accounting	3	0	0	0	3
2	MGT1002	Principles of Management	2	0	0	4	3
3	MGT1003	Economics for Engineers	2	0	0	4	3
4	MGT1004	Resource Management	2	0	0	4	3
5	MGT1005	Design, Systems and Society	2	0	0	4	3
6	MGT1006	Environmental and Sustainability Assessment	2	0	0	4	3
7	MGT1007	Gender, Culture and Technology	2	0	0	4	3
8	MGT1008	Impact of Information Systems on Society	2	0	0	4	3
9	MGT1009	Technological Change and Entrepreneurship	2	0	0	4	3
10	MGT1010	Total Quality Management	2	2	0	0	3
11	MGT1014	Supply Chain Management	3	0	0	0	3
12	MGT1015	Business Mathematics	3	0	0	0	3
13	MGT1016	Intellectual Property Rights	3	0	0	0	3
14	MGT1017	Business Regulatory Framework For Start-ups	3	0	0	0	3
15	MGT1018	Consumer Behaviour	3	0	0	0	3
16	MGT1019	Services Marketing	3	0	0	0	3
17	MGT1020	Marketing Analytics	2	0	2	0	3
18	MGT1021	Digital and Social Media Marketing	3	0	0	0	3
19	MGT1022	Lean Start-up Management	1	0	0	4	2
20	MGT1023	Fundamentals of Human Resource Management	3	0	0	4	4
21	MGT1024	Organizational Behaviour	3	0	0	4	4

22	MGT1025	Foundations of Management And Organizational Behaviour	3	0	0	4	4
23	MGT1026	Information Assurance and Auditing	2	0	0	4	3
24	MGT1028	Accounting and Financial Management	2	2	0	4	4
25	MGT1029	Financial Management	2	1	0	4	4
26	MGT1030	Entrepreneurship Development	3	0	0	4	4
27	MGT1031	International Business	3	0	0	4	4
28	MGT1032	Managing Asian Business	3	0	0	4	4
29	MGT1033	Research Methods in Management	2	1	0	4	4
30	MGT1034	Project Management	3	0	0	4	4
31	MGT1035	Operations Management	3	0	0	0	3
32	MGT1036	Principles of Marketing	3	0	0	4	4
33	MGT1037	Financial Accounting and Analysis	2	1	0	4	4
34	MGT1038	Financial Econometrics	2	0	0	4	3
35	MGT1039	Financial Markets and Institutions	2	0	0	4	3
36	MGT1040	Personal Financial Planning	2	0	0	4	3
37	MGT1041	Financial Derivatives	2	1	0	4	4
38	MGT1042	Investment Analysis and Portfolio Management	2	0	0	4	3
39	MGT1043	Applications in Neuro Marketing	3	0	0	4	4
40	MGT1044	Global Brand Marketing Strategies	3	0	0	4	4
41	MGT1045	Industrial Marketing	3	0	0	4	4
42	MGT1046	Sales and Distribution Management	3	0	0	4	4
43	MGT1047	Social Marketing	3	0	0	4	4
44	MGT1048	Political Economy of Globalization	3	0	0	4	4
45	MGT1049	Sustainable Business Models	3	0	0	4	4
46	MGT1050	Software Engineering Management	2	0	0	4	3
47	MGT1051	Business Analytics for Engineers	2	2	0	0	3
48	MGT1052	Bottom of the Pyramid Operations	3	0	0	0	3
49	MGT1053	Entrepreneurship Development, Business Communication and IPR	1	0	2	0	2
50	MGT1054	Product Planning and Strategy	2	2	0	0	3
51	MGT1055	Design Management	2	2	0	0	3
52	MGT1056	Accounting and Financial Management	3	0	0	4	4
53	MGT6001	Organizational Behaviour	2	0	0	4	3

Humanities courses

Sl.No	**Code**	**Title**	**L**	**T**	**P**	**J**	**C**
1	HUM1001	Fundamentals of Cyber Laws	3	0	0	0	3
2	HUM1002	Business Laws	3	0	0	0	3
3	HUM1003	Basic Taxation for Engineers	3	0	0	0	3

4	HUM1004	Corporate Law for Engineers	3	0	0	0	3
5	HUM1005	Cost Accounting for Engineers	3	0	0	0	3
6	HUM1006	Business Accounting for Engineers	3	0	0	0	3
7	HUM1007	Contemporary Legal Framework for Business	3	0	0	0	3
8	HUM1009	International Business	3	0	0	0	3
9	HUM1010	Foreign Trade Environment	3	0	0	0	3
10	HUM1011	Export Business	3	0	0	0	3
11	HUM1012	Introduction to Sociology	3	0	0	0	3
12	HUM1013	Population Studies	3	0	0	0	3
13	HUM1021	Ethics and Values	2	0	0	0	2
14	HUM1022	Psychology in Everyday Life	2	0	0	4	2
15	HUM1023	Indian Heritage and Culture	2	0	0	4	2
16	HUM1024	India and Contemporary World	2	0	0	4	2
17	HUM1025	Indian Classical Music	1	0	2	4	1
18	HUM1033	Micro Economics	3	0	0	0	3
19	HUM1034	Macro Economics	3	0	0	0	3
20	HUM1035	Introductory Econometrics	2	0	2	0	2
21	HUM1036	Engineering Economics and Decision Analysis	2	0	0	4	2
22	HUM1037	Applied Game Theory	2	0	0	4	2
23	HUM1038	International Economics	3	0	0	0	3
24	HUM1039	Community Development in India	2	0	0	4	2
25	HUM1040	Indian Social Problems	3	0	0	0	3
26	HUM1041	Indian Society Structure and Change	3	0	0	0	3
27	HUM1042	Industrial Relations and Labour Welfare in India	3	0	0	0	3
28	HUM1043	Mass Media and Society	2	0	0	4	2
29	HUM1044	Network Society	3	0	0	0	3
30	HUM1045	Introduction to Psychology	2	0	2	0	2
31	HUM1706	Business Accounting for Engineers	3	0	0	0	3

Course code	Environmental Sciences	L	T	P	J	C
CHY1002		3	0	0	0	3
Pre-requisite	Chemistry of 12th standard or equivalent	Syllabus version				
		V:1.1				

Course Objectives:

1. To make students understand and appreciate the unity of life in all its forms, the implications of life style on the environment.
2. To understand the various causes for environmental degradation.
3. To understand individuals contribution in the environmental pollution.
4. To understand the impact of pollution at the global level and also in the local environment.

Course Outcome:

Students will be able to

1. Students will recognize the environmental issues in a problem oriented interdisciplinary perspectives
2. Students will understand the key environmental issues, the science behind those problems and potential solutions.
3. Students will demonstrate the significance of biodiversity and its preservation
4. Students will identify various environmental hazards
5. Students will design various methods for the conservation of resources
6. Students will formulate action plans for sustainable alternatives that incorporate science, humanity, and social aspects
7. Students will have foundational knowledge enabling them to make sound life decisions as well as enter a career in an environmental profession or higher education.

Module:1	Environment and Ecosystem	7 hours	CO: 1, 2

Key environmental problems, their basic causes and sustainable solutions. IPAT equation. Ecosystem, earth – life support system and ecosystem components; Food chain, food web, Energy flow in ecosystem; Ecological succession- stages involved, Primary and secondary succession, Hydrarch, mesarch, xerarch; Nutrient, water, carbon, nitrogen, cycles; Effect of human activities on these cycles.

Module:2	Biodiversity	6 hours	CO: 1, 3

Importance, types, mega-biodiversity; Species interaction - Extinct, endemic, endangered and rare species; Hot-spots; GM crops- Advantages and disadvantages; Terrestrial biodiversity and Aquatic biodiversity – Significance, Threats due to natural and anthropogenic activities and Conservation methods.

Module:3	Sustaining Natural Resources and Environmental Quality	7 hours	CO: 4, 5

Environmental hazards – causes and solutions. Biological hazards – AIDS, Malaria, Chemical hazards- BPA, PCB, Phthalates, Mercury, Nuclear hazards- Risk and evaluation of hazards. Water footprint; virtual water, blue revolution. Water quality management and its conservation. Solid and hazardous waste – types and waste management methods.

Module:4	Energy Resources	6 hours	CO: 5, 6

Renewable - Non renewable energy resources- Advantages and disadvantages - oil, Natural gas, Coal, Nuclear energy. Energy efficiency and renewable energy. Solar energy, Hydroelectric power, Ocean thermal energy, Wind and geothermal energy. Energy from biomass, solar- Hydrogen revolution.			
Module:5	**Environmental Impact Assessment**	**6 hours**	**CO: 6, 7**
Introduction to environmental impact analysis. EIA guidelines, Notification of Government of India (Environmental Protection Act – Air, water, forest and wild life). Impact assessment methodologies. Public awareness. Environmental priorities in India.			
Module:6	**Human Population Change and Environment**	**6 hours**	**CO: 1, 7**
Urban environmental problems; Consumerism and waste products; Promotion of economic development – Impact of population age structure – Women and child welfare, Women empowerment. Sustaining human societies: Economics, environment, policies and education.			
Module:7	**Global Climatic Change and Mitigation**	**5 hours**	**CO: 2, 7**
Climate disruption, Green house effect, Ozone layer depletion and Acid rain. Kyoto protocol, Carbon credits, Carbon sequestration methods and Montreal Protocol. Role of Information technology in environment-Case Studies.			
Module:8	**Contemporary issues**	**2 hours**	**CO: 7**
Lecture by Industry Experts			
	Total Lecture hours:	**45 hours**	

Text Books

1. G. Tyler Miller and Scott E. Spoolman (2016), Environmental Science, 15th Edition, Cengage learning.
2. George Tyler Miller, Jr. and Scott Spoolman (2012), Living in the Environment – Principles, Connections and Solutions, 17th Edition, Brooks/Cole, USA.

Reference Books

1. David M.Hassenzahl, Mary Catherine Hager, Linda R.Berg (2011), Visualizing Environmental Science, 4thEdition, John Wiley & Sons, USA.

Mode of evaluation: Internal Assessment (CAT, Quizzes, Digital Assignments) & FAT

Recommended by Board of Studies	12.08.2017		
Approved by Academic Council	No. 46	Date	24.08.2017

Course code	Engineering Chemistry	L	T	P	J	C
CHY1701		3	0	2	0	4
Pre-requisite	Chemistry of 12th standard or equivalent	Syllabus version				
		1.1				

Course Objectives:

1. To impart technological aspects of applied chemistry
2. To lay foundation for practical application of chemistry in engineering aspects

Course Outcomes (CO):

Students will be able to

1. Recall and analyze the issues related to impurities in water and their removal methods and apply recent methodologies in water treatment for domestic and industrial usage
2. Evaluate the causes of metallic corrosion and apply the methods for corrosion protection of metals
3. Evaluate the electrochemical energy storage systems such as lithium batteries, fuel cells and solar cells, and design for usage in electrical and electronic applications
4. Assess the quality of different fossil fuels and create an awareness to develop the alternative fuels
5. Analyze the properties of different polymers and distinguish the polymers which can be degraded and demonstrate their usefulness
6. Apply the theoretical aspects: (a) in assessing the water quality; (b) understanding the construction and working of electrochemical cells; (c) analyzing metals, alloys and soil using instrumental methods; (d) evaluating the viscosity and water absorbing properties of polymeric materials

Module:1	Water Technology	5 hours	CO1

Characteristics of hard water - hardness, DO, TDS in water and their determination – numerical problems in hardness determination by EDTA; Modern techniques of water analysis for industrial use - Disadvantages of hard water in industries.

Module:2	Water Treatment	8 hours	CO1

Water softening methods: - Lime-soda, Zeolite and ion exchange processes and their applications. Specifications of water for domestic use (ICMR and WHO); Unit processes involved in water treatment for municipal supply - Sedimentation with coagulant- Sand Filtration - chlorination; Domestic water purification – Candle filtration- activated carbon filtration; Disinfection methods- Ultrafiltration, UV treatment, Ozonolysis, Reverse Osmosis; Electro dialysis.

Module:3	Corrosion	6 hours	CO 2

Dry and wet corrosion - detrimental effects to buildings, machines, devices & decorative art forms, emphasizing Differential aeration, Pitting, Galvanic and Stress corrosion cracking; Factors that enhance corrosion and choice of parameters to mitigate corrosion.

Module:4	Corrosion Control	4 hours	CO 2

Corrosion protection - cathodic protection – sacrificial anodic and impressed current protection methods; Advanced protective coatings: electroplating and electroless plating, PVD and CVD. Alloying for corrosion protection – Basic concepts of Eutectic composition and Eutectic mixtures - Selected examples – Ferrous and non-ferrous alloys.

Module:5	Electrochemical Energy Systems	6 hours	CO 3

Brief introduction to conventional primary and secondary batteries; High energy electrochemical energy systems: Lithium batteries – Primary and secondary, its Chemistry, advantages and

applications.
Fuel cells – Polymer membrane fuel cells, Solid-oxide fuel cells- working principles, advantages, applications.
Solar cells – Types – Importance of silicon single crystal, polycrystalline and amorphous silicon solar cells, dye sensitized solar cells - working principles, characteristics and applications.

Module:6	**Fuels and Combustion**	**8 hours**	**CO 4**

Calorific value - Definition of LCV, HCV. Measurement of calorific value using bomb calorimeter and Boy's calorimeter including numerical problems.
Controlled combustion of fuels - Air fuel ratio – minimum quantity of air by volume and by weight-Numerical problems-three way catalytic converter- selective catalytic reduction of NO_X; Knocking in IC engines-Octane and Cetane number - Antiknocking agents.

Module:7	**Polymers**	**6 hours**	**CO 5**

Difference between thermoplastics and thermosetting plastics; Engineering application of plastics - ABS, PVC, PTFE and Bakelite; Compounding of plastics: moulding of plastics for Car parts, bottle caps (Injection moulding), Pipes, Hoses (Extrusion moulding), Mobile Phone Cases, Battery Trays, (Compression moulding), Fibre reinforced polymers, Composites (Transfer moulding), PET bottles (blow moulding);

Conducting polymers- Polyacetylene- Mechanism of conduction – applications (polymers in sensors, self-cleaning windows)

Module:8	**Contemporary issues:**	**2 hours**	
Lecture by Industry Experts			
	Total Lecture hours:	**45 hours**	

Text Book(s)

1. Sashi Chawla, A Text book of Engineering Chemistry, Dhanpat Rai Publishing Co., Pvt. Ltd., Educational and Technical Publishers, New Delhi, 3rd Edition, 2015.
2. O.G. Palanna, McGraw Hill Education (India) Private Limited, 9th Reprint, 2015.
3. B. Sivasankar, Engineering Chemistry 1st Edition, Mc Graw Hill Education (India), 2008
4. "Photovoltaic solar energy : From fundamentals to Applications", AngÃ¨le Reinders, Pierre Verlinden, Wilfried van Sark, Alexandre Freundlich, Wiley publishers, 2017.

Reference Books

1. O.V. Roussak and H.D. Gesser, Applied Chemistry-A Text Book for Engineers and Technologists, Springer Science Business Media, New York, 2nd Edition, 2013.
2. S. S. Dara, A Text book of Engineering Chemistry, S. Chand & Co Ltd., New Delhi, 20th Edition, 2013.

Mode of Evaluation: Internal Assessment (CAT, Quizzes, Digital Assignments) & FAT

List of Experiments		**CO: 6**
1.	Water Purification: Estimation of water hardness by EDTA method and its removal by ion-exchange resin	1 h 30 min
2. 3.	Water Quality Monitoring: Assessment of total dissolved oxygen in different water samples by Winkler's method Estimation of sulphate / chloride in drinking water by conductivity method	3 h
4/5	Material Analysis: Quantitative colorimetric determination of divalent metal ions of Ni/Fe/Cu using conventional and smart phone digital-imaging methods	**3h**
6.	Analysis of Iron in carbon steel by potentiometry	1 h 30 min

7.	Construction and working of an Zn-Cu electrochemical cell	1 h 30 min
8.	Determination of viscosity-average molecular weight of different natural/ synthetic polymers	1 h 30 min
9.	Arduino microcontroller based sensor for monitoring temperature / conductivity in samples.	1 h 30 min
	Total Laboratory Hours	**17 hours**

Mode of Evaluation: Viva-voce and Lab performance & FAT			
Recommended by Board of Studies	31-05-2019		
Approved by Academic Council	54th ACM	Date	13-06-2019

Course code	PROBLEM SOLVING AND PROGRAMMING	L	T	P	J	C
CSE1001		0	0	6	0	3
Pre-requisite	NIL	Syllabus version				
		1.0				

Course Objectives:

1. To develop broad understanding of computers, programming languages and their generations
2. Introduce the essential skills for a logical thinking for problem solving
3. To gain expertise in essential skills in programming for problem solving using computer

Course Outcome:

1.Understand the working principle of a computer and identify the purpose of a computer programming language
2. Learn various problem solving approaches and ability to identify an appropriate approach to solve the problem
3. Differentiate the programming Language constructs appropriately to solve any problem
4. Solve various engineering problems using different data structures
5. Able to modulate the given problem using structural approach of programming
6. Eefficiently handle data using at les to process and store data for the given problem

List of Challenging Experiments (Indicative)

1.	Steps in Problem Solving Drawing Flowchart using yEd tool/Raptor Tool	4 hours
2.	Introduction to Python, Demo on IDE, Keywords, Identifiers, I/O Statements, Simple Program to display Hello world in Python.	4 hours
3.	Operators and Expressions in Python	4 hours
4.	Algorithmic Approach 1: Sequential	2
5.	Algorithmic Approach 2: Selection (if, elif, if.. else, nested if else	2 hours
6.	Algorithmic Approach 3: Iteration (while and for)	4 hours
7.	Strings and its Operations	2 hours
8.	Regular Expressions	2 hours
9.	List and its operations.	2 hours
10.	Dictionaries: operations	2 hours
11.	Tuples and its operations	2 hours
12.	Set and its operations	2 hours
13.	Functions, Recursions	2 hours
14.	Sorting Techniques (Bubble/Selection/Insertion)	4 hours
15.	Searching Techniques : Sequential Search and Binary Search	3 hours
16.	Files and its Operations	4 hours
	Total Laboratory hours	**45 hours**

Text Book(s)

1.	John V. Guttag., 2016. Introduction to computation and programming using python: with applications to understanding data. PHI Publisher.

Reference Books

1.	Charles Severance.2016.Python for everybody: exploring data in Python 3, Charles Severance.
2	Charles Dierbach.2013.Introduction to computer science using python: a computational

	problem-solving focus. Wiley Publishers.Mode of Evaluation: PAT / CAT/ FAT		
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar			
Recommended by Board of Studies			
Approved by Academic Council			

Course code	Problem Solving And Object Oriented Programming	L	T	P	J	C
CSE1002		0	0	6	0	3
Pre-requisite	NIL	Syllabus version				
		v1.0				

Course Objectives:

4. To emphasize the benefits of object oriented concepts.
5. To enable students to solve the real time applications using object oriented programming features
6. To improve the skills of a logical thinking and to solve the problems using any processing elements

Course Outcome:

Upon Successful Completion of this course, student will be able to

1. Demonstrate the basics of procedural programming and to represent the real world entities as programming constructs.
2. Enumerate object oriented concepts and translate real-world applications into graphical representations.
3. Demonstrate the usage of classes and objects of the real world entities in applications.
4. Discriminate the reusability and multiple interfaces with same functionality based features to solve complex computing problems.
5. Illustrate possible error-handling constructs for unanticipated states/inputs and to use generic programming constructs to accommodate different datatypes.
6. Validate the program against le inputs towards solving the problem.

Module:1	Structured Programming	12 hours

Structured Programming conditional and looping statements - arrays - functions - pointers - dynamic memory allocation - structure

Module:2	Introduction to object oriented approach	10 hours

Introduction to object oriented approach: Why object oriented programming? - Characteristics of object oriented language: classes and objects - encapsulation - data abstraction - inheritance - polymorphism - Merits and Demerits of object oriented programming. UML - class diagram of OOP - Inline function default argument function - Exception handling (Standard) - reference: independent reference function returning reference pass by reference.

Module:3	Classes and objects	14 hours

Classes and objects: Denition of classes access specier class versus structure constructor destructor copy constructor and its importance array of objects dynamic objects - friend function-friend class

Module:4	Polymorphism and Inheritance	26 hours

Polymorphism and Inheritance: Polymorphism - compile time polymorphism function over-loading operator overloading. Inheritance - types of inheritance - constructors and destructors in inheritance constraints of multiple inheritance - virtual base class - run time polymorphism - function overriding.

Module:5	**Exception handling and Templates**	**18 hours**
Exception handling and Templates Exception handling(user-dened exception) - Function template , Class template Template with inheritance , STL Container, Algorithm, Iterator - vector, list, stack, map.		
Module:6	**IO Streams and Files**	**18 hours**
IOstreams and Files IOstreams, Manipulators - overloading Inserters() and Extractors(), Sequential and Random les writing and reading objects into/from les		
	Total Lecture hours:	**98 hours**

Text Book(s)

1.	Stanley B Lippman, Josee Lajoie, Barbara E, Moo, C++ primer, Fifth edition, Addison-Wesley, 2012.
2	Ali Bahrami, Object oriented Systems development, Tata McGraw - Hill Education, 1999.
3	Brian W. Kernighan, Dennis M. Ritchie , The C programming Language, 2nd edition, Prentice Hall Inc., 1988.

Reference Books

1.	Bjarne stroustrup, The C++ programming Language, Addison Wesley, 4th edition, 2013.
2	Harvey M. Deitel and Paul J. Deitel, C++ How to Program, 7th edition, Prentice Hall, 2010.
3	Maureen Sprankle and Jim Hubbard, Problem solving and Programming concepts, 9th

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

List of Challenging Experiments (Indicative)

	Postman Problem A postman needs to walk down every street in his area in order to deliver the mail. Assume that the distances between the streets along the roads are given. The postman starts at the post once and returns back to the post o_ce after delivering all the mails. Implement an algorithm to help the post man to walk minimum distance for the purpose.	10 hrs
	Budget Allocation for Marketing Campaign A mobile manufacturing company has got several marketing options such as Radio advertisement campaign, TV non peak hours campaign, City top paper network, Viral marketing campaign, Web advertising. From their previous experience, they have got a statistics about paybacks for each marketing option. Given the marketing budget (rupees in crores) for the current year and details of paybacks for each option, implement an algorithm to determine the amount that shall spent on each marketing option so that the company attains the maximum pro_t.	15 hrs.
	Missionaries and Cannibals Three missionaries and three cannibals are on one side of a river, along with a boat that can hold one or two people. Implement an algorithm to find a way to get everyone to the other side of the river, without ever leaving a group of missionaries in one place outnumbered by the cannibals in that place.	10 hrs.

Recommended by Board of Studies			
Approved by Academic Council			

Course code	**English for Engineers**	**L**	**T**	**P**	**J**	**C**
ENG1011		**0**	**0**	**4**	**0**	**2**

Pre-requisite	Cleared EPT / Effective English	**Syllabus version**
		v. 2.2

Course Objectives:

1. To facilitate effective language skills for academic purposes and real-life situations.
2. To enhance students' language and communication with focus on placement skills development.
3. To aid students apply language and communication skills in professional reading and reporting.

Course Outcome:

1. Apply language skills with ease in academic and real-life situations.
2. Build up a job winning digital foot print and learn to face interviews confidently.
3. Develop good interpreting and reporting skills to aid them in research.
4. Comprehend language and communication skills in academic and social contexts.
5. Acquire vocabulary and learn strategies for error-free communication.

Module:1	**Listening**	**4 hours**
Casual and Academic		
Module:2	**Speaking**	**4 hours**
Socializing Skills - Introducing Oneself- His / Her Goals & SWOT		
Module:3	**Reading**	**2 hours**
Skimming and Scanning		
Module:4	**Writing**	**2 hours**
Error-free sentences, Paragraphs		
Module:5	**Listening**	**4 hours**
News (Authentic Material): Analyzing General and Domain Specific Information		
Module:6	**Speaking**	**4 hours**
Group Discussion on factual, controversial and abstract issues		
Module:7	**Reading:**	**2 hours**
Extensive Reading		
Module:8	**Writing**	**2 hours**
Email Etiquette with focus on Content and Audience		
Module:9	**Listening**	**4 hours**
Speeches : General and Domain Specific Information		
Module:10	**Speaking**	**4 hours**
Developing Persuasive Skills - Turncoat and Debate		
Module:11	**Reading**	**2 hours**
Intensive Reading		

Module:12	**Writing**	**2 hours**
Data Transcoding		
Module:13	**Cross Cultural Communication**	**4 hours**
Understanding Inter and Cross-Cultural Communication Nuances		
Module:14	**Speaking**	**4 hours**
Public Speaking/Extempore /Monologues		
Module:15	**Reading for research**	**2 hours**
Reading Scientific/Technical Articles		
Module:16	**Writing**	**2 hours**
Creating a Digital/Online Profile – LinkedIn (Résumé/Video Profile)		
Module:17	**Speaking:**	**4 hours**
Mock Job/Placement Interviews		
Module:18	**Writing**	**2 hours**
Report Writing		
Module:19	**Speaking**	**4 hours**
Presentation using Digital Tools		
Module:20	**Vocabulary**	**2 hours**
Crossword Puzzles/Word games		
	Total Lecture hours:	**60 hours**

Text Book(s)

1.	Clive Oxenden and Christina Latham-Koenig, New English File: Advanced: Teacher's Book with Test and Assessment CD-ROM: Six-level general English course for adults Paperback –Feb 2013, Oxford University Press, UK
2.	Clive Oxenden and Christina Latham-Koenig,New English File: Advance Students
3.	Book Paperback – Feb 2012, Oxford University Press, UK Michael Vince, Language Practice for Advanced - Students Book, Feb. 2014, 4th Edition, Macmillan Education, Oxford, United Kingdom

Reference Books

1.	Steven Brown, Dorolyn Smith, Active Listening 3, 2011, 3rd Edition, Cambridge University Press,UK
2.	Tony Lynch, Study Listening, 2013, 2nd Edition, Cambridge University Press, UK
3.	Liz Hamp-Lyons, Ben Heasley, Study Writing, 2010, 2nd Edition, Cambridge University Press, UK
4.	Kenneth Anderson, Joan Maclean, Tony Lynch, Study Speaking, 2013, 2nd Edition, Cambridge, University Press, UK

5.	Eric H. Glendinning, Beverly Holmstrom, Study Reading, 2012, 2nd Edition Cambridge University Press, UK
6.	Michael Swan, Practical English Usage (Practical English Usage), Jun 2017, 4th edition, Oxford University Press, UK
7.	Michael McCarthy, Felicity O'Dell, English Vocabulary in Use Advanced (South Asian Edition), May 2015, Cambridge University Press, UK
8.	Michael Swan, Catherine Walter, Oxford English Grammar Course Advanced, Feb 2012, 4th Edition, Oxford University Press, UK
9.	Heather Silyn-Roberts, Writing for Science and Engineering: Papers, Presentations and Reports, Jun 2016, 2nd Edition, Butterworth-Heinemann, UK

Mode of Evaluation: Assignment and FAT- Mini Project, Flipped Class Room, Lecture, PPT's, Role play, Assignments Class/Virtual Presentations, Report and beyond the classroom activities

List of Challenging Experiments (Indicative)

1.	Create a Digital or Online Profile or a Digital Footprint	6 hours
2.	Prepare a video resume	8 hours
3.	Analyse a documentary critically	4 hours
4.	Turn Coat- Speaking for and against the topic / Activities through VIT Community Radio	6 hours
5.	Present a topic using 'Prezi'	6 hours
6.	Analyse a case on cross cultural communication critically	6 hours
7.	Create a list of words relating to your domain	4 hours
8.	Listen to a conversation of native speakers of English and answer the following questions	6 hours
9.	Read an article and critically analyse the text in about 150 words	6 hours
10.	Read an autobiography and role play the character in class by taking an excerpt from the book	8 hours
	Total Practical Hours	**60 hours**

Mode of assessment:

Recommended by Board of Studies	22-07-2017		
Approved by Academic Council	No. 47	Date	24.08.2017

Course Code	Ethics and Values	L	T	P	J	C
HUM 1021 / HUM1032		2	0	0	0	2
Pre-requisite	Nil	Syllabus Version				
		1.1				

Course Objectives:

1. To understand and appreciate the ethical issues faced by an individual in profession, society and polity
2. To understand the negative health impacts of certain unhealthy behaviors
3. To appreciate the need and importance of physical, emotional health and social health

Course Outcomes:

Students will be able to:

1. Follow sound morals and ethical values scrupulously to prove as good citizens
2. Understand various social problems and learn to act ethically
3. Understand the concept of addiction and how it will affect the physical and mental health
4. Identify ethical concerns in research and intellectual contexts, including academic integrity, use and citation of sources, the objective presentation of data, and the treatment of human subjects
5. Identify the main typologies, characteristics, activities, actors and forms of cybercrime

Module:1	Being Good and Responsible	5 hours	CO: 1

Gandhian values such as truth and non-violence – Comparative analysis on leaders of past and present – Society's interests versus self-interests - Personal Social Responsibility: Helping the needy, charity and serving the society

Module:2	Social Issues 1	4 hours	CO: 2

Harassment – Types - Prevention of harassment, Violence and Terrorism

Module:3	Social Issues 2	4 hours	CO: 2

Corruption: Ethical values, causes, impact, laws, prevention – Electoral malpractices;
White collar crimes - Tax evasions – Unfair trade practices

Module:4	Addiction and Health	5 hours	CO: 3

Peer pressure - Alcoholism: Ethical values, causes, impact, laws, prevention – Ill effects of smoking - Prevention of Suicides;
Sexual Health: Prevention and impact of pre-marital pregnancy and Sexually Transmitted Diseases

Module:5	Drug Abuse	3 hours	CO: 3

Abuse of different types of legal and illegal drugs: Ethical values, causes, impact, laws and prevention

Module:6	Personal and Professional Ethics	4 hours	CO: 4

Dishonesty - Stealing - Malpractices in Examinations – Plagiarism

Module:7	Abuse of Technologies	3 hours	CO:3,5

Hacking and other cyber crimes, Addiction to mobile phone usage, Video games and Social

networking websites			
Module:8	**Contemporary Issues:**	**2 hours**	**CO: 1,2,3,4,5**
Guest lectures by Industrial Experts			
	Total Lecture Hours:	**30 hours**	

Reference Books

1.	Dhaliwal, K.K (2016), "Gandhian Philosophy of Ethics: A Study of Relationship between his Presupposition and Precepts, Writers Choice, New Delhi, India.
2.	Vittal, N (2012), "Ending Corruption? - How to Clean up India?", Penguin Publishers, UK.
3.	Pagliaro, L.A. and Pagliaro, A.M (2012), "Handbook of Child and Adolescent Drug and Substance Abuse: Pharmacological , Developmental and Clinical Considerations", Wiley Publishers, U.S.A.
4.	Pandey, P. K (2012), "Sexual Harassment and Law in India", Lambert Publishers, Germany.

Mode of Evaluation: Quizzes, CAT, FAT, Digital assignments, poster/collage making and Seminars

Recommended by Board of Studies	26-07-2017		
Approved by Academic Council	No. 46	Date	24-08-2017

Course Code	Calculus for Engineers	L	T	P	J	C
MAT1011		3	0	2	0	4
Pre-requisite	10+2 Mathematics or MAT1001	Syllabus Version				
		1.0				

Course Objectives (CoB):1,2,3

1. To provide the requisite and relevant background necessary to understand the other important engineering mathematics courses offered for Engineers and Scientists.
2. To introduce important topics of applied mathematics, namely Single and Multivariable Calculus and Vector Calculus etc.
3. To impart the knowledge of Laplace transform, an important transform technique for Engineers which requires knowledge of integration

Course Outcome (CO): 1,2,3,4,5,6

At the end of this course the students should be able to

1. apply single variable differentiation and integration to solve applied problems in engineering and find the maxima and minima of functions
2. understand basic concepts of Laplace Transforms and solve problems with periodic functions, step functions, impulse functions and convolution
3. evaluate partial derivatives, limits, total differentials, Jacobians, Taylor series and optimization problems involving several variables with or without constraints
4. evaluate multiple integrals in Cartesian, Polar, Cylindrical and Spherical coordinates.
5. understand gradient, directional derivatives, divergence, curl and Greens', Stokes, Gauss theorems
6. demonstrate MATLAB code for challenging problems in engineering

Module:1	Application of Single Variable Calculus	9 hours	CO: 1

Differentiation- Extrema on an Interval-Rolle's Theorem and the Mean Value Theorem-Increasing and Decreasing functions and First derivative test-Second derivative test-Maxima and Minima-Concavity. Integration-Average function value - Area between curves - Volumes of solids of revolution -

Module:2	Laplace transforms	7 hours	CO: 2

Definition of Laplace transform-Properties-Laplace transform of periodic functions-Laplace transform of unit step function, Impulse function-Inverse Laplace transform-Convolution.

Module:3	Multivariable Calculus	4 hours	CO: 3

Functions of two variables-limits and continuity-partial derivatives –total differential-Jacobian and its properties.

Module:4	Application of Multivariable Calculus	5 hours	CO: 3

Taylor's expansion for two variables–maxima and minima–constrained maxima and minima-Lagrange's multiplier method.

Module:5	Multiple integrals	8 hours	CO: 4

Evaluation of double integrals–change of order of integration–change of variables between Cartesian and polar co-ordinates - Evaluation of triple integrals-change of variables between Cartesian and cylindrical and spherical co-ordinates- Beta and Gamma functions–interrelation -evaluation of multiple integrals using gamma and beta functions.			
Module:6	**Vector Differentiation**	**5 hours**	**CO: 5**
Scalar and vector valued functions – gradient, tangent plane–directional derivative-divergence and curl–scalar and vector potentials–Statement of vector identities-Simple problems			
Module:7	**Vector Integration**	**5 hours**	**CO: 5**
line, surface and volume integrals - Statement of Green's, Stoke's and Gauss divergence theorems -verification and evaluation of vector integrals using them.			
Module:8	**Contemporary Issues:**	**2 hours**	**CO: 1, 2, 3,4,5**
Industry Expert Lecture			
	Total Lecture hours:	**45 hours**	
Text Book(s)			
[1] Thomas' Calculus, George B.Thomas, D.Weir and J. Hass, 13th edition, Pearson, 2014. [2] Advanced Engineering Mathematics, Erwin Kreyszig, 10th Edition, Wiley India, 2015.			
Reference Books			
1. Higher Engineering Mathematics, B.S. Grewal, 43rd Edition ,Khanna Publishers, 2015 2. Higher Engineering Mathematics, John Bird, 6th Edition, Elsevier Limited, 2017. 3. Calculus: Early Transcendentals, James Stewart, 8th edition, Cengage Learning, 2017. 4. Engineering Mathematics, K.A.Stroud and Dexter J. Booth, 7th Edition, Palgrave Macmillan (2013)			
Mode of Evaluation			
Digital Assignments, Quiz, Continuous Assessments, Final Assessment Test			

List of Challenging Experiments (Indicative)		**CO: 6**
1.	Introduction to MATLAB through matrices, and general Syntax	2 hours
2	Plotting and visualizing curves and surfaces in MATLAB – Symbolic computations using MATLAB	2 hours
3.	Evaluating Extremum of a single variable function	2 hours
4.	Understanding integration as Area under the curve	2 hours
5.	Evaluation of Volume by Integrals (Solids of Revolution)	2 hours
6.	Evaluating maxima and minima of functions of several variables	2 hours
7.	Applying Lagrange multiplier optimization method	2 hours
8.	Evaluating Volume under surfaces	2 hours
9.	Evaluating triple integrals	2 hours
10.	Evaluating gradient, curl and divergence	2 hours
11.	Evaluating line integrals in vectors	2 hours

12.	Applying Green's theorem to real world problems		2 hours
	Total Laboratory Hours		**24 hours**
Mode of Evaluation:			
Weekly Assessment, Final Assessment Test			
Recommended by Board of Studies	03-06-2019		
Approved by Academic Council	No. 55	Date	13-06-2019

Course Code	Statistics for Engineers	L	T	P	J	C
MAT2001		2	1	2	0	4
Prerequisites	MAT1011 – Calculus for Engineers	Syllabus Version: 1.0				

Course Objectives (CoB): 1,2,3

1. To provide students with a framework that will help them choose the appropriate descriptive methods in various data analysis situations.
2. To analyse distributions and relationship of real-time data.
3. To apply estimation and testing methods to make inference and modelling techniques for decision making.

Course Outcome (CO): 1,2,3,4,5

At the end of the course the student should be able to:

1. Compute and interpret descriptive statistics using numerical and graphical techniques.
2. Understand the basic concepts of random variables and find an appropriate distribution for analysing data specific to an experiment.
3. Apply statistical methods like correlation, regression analysis in analysing, interpreting experimental data.
4. Make appropriate decisions using statistical inference that is the central to experimental research.
5. Use statistical methodology and tools in reliability engineering problems.
6. demonstrate R programming for statistical data

Module: 1	**Introduction to Statistics**	6 hours	**CO: 1**
Introduction to statistics and data analysis-Measures of central tendency –Measures of variability-[Moments-Skewness-Kurtosis (Concepts only)].			
Module: 2	**Random variables**	8 hours	**CO: 2**
Introduction -random variables-Probability mass Function, distribution and density functions - joint Probability distribution and joint density functions- Marginal, conditional distribution and density functions- Mathematical expectation, and its properties Covariance , moment generating function – characteristic function.			
Module: 3	**Correlation and regression**	4 hours	**CO: 3**
Correlation and Regression – Rank Correlation- Partial and Multiple correlation- Multiple regression.			
Module: 4	**Probability Distributions**	7 hours	**CO: 2**
Binomial and Poisson distributions – Normal distribution – Gamma distribution – Exponential distribution – Weibull distribution.			
Module: 5	**Hypothesis Testing I**	4 hours	**CO: 4**
Testing of hypothesis – Introduction-Types of errors, critical region, procedure of testing hypothesis-Large sample tests- Z test for Single Proportion, Difference of Proportion, mean and difference of means.			
Module: 6	**Hypothesis Testing II**	9 hours	**CO: 4**
Small sample tests- Student's t-test, F-test- chi-square test- goodness of fit - independence of attributes- Design of Experiments - Analysis of variance – one and two way classifications - CRD-RBD- LSD.			
Module: 7	**Reliability**	5 hours	**CO: 5**
Basic concepts- Hazard function-Reliabilities of series and parallel systems- System Reliability - Maintainability-Preventive and repair maintenance- Availability.			

Module: 8	**Contemporary Issues**	2 hours	**CO: 4, 5**
Industry Expert Lecture			
	Total Lecture hours	**45 hours**	

Text book(s)

1. Probability and Statistics for engineers and scientists, R.E.Walpole, R.H.Myers, S.L.Mayers and K.Ye, 9th Edition, Pearson Education (2012).
2. Applied Statistics and Probability for Engineers, Douglas C. Montgomery, George C. Runger, 6th Edition, John Wiley & Sons (2016).

Reference books

1. Reliability Engineering, E.Balagurusamy, Tata McGraw Hill, Tenth reprint 2017.
2. Probability and Statistics, J.L.Devore, 8th Edition, Brooks/Cole, Cengage Learning (2012).
3. Probability and Statistics for Engineers, R.A.Johnson, Miller Freund's, 8th edition, Prentice Hall India (2011).
4. Probability, Statistics and Reliability for Engineers and Scientists, Bilal M. Ayyub and Richard H. McCuen, 3rd edition, CRC press (2011).

Mode of Evaluation

Digital Assignments (Solutions by using soft skills), Continuous Assessment Tests, Quiz, Final Assessment Test.

List of Experiments (Indicative)		**CO: 6**
1.	Introduction: Understanding Data types; importing/exporting data.	2 hours
2.	Computing Summary Statistics /plotting and visualizing data using Tabulation and Graphical Representations.	2 hours
3.	Applying correlation and simple linear regression model to real dataset; computing and interpreting the coefficient of determination.	2 hours
4.	Applying multiple linear regression model to real dataset; computing and interpreting the multiple coefficient of determination.	2 hours
5.	Fitting the following probability distributions: Binomial distribution	2 hours
6.	Normal distribution, Poisson distribution	2 hours
7.	Testing of hypothesis for One sample mean and proportion from real-time problems.	2 hours
8.	Testing of hypothesis for Two sample means and proportion from real-time problems	2 hours
9.	Applying the t test for independent and dependent samples	2 hours
10.	Applying Chi-square test for goodness of fit test and Contingency test to real dataset	2 hours
11.	Performing ANOVA for real dataset for Completely randomized design, Randomized Block design ,Latin square Design	2 hours
	Total laboratory hours	**22 hours**

Mode of Evaluation: Weekly Assessment, Final Assessment Test

Recommended by Board of Studies	03-06-2019		
Approved by Academic Council	No. 55	Date:	13-06-2019

MEE3099	**Industrial Internship**	**L**	**T**	**P**	**J**	**C**
		0	**0**	**0**	**0**	**2**
Pre-requisite	Completion of minimum of Two semesters					
Course Objectives:						

The course is designed so as to expose the students to industry environment and to take up on-site assignment as trainees or interns.				
Course Outcome:				
At the end of this internship the student should be able to: 1. Have an exposure to industrial practices and to work in teams 2. Communicate effectively 3. Understand the impact of engineering solutions in a global, economic, environmental and societal context 4. Develop the ability to engage in research and to involve in life-long learning 5. Comprehend contemporary issues 6. Engage in establishing his/her digital footprint				
Contents			**4**	**Weeks**
Four weeks of work at industry site. Supervised by an expert at the industry.				
Mode of Evaluation: Internship Report, Presentation and Project Review				
Recommended by Board of Studies	28-02-2016			
Approved by Academic Council	No. 37	Date	16-06-2015	

Course code	TECHNICAL ANSWERS FOR REAL WORLD PROBLEMS (TARP)	L	T	P	J	C
MEE3999		1	0	0	8	3
Pre-requisite	PHY1999 and 115 Credits Earned	Syllabus version				
		v. 2.2				

Course Objectives:

1. To help students to identify the need for developing newer technologies for industrial / societal needs
2. To train students to propose and implement relevant technology for the development of the prototypes / products
3. To make the students learn to the use the methodologies available for analysing the developed prototypes / products

Course Outcome:

Upon successful completion of the course the students will be able to

1. Identify real life problems related to society
2. Apply appropriate technology (ies) to address the identified problems using engineering principles and arrive at innovative solutions

Module:1		2 hours

1. Identification of real life problems
2. Field visits can be arranged by the faculty concerned
3. 6 – 10 students can form a team (within the same / different discipline)
4. Minimum of eight hours on self-managed team activity
5. Appropriate scientific methodologies to be utilized to solve the identified issue
6. Solution should be in the form of fabrication/coding/modeling/product design/process design/relevant scientific methodology(ies)
7. Consolidated report to be submitted for assessment
8. Participation, involvement and contribution in group discussions during the contact hours will be used as the modalities for the continuous assessment of the theory component
9. Project outcome to be evaluated in terms of technical, economical, social, environmental, political and demographic feasibility
10. Contribution of each group member to be assessed

The project component to have three reviews with the weightage of 20:30:50

Mode of Evaluation: (No FAT) Continuous Assessment the project done – Mark weightage of 20:30:50 – project report to be submitted.

Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-10-2017

Course Code	Comprehensive Examination	L	T	P	J	C
MEE4098		0	0	0	0	2
Pre-requisite	NIL	Syllabus version				
		2.2				

Course Objectives:

1. To evaluate the overall understanding of the students in the core areas of B.Tech Mechanical Engineering Programme.

Course Outcome:

1. Define, explain, evaluate, and interpret the fundamental knowledge pertaining to the field of Mechanical Engineering and apply those essential knowledge to the field of Energy Engineering.

Module:1	Engineering Mechanics, Mechanics of Machines, Machine Drawing, Linkage Mechanism:	

Terminologies, Degree of Freedom – Study of planar mechanisms and their inversions. Velocity and accelerations in planar mechanisms, Coriolis component of acceleration. D'Alembert's Principle, Dynamic Analysis of planar Mechanism. Turning Moment Diagrams – Flywheels – Applications. Dynamic Balancing of Rotating masses, Balancing of Reciprocating masses. Cams with different Follower Motion. Gear terminologies- Law of gearing- Interference and undercutting- Epicyclic gear train. Three position synthesis of planar mechanism – Graphical and analytical methods – Freudentein equation. Vibration: Introduction – Terminologies- Single degree of freedom- damped and undamped free and forced vibration. Governors- types and its characteristics. Gyroscopic Effects on the Movement of airplanes and Ships. Resultant of system of forces-Equivalent force couple system-Principle of statics-Concept of free body diagram-Application problem on beams, trusses and frames. Theory of dry friction- wedge ladder friction. Concept of first moment of area and second moment of area. Principal moment of inertia. Kinematics of particles and rigid bodies - Types of motion - Rectilinear translation, curvilinear translation, General plane motion. ICR method and Relative velocity method for kinematics of rigid bodies. Kinetics of particles and rigid bodies - D'Alembert's principle- Work and energy methods. Linear Impulse and momentum principle. Elastic impact problems. Conventional representation – Welding symbols - Riveted joints - Keys – Fasteners - Bolts - Nuts - Screws – Keys- Limits - Fits and Tolerances – Allocation of fits for various mating parts –Geometric tolerance.

Module:2	Strength of Materials, Design of Machine Elements, Design of Transmission Systems, CAD/CAM	

Stress and strain in two dimensions, Principal stresses and strains, Mohr's construction, linear elastic materials, stress-strain relations, uniaxial loading, thermal stresses. Bending moment and shear force diagram, bending stresses and deflection of beams. Shear stress distribution. Torsion of shafts, helical springs. Combined stresses, thick-and thin-walled pressure vessels. Struts and columns. Strain energy concepts and theories of failure. Design for static and dynamic loading, failure theories, fatigue strength and the S-N diagram, principles of the design of machine elements such as bolted, riveted and welded joints, design of springs, shafts, keys and couplings. Design for rolling and sliding contact bearings, belt drives, chain drives, wire ropes, spur gears, helical gears, bevel gears, worm gear drives, brakes and clutches. Bresenham‟s Algorithm and DDA, Clipping, Hidden line/surface removal, Color models Lighting and shading- Graphics Standards - Wire frame, surface and solid modeling techniques, Parametric representation of

curves & surfaces, geometric transformations
NC part programming-– Canned cycles and subroutines-APT language, Rapid prototyping, part families- group technology – CAPP – Flexible manufacturing systems –CIM-OSI Model–Virtual Reality, Augmented Reality-Expert systems in CIM

Module:3	**Materials Engineering and Technology, Manufacturing Processes, Machining Processes and Metrology**	

Crystal systems, Density computations, Allotropy, Nucleation & growth, Phase diagrams (Isomorphous, Eutectic and Iron-Iron carbide), TTT & CCT diagrams, Heat treatment of steels, Non-ferrous metals (Al, Zn, Mg, Cu, Ni, Ti and their alloys), Mechanical behaviour of materials, Advanced engineering materials.
Casting, Forming and Joining Processes: Different types of castings, design of patterns, moulds and cores; solidification and cooling; riser and gating design. Plastic deformation and yield criteria; fundamentals of hot and cold working processes; load estimation for bulk (forging, rolling, extrusion, drawing) and sheet (shearing, deep drawing, bending) metal forming processes; principles of powder metallurgy. Principles of welding, types of welding processes, Arc welding types and Friction welding types. Mechanics of metal cutting - cutting tool materials, temperature, wear, and tool life, geometry and chip formation, surface finish and machinability-Lathe and its types Operational details of Shaping - Planing - Slotting –Drilling - Boring – Reaming Tapping – Broaching-Milling operations - Indexing –Gear generating principles- Gear Hobber - Gear finishing methods - Bevel gear generator-surface, cylindrical and centreless grinding processes, dressing, truing and balancing of grinding Wheels, micro-finishing honing, lapping -EDM-ECM-AJM-LAM process-Linear and angular measurements – taper measurement, threads, surface finish, inspection of straightness, flatness and alignment- Comparators - Gear testing-Coordinate measuring machines, Optical Tool Maker's Microscope, Profile Projector, SEM, AFM, TEM.

Module:4	**Engineering Thermodynamics, Thermal Engineering Systems, Heat Transfer**	

Thermodynamic systems and processes; properties of pure substances, behaviour of ideal and real gases; zeroth and first laws of thermodynamics, calculation of work and heat in various processes; second law of thermodynamics; thermodynamic property charts and tables, availability and irreversibility; thermodynamic relations. I.C. Engines: Air-standard Otto, Diesel and dual cycles- Types- working principles- Valve and port timing diagrams- combustion- knocking- Factors- Testing of IC engines- Frictional power measurement; Air compressors- Types- volumetric efficiency- Steam nozzles- critical pressure ratio - Nozzle efficiency: Refrigeration systems – Types – COP – Refrigerating capacity; Air conditioning types – properties of moist air, psychrometric chart, basic psychrometric processes – cooling load calculations. Modes of heat transfer; one dimensional heat conduction, resistance concept and electrical analogy, heat transfer through fins; unsteady heat conduction, lumped parameter system, Free and forced convection heat transfer, heat exchanger performance, LMTD and NTU methods; radiative heat transfer, black and grey surfaces, Shape factors, radiation network analysis, radiation shield, dimensionless numbers involved in all the modes of heat transfer.

Module:5	**Industrial Engineering and Management, Operations Research, Turbomachines, Fluid Mechanics**	

Economics - Elasticity of Demand ; Quantitative forecasting - time series analysis - Regression modelling; Productivity calculation; Method study - Charts - time study calculation; Plant layout -

types- layout design algorithms - Just in Time inventory management - KANBAN system; Materials Requirement Planning (MRP) calculation. Linear Programming Problems (LPP) - Transportation Model - Assignment Model, Problem of Sequencing - Program evaluation and review techniques(PERT) - Critical Path Method (CPM) Inventory Models - EOQ – Buffer stock – Shortage quantity , Queuing theory - Replacement Models – Replacement Policy. T-s, h-s diagrams, flow and non-flow work, control volume, differential and integral conservation equations. Definition and classification of Turbomachines: Cascading, efficiencies, stage losses, blade parameters and design, velocity triangles. Centrifugal fans, blowers and compressors: Stage pressure rise, slip factor, degree of reaction, stage losses, backward, forward and radial tip blades. Axial fans, blowers and compressors: Stage pressure rise, blade loading factor, flow coefficient, UGV and DGV, stalling and surging, transient flow phenomena. Steam and Gas Turbines: Work, power calculations, Impulse and Reaction stages, Velocity, Pressure and P-V compounding, Degree of reaction. Zero, Fifty, hundred percent and negative degree of reaction; IFR and OFR turbines; Layout and features of gas turbines; Governing of steam turbines. Hydraulic pumps and turbines: Centrifugal and axial flow pumps, operating head and manometric efficiency, stage losses, cavitation, Starting and specific speeds, Priming and self-priming pumps, Pelton, Francis, Kaplan and Propeller turbines, Draft tube and design. Fluid properties and pressure measurement: Properties - density, viscosity, surface tension, capillarity, and compressibility, classification of fluids, Pascal's law, fluid pressure and its measurement, manometry. Hydrostatic forces, buoyancy and metacentre: Hydrostatic forces on plane, inclined and curved surfaces, buoyancy, condition of equilibrium for submerged and floating bodies, centre of buoyancy, metacentre. Fluid dynamics: Types of flows, fluid kinematics, Lagrangian and Eulerian methods of fluid motion, control volume approach, reynolds transport theorem, continuity, Euler and Bernoulli's equations, momentum equation, Navier-Stokes equations - applications. Flow through pipes: Measurement in pipe flow, major loss, minor losses, multi reservoir problems, pipe network design, Moody's diagram, Hagen Poiseuille equation, turbulent flow. Open channel flow: Types of open channel flows, specific energy, specific force, critical flow, hydraulic jumps/surges and gradually varying flow concepts, measurement of discharge in open channels. Dimensional analysis: Dimensional homogeneity, Raleigh and Buckingham π theorems, non-dimensional numbers, model laws and distorted models, modelling and similitude. Boundary layers: Boundary layers, laminar flow and turbulent flow, boundary layer thickness, momentum Integral equation, drag and lift, separation of boundary layer, methods of separation of boundary layer.

Mode of Evaluation: Online Exam

Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-10-2017

Course code	CAPSTONE PROJECT	L	T	P	J	C
MEE4099		-	-	-	-	20
Pre-requisite	As per the academic regulations	Syllabus version				
		v. 2.2				

Course Objectives:

1. To provide a definite context, to apply the leanings from various courses of the program and solve unstructured and ill-defined problems
2. To develop an integrated approach for problem solving
3. To provide an exposure to take up a real life research problem / product development / industrial problem and arrive at meaningful conclusions / product design / solution

Course Outcome:

Upon successful completion of the course the students will be able to

1. Formulate specific problem statements for ill-defined real life problems with reasonable assumptions and constraints
2. Perform literature search and / or patent search in the area of interest
3. Develop a suitable solution methodology for the problem
4. Conduct experiments / Design & Analysis / solution iterations and document the results
5. Perform error analysis / benchmarking / costing
6. Synthesise the results and arrive at scientific conclusions / products / solution
7. Document the results in the form of technical report / presentation

Topics

Capstone Project may be a theoretical analysis, modeling & simulation, experimentation & analysis, prototype design, fabrication of new equipment, correlation and analysis of data, software development, etc. or a combination of these.

Project can be for one or two semesters based on the completion of required number of credits as per the academic regulations.

Criteria

1. Can be individual work or a group project, with a maximum of 3 students.
2. In case of group projects, the individual project report of each student should specify the individual's contribution to the group project.
3. Carried out inside or outside the university, in any relevant industry or research institution.
4. Publications in the peer reviewed journals / International Conferences will be an added advantage
5. Plagiarism checking by Turnitin is compulsory part of UG Project Report. Plagiarism level should not exceed more than 13%.

Mode of Evaluation: Mid reviews, Final Viva-Voce, Thesis and Poster Submission

Recommended by Board of Studies	17-08-2017

Approved by Academic Council	47	Date	05-10-2017

Course code	LEAN START-UP MANAGEMENT	L	T	P	J	C
MGT1022		1	0	0	4	2
Pre-requisite	Nil	Syllabus version				
		v. 2.2				

Course Objectives:

The objective of the course is to make a student to create and commercialize the product

Course Outcome:

Upon successful completion of the course the students will be able to

1. Understand developing business models and growth drivers
2. Use the business model canvas to map out key components of enterprise
3. Analyze market size, cost structure, revenue streams, and value chain
4. Understand build-measure-learn principles
5. Foreseeing and quantifying business and financial risks

Module:1		**2 hours**
Creativity and Design Thinking (identify the vertical for business opportunity, understand your customers, accurately assess market opportunity)		
Module:2		**3 hours**
Minimum Viable Product (Value Proposition, Customer Segments, Build-measure-learn process)		
Module:3		**3 hours**
Business Model Development(Channels and Partners, Revenue Model and streams, Key Resources, Activities and Costs, Customer Relationships and Customer Development Processes, Business model canvas –the lean model-templates)		
Module:4		**3 hours**
Business Plan and Access to Funding(visioning your venture, taking the product/ service to market, Market plan including Digital & Viral Marketing, start-up finance - Costs/Profits & Losses/cash flow, Angel/VC,/Bank Loans and Key elements of raising money)		
Module:5		**2 hours**
Legal, Regulatory, CSR, Standards, Taxes		
Module:6	**Contemporary discussion**	**2 hours**
	Total Lecture hours:	**15 hours**

Text Book(s)

1. Steve Blank, K & S Ranch (2012)The Startup Owner's Manual: The Step-By-Step Guide

	for Building a Great Company, 1st edition
2.	Steve Blank (2013)The Four Steps to the Epiphany, K&S Ranch; 2nd edition
3.	Eric Ries (2011) The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses, Crown Business
Reference Books	
1.	Steve Blank (2014) Holding a Cat by the Tail, , K&S Ranch Publishing LLC
2.	Karal T Ulrich, Product Design and Development, SDEppinger, McGraw Hill
3.	Peter Thiel, (2014) Zero to One: Notes on Startups, or How to Build the Future, Crown Business;
4.	Lean Analytics: Use Data to Build a Better Startup Faster(Lean Series), Alistair Croll & Benjamin Yoskovitz,O'Reilly Media; 1stEdition
5.	Marty Cagan, (2008) Inspired: How To Create Products Customers Love, SVPG Press; 1stedition

Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-10-2017

Course code	Course title	L	T	P	J	C
PHY1701	Engineering Physics	3	0	2	0	4
Pre-requisite	Physics of 12th standard or equivalent	Syllabus version				
		V.2.1				

Course Objectives:

To enable the students to understand the basics of the latest advancements in Physics viz., Quantum Mechanics, Nanotechnology, Lasers, Electro Magnetic Theory and Fiber Optics.

Course Outcome:

1. To understand the dual nature of radiation and matter.
2. To apply Schrodinger's equations to solve finite and infinite potential problems.
3. To apply quantum ideas at the nanoscale.
4. To apply quantum ideas for understanding the operation and working principle of optoelectronic devices.
5. To analyze the Maxwell's equations in differential and integral form.
6. To classify the optical fiber for different Engineering applications.
7. To apply concept of Lorentz Transformation for Engineering applications.
8. To demonstrate the quantum mechanical ideas – LAB

Module:1	Introduction to Modern Physics	6 hours	CO: 1

Planck's concept (hypothesis), Compton Effect, Particle properties of wave: Matter Waves, Davisson Germer Experiment, Heisenberg Uncertainty Principle, Wave function, and Schrodinger equation (time dependent & independent).

Module:2	Applications of Quantum Physics	5 hours	CO: 2

Particle in a 1-D box (Eigen Value and Eigen Function), 3-D Analysis (Qualitative), Tunneling Effect (Qualitative) (AB 205), Scanning Tunneling Microscope (STM).

Module:3	Nanophysics	5 hours	CO: 3

Introduction to Nano-materials, Moore's law, Properties of Nano-materials, Quantum confinement, Quantum well, wire & dot, Carbon Nano-tubes (CNT), Applications of nanotechnology in industry.

Module:4	Laser Principles and Engineering Application	6 hours	CO: 4

Laser Characteristics, Spatial and Temporal Coherence, Einstein Coefficient & its significance, Population inversion, Two, three & four level systems, Pumping schemes, Threshold gain coefficient, Components of laser, Nd-YAG, He-Ne, CO2 and Dye laser and their engineering applications.

Module:5	Electromagnetic Theory and its application	6 hours	CO: 5

Physics of Divergence, Gradient and Curl, Qualitative understanding of surface and volume integral, Maxwell Equations (Qualitative), Wave Equation (Derivation), EM Waves, Phase velocity, Group velocity, Group index , Wave guide (Qualitative)

Module:6	Propagation of EM waves in Optical fibers	10	CO: 6

	and Optoelectronic Devices	**hours**	
Light propagation through fibers, Acceptance angle, Numerical Aperture, Types of fibers - step index, graded index, single mode & multimode, Attenuation, Dispersion-intermodal and intramodal. Sources-LED & Laser Diode, Detectors-Photodetectors- PN & PIN - Applications of fiber optics in communication- Endoscopy.			
Module:7	**Special Theory of Relativity**	**5 hours**	**CO: 7**
Frame of reference, Galilean relativity, Postulate of special theory of relativity, Simultaneity, length contraction and time dilation.			
Module:8	**Contemporary issues:**	**2 hours**	**CO: 1-7**
Lecture by Industry Experts			
	Total Lecture hours:	**45 hours**	

Text Book(s)

1. Arthur Beiser et al., Concepts of Modern Physics, 2013, Sixth Edition, Tata McGraw Hill.
2. William Silfvast, Laser Fundamentals, 2008, Cambridge University Press.
3. D. J. Griffith, Introduction to Electrodynamics, 2014, 4th Edition, Pearson.
4. Djafar K. Mynbaev and Lowell L.Scheiner, Fiber Optic Communication Technology, 2011, Pearson

Reference Books

1. Raymond A. Serway, Clement J. Mosses, Curt A. Moyer Modern Physics, 2010, 3rd Indian Edition Cengage learning.
2. John R. Taylor, Chris D. Zafiratos and Michael A. Dubson, Modern Physics for Scientists and Engineers, 2011, PHI Learning Private Ltd.
3. Kenneth Krane Modern Physics, 2010, Wiley Indian Edition.
4. Nityanand Choudhary and Richa Verma, Laser Systems and Applications, 2011, PHI Learning Private Ltd.
5. S. Nagabhushana and B. Sathyanarayana, Lasers and Optical Instrumentation, 2010, I.K. International Publishing House Pvt. Ltd.,
6. R. Shevgaonkar, Electromagnetic Waves, 2005, 1st Edition, Tata McGraw Hill
7. Principles of Electromagnetics, Matthew N.O. Sadiku, 2010, Fourth Edition, Oxford.
8. Ajoy Ghatak and K. Thyagarajan, Introduction to Fiber Optics, 2010, Cambridge University Press.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

List of Experiments		**CO: 8**
1.	Determination of Planck's constant using electroluminescence process	2 hrs
2.	Electron diffraction	2 hrs
3.	Determination of wavelength of laser source (He -Ne laser and diode lasers of different wavelengths) using diffraction technique	2 hrs
4.	Determination of size of fine particle using laser diffraction	2 hrs
5.	Determination of the track width (periodicity) in a written CD	2 hrs
6.	Optical Fiber communication (source + optical fiber + detector)	2 hrs

7.	Analysis of crystallite size and strain in a nano -crystalline film using X-ray diffraction	2 hrs
8.	Numerical solutions of Schrödinger equation (e.g. particle in a box problem) (can be given as an assignment)	2 hrs
9.	Laser coherence length measurement	2 hrs
10.	Proof for transverse nature of E.M. waves	2 hrs
11.	Quantum confinement and Heisenberg's uncertainty principle	2 hrs
12.	Determination of angle of prism and refractive index for various colour – Spectrometer	2 hrs
13.	Determination of divergence of a laser beam	2 hrs
14.	Determination of crystalline size for nanomaterial (Computer simulation)	2 hrs
15.	Demonstration of phase velocity and group velocity (Computer simulation)	2 hrs
	Total Laboratory Hours	**30 hrs**

Mode of evaluation: CAT / FAT			
Recommended by Board of Studies	04-06-2019		
Approved by Academic Council	No. 55	Date	13-06-2019

Course code	Course title	L	T	P	J	C
PHY1999	Introduction to Innovative Projects	1	0	0	4	2
Pre-requisite	Nil	Syllabus version				
		1.0				

Course Objectives:

This course is offered to the students in the 1st Year of B.Tech. in order to orient them towards independent, systemic thinking and be innovative.

1. To make students confident enough to handle the day to day issues.
2. To develop the "Thinking Skill" of the students, especially Creative Thinking Skills
3. To train the students to be innovative in all their activities
4. To prepare a project report on a socially relevant theme as a solution to the existing issues

Course Outcome:

1. To understand the various types of thinking skills.
2. To enhance the innovative and creative ideas.
3. To find out a suitable solution for socially relevant issues- J component

Module:1 A	**Self Confidence**	**1 hour**	**CO1**

Understanding self – Johari Window –SWOT Analysis – Self Esteem – Being a contributor – Case Study

Project : Exploring self, understanding surrounding, thinking about how s(he) can be a contributor for the society, Creating a big picture of being an innovator – writing a 1000 words imaginary autobiography of self – Topic "Mr X – the great innovator of 2015" and upload. **(4 non- contact hours)**

Module:1 B	**Thinking Skill**	**1 hour**	**CO1**

Thinking and Behaviour – Types of thinking– Concrete – Abstract, Convergent, Divergent, Creative, Analytical, Sequential and Holistic thinking – Chunking Triangle – Context Grid – Examples – Case Study.

Project : Meeting at least 50 people belonging to various strata of life and talk to them / make field visits to identify a min of100 society related issues, problems for which they need solutions and categories them and upload along with details of people met and lessons learnt. **(4 non-contact hours)**

Module:1 C	**Lateral Thinking Skill**	**1 hour**	**CO1**

Blooms Taxonomy – HOTS – Outof the box thinking – deBono lateral thinking model – Examples

Project : Last weeks - incomplete portion to be done and uploaded

Module:2 A	**Creativity**	**1 hour**	**CO1**

Creativity Models – Walla – Barrons – Koberg & Begnall – Examples

Project : Selecting 5 out of 100 issues identified for future work. Criteria based approach for prioritisation, use of statistical tools & upload . **(4 non- contact hours)**

Module:2 B	**Brainstorming**	**1 hour**	**CO1**

25 brainstorming techniques and examples

Project : Brainstorm and come out with as many solutions as possible for the top 5 issues identified & upload . **(4 non- contact hours)**

Module:3	**Mind Mapping**	**1 hour**	**CO1**

Mind Mapping techniques and guidelines. Drawing a mind map

Project : Using Mind Maps get another set of solutions forthe next 5 issues (issue 6 – 10) . **(4 non- contact hours)**			
Module:4 A	**Systems thinking**	**1 hour**	**CO1**
Systems Thinking essentials – examples – Counter Intuitive condemns **Project :** Select 1 issue / problem for which the possible solutions are available with you. Apply Systems Thinking process and pick up one solution [explanation should be given why the other possible solutions have been left out]. Go back to the customer and assess the acceptability and upload. . **(4 non- contact hours)**			
Module:4 B	**Design Thinking**	**1 hour**	**CO1**
Design thinking process – Human element of design thinking – case study **Project :** Apply design thinking to the selected solution, apply the engineering & scientific tinge to it. Participate in "design week" celebrations upload the weeks learning out come.			
Module:5 A	**Innovation**	**1 hour**	**CO2**
Difference between Creativity and Innovation – Examples of innovation –Being innovative. **Project:** A literature searches on prototyping of your solution finalized. Prepare a prototype model or process and upload. . **(4 non- contact hours)**			
Module:5 B	**Blocks for Innovation**	**1 hour**	**CO2**
Identify Blocks for creativity and innovation – overcoming obstacles – Case Study **Project :** Project presentation on problem identification, solution, innovations-expected results – Interim review with PPT presentation. . **(4 non- contact hours)**			
Module:5 C	**Innovation Process**	**1 hour**	**CO2**
Steps for Innovation – right climate for innovation **Project:** Refining the project, based on the review report and uploading the text. . **(4 non- contact hours)**			
Module:6 A	**Innovation in India**	**1 hour**	**CO2**
Stories of 10 Indian innovations **Project:** Making the project better with add ons. . **(4 non- contact hours)**			
Module:6 B	**JUGAAD Innovation**	**1 hour**	**CO2**
Frugal and flexible approach to innovation - doing more with less Indian Examples **Project:** Fine tuning the innovation project with JUGAAD principles and uploading (Credit for JUGAAD implementation) . **(4 non- contact hours)**			
Module:7 A	**Innovation Project Proposal Presentation**	**1 hour**	**CO2**
Project proposal contents, economic input, ROI – Template **Project:** Presentation of the innovative project proposal and upload . **(4 non- contact hours)**			
Module:8 A	Contemporary issue in Innovation	**1 hour**	**CO3**
Contemporary issue in Innovation **Project:** Final project Presentation , Viva voce Exam (**4 non- contact hours)**			
	Total Lecture hours:	**15 hours**	

Text Book(s)	
1.	How to have Creative Ideas, Edward debone, Vermilon publication, UK, 2007
2.	The Art of Innovation, Tom Kelley & Jonathan Littman, Profile Books Ltd, UK, 2008

Reference Books	
1.	Creating Confidence, Meribeth Bonct, Kogan Page India Ltd, New Delhi, 2000
2.	Lateral Thinking Skills, Paul Sloane, Keogan Page India Ltd, New Delhi, 2008
3.	Indian Innovators, Akhat Agrawal, Jaico Books, Mumbai, 2015

4.	JUGAAD Innovation, Navi Radjou, Jaideep Prabhu, Simone Ahuja Random house India, Noida, 2012.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

Three reviews with weightage of 25 : 25 : 50 along with reports

Recommended by Board of Studies	15-12-2015		
Approved by Academic Council	No. xx	Date	17-12-2015

Course code	Grundstufe Deutsch	L	T	P	J	C
GER1001		0	0	0	0	2
Pre-requisite	Nil	Syllabus version				
		v.1				

Course Objectives:

The course gives students the necessary background to:

1. Demonstrate Proficiency in reading, writing, and speaking in basic German. Learning vocabulary related to profession, education centres, day-to-day activities, food, culture, sports and hobby, family set up, workplace, market and classroom activities are essential.
2. Make the students industry oriented and make them adapt in the German culture.

Course Outcome:

The students will be able to

1. remember greeting people, introducing oneself and understanding basic expressions in German.
2. understand basic grammar skills to use these in a meaning way.
3. remember beginner's level vocabulary
4. create sentences in German on a variety of topics with significant precision and in detail.
5. apply good comprehension of written discourse in areas of special interests.

Module:1	3 hours

Begrüssung, Landeskunde, Alphabet, Personalpronomen, Verben- heissen, kommen, wohnen, lernen, Zahlen (1-100), W-Fragen, Aussagesätze, Nomen- Singular und Plural, der Artikel - Bestimmter- Unbestimmter Artikel)

Lernziel :

Sich vorstellen, Grundlegendes Verständnis von Deutsch, Deutschland in Europa

Module:2	3 hours

Konjugation der Verben (regelmässig /unregelmässig),das Jahr- Monate, Jahreszeiten und die Woche, Hobbys, Berufe, Artikel, Zahlen (Hundert bis eine Million), Ja-/Nein- Frage, Imperativ mit „Sie''

Lernziel:

Sätze schreiben, über Hobbys, Berufe erzählen, usw

Module:3	6 hours

Possessivpronomen, Negation, Kasus (Bestimmter- Unbestimmter Artikel) Trennbareverben, Modalverben, Uhrzeit, Präpositionen, Lebensmittel, Getränkeund Essen, Farben, Tiere

Lernziel :

Sätze mit Modalverben, Verwendung von Artikel, Adjektiv beim Verb

Module:4	4 hours

Übersetzung: (Deutsch – Englisch / Englisch – Deutsch)

Lernziel :

Die Übung von Grammatik und Wortschatz

Module:5	5 hours

Leserverständnis. Mindmap machen, Korrespondenz- Briefe und Email

Lernziel: Übung der Sprache, Wortschatzbildung		
Module:6		**5 hours**
Aufsätze : Die Familie, Bundesländer in Deutschland, Ein Fest in Deutschland, **Lernziel :** Aktiver, selbständiger Gebrauch der Sprache		
Module:7		**4 hours**
Dialoge: a) Gespräche mit einem/einer Freund /Freundin. b) Gespräche beim Einkaufen ; in einem Supermarkt ; in einer Buchhandlung ; c) in einem Hotel - an der Rezeption ; ein Termin beim Arzt. d) Ein Telefongespräch ; Einladung–Abendessen		
Module:8		**2 hours**
Guest Lectures/ Native Speakers (Einleitung in die deustche Kultur und Politik		
	Total Lecture hours:	**30 hours**

Text Book(s)	
1.	Netzwerk Deutsch als Fremdsprache A1, Stefanie Dengler, Paul Rusch, Helen Schmtiz, Tanja Sieber, Klett-Langenscheidt Verlag, München : 2013
Reference Books	
1.	Lagune, Hartmut Aufderstrasse, Jutta Müller, Thomas Storz, 2012.
2	Deutsche Sprachlehre für Ausländer, Heinz Griesbach, Dora Schulz, 2013
3	Studio d A1, Hermann Funk, Christina Kuhn, CorneslenVerlag, Berlin :2010
4	Tangram Aktuell-I, Maria-Rosa, SchoenherrTil, Max Hueber Verlag, Muenchen :2012
	www.goethe.de wirtschaftsdeutsch.de hueber.de klett-sprachen.de www.deutschtraning.org

Mode of Evaluation: CAT / Assignment / Quiz / FAT			
Recommended by Board of Studies			
Approved by Academic Council	No.	Date	

Course code	Français quotidien	L	T	P	J	C
FRE1001		0	0	0	0	2
Pre-requisite	NIL	Syllabus version				
		v.1				

Course Objectives:

The course gives students the necessary background to:

1. learn the basics of French language and to communicate effectively in French in their day to day life.
2. Achieve functional proficiency in listening, speaking, reading and writing
3. Recognize culture-specific perspectives and values embedded in French language.

Course Outcome:

The students will be able to :

1. identify in French language the daily life communicative situations via personal pronouns, emphatic pronouns, salutations, negations and interrogations.
2. communicate effectively in French language via regular / irregular verbs.
3. demonstrate comprehension of the spoken / written language in translating simple sentences.
4. understand and demonstrate the comprehension of some particular new range of unseen written materials
5. demonstrate a clear understanding of the French culture through the language studied

Module:1	Expressions simples	3 hours

Les Salutations, Les nombres (1-100), Les jours de la semaine, Les mois de l'année, Les Pronoms Sujets, Les Pronoms Toniques, La conjugaison des verbes irréguliers- avoir / être / aller / venir / faire etc.

Savoir-faire pour:

Saluer, Se présenter, Présenter quelqu'un, Etablir des contacts

Module:2	La conjugaison des verbes réguliers	3 hours

La conjugaison des verbes réguliers, La conjugaison des verbes pronominaux, La Négation, L'interrogation avec 'Est-ce que ou sans Est-ce que'.

Savoir-faire pour:

Chercher un(e) correspondant(e), Demander des nouvelles d'une personne.

Module:3	La Nationalité du Pays, L'article (défini/ indéfini), Les prépositions	6 hours

La Nationalité du Pays, L'article (défini/ indéfini), Les prépositions (à/en/au/aux/sur/dans/avec etc.), L'article contracté, Les heures en français, L'adjectif (La Couleur, L'adjectif possessif, L'adjectif démonstratif/ L'adjectif interrogatif (quel/quelles/quelle/quelles), L'accord des adjectifs avec le nom, L'interrogation avec Comment/ Combien / Où etc.

Savoir-faire pour:

Poser des questions, Dire la date et les heures en français,

Module:4	La traduction simple	4 hours

La traduction simple :(français-anglais / anglais –français),

Savoir-faire pour :

Faire des achats, Comprendre un texte court, Demander et indiquer le chemin.

Module:5	**L'article Partitif, Mettez les phrases aux pluriels**	**5 hours**
L'article Partitif, Mettez les phrases aux pluriels, Faites une phrase avec les mots donnés, Trouvez les questions. Savoir-faire pour : Répondez aux questions générales en français, Exprimez les phrases données au Masculin ou au Féminin, Associez les phrases.		
Module:6	**Décrivez :**	**3 hours**
Décrivez : La Famille / La Maison / L'université /Les Loisirs/ La Vie quotidienne etc.		
Module:7	Dialogue	**4 hours**
Dialogue : 1. Décrire une personne. 2. Des conversations à la cafeteria. 3. Des conversations avec les membres de la famille 4. Des dialogues entre les amis.		
Module:8	**Guest lecures**	**2 hours**
Guest lecures/ Natives speakers		
	Total Lecture hours:	**30 hours**

Text Book(s)	
1.	Fréquence jeunes-1, Méthode de français, G. Capelle et N.Gidon, Hachette, Paris, 2010.
2.	Fréquence jeunes-1, Cahier d'exercices, G. Capelle et N.Gidon, Hachette, Paris, 2010.
Reference Books	
1.	CONNEXIONS 1, Méthode de français, Régine Mérieux, Yves Loiseau,Les Éditions Didier, 2010.
2	CONNEXIONS 1, Le cahier d'exercices, Régine Mérieux, Yves Loiseau, Les Éditions Didier, 2010
3	ALTER EGO 1, Méthode de français, Annie Berthet, Catherine Hugo, Véronique M. Kizirian, Béatrix Sampsonis, Monique Waendendries, Hachette livre Paris 2011
4	ALTER EGO 1, Le cahier d'activités, Annie Berthet, Catherine Hugo, Béatrix Sampsonis, Monique Waendendries , Hachette livre, Paris 2011

Mode of Evaluation: CAT / Assignment / Quiz / FAT			
Recommended by Board of Studies			
Approved by Academic Council	No.	Date	

EEE1001	Basic Electrical and Electronics Engineering	L	T	P	J	C
		2	0	2	0	3
Pre-requisite	Nil	Syllabus version				
Anti-requisite		v. 1.0				

Course Objectives:

[1] To understand the various laws and theorems applied to solve electric circuits and networks
[2] To provide the students with an overview of the most important concepts in Electrical and Electronics Engineering which is the basic need for every engineer

Course Outcome:

On the completion of this course the student will be able to:

[1] Solve basic electrical circuit problems using various laws and theorems.
[2] Analyze AC power circuits and networks, its measurement and safety concerns
[3] Classify and compare various types of electrical machines
[4] Design and implement various digital circuits
[5] Analyze the characteristics of semiconductor devices and comprehend the various modulation techniques in communication engineering
[6] Design and conduct experiments to analyze and interpret data

Module:1	DC circuits	Hours:5	

Basic circuit elements and sources, Ohms law, Kirchhoff's laws, series and parallel connection of circuit elements, Node voltage analysis, Mesh current analysis, Thevenin's and Maximum power transfer theorem.

Module:2	AC circuits	Hours:6	

Alternating voltages and currents, AC values, Single Phase RL, RC, RLC Series circuits, Power in AC circuits-Power Factor- Three Phase Systems – Star and Delta Connection- Three Phase Power Measurement – Electrical Safety –Fuses and Earthing, Residential wiring

Module:3	Electrical Machines	Hours:7	

Construction, Working Principle and applications of DC Machines, Transformers, Single phase and Three-phase Induction motors, Special Machines-Stepper motor, Servo Motor and BLDC motor

Module:4	Digital Systems	Hours:5	

Basic logic circuit concepts, Representation of Numerical Data in Binary Form- Combinational logic circuits, Synthesis of logic circuits.

Module:5	Semiconductor devices and Circuits	Hours:7	

Conduction in Semiconductor materials, PN junction diodes, Zener diodes, BJTs, MOSFETs, Rectifiers, Feedback Amplifiers using transistors. **Communication Engineering:** Modulation and Demodulation - Amplitude and Frequency Modulation

	Total Lecture hours:	30 Hours	

Mode: Flipped Class Room, Use of physical and computer models to lecture, visit to industries. Minimum of 2 lectures by industry experts.

Proposed Laboratory Experiments: (Hardware and Simulation)		

1. Thevenin's and Maximum Power Transfer Theorems – Impedance matching of source and load. 2. Sinusoidal steady state Response of RLC circuits. 3. Three phase power measurement for ac loads. 4. Staircase wiring circuit layout for multi storey building. 5. Fabricate and test a PCB layout for a rectifier circuit. 6. Half and full adder circuits. 7. Full wave Rectifier circuits used in DC power supplies. Study the characteristics of the semiconductor device used. 8. Regulated power supply using zener diode. Study the characteristics of the Zener diode used. 9. Lamp dimmer circuit (Darlington pair circuit using transistors) used in cars. Study the characteristics of the transistor used. 10. Characteristics of MOSFET.

Text Book(s)	
1.	1. John Bird, 'Electrical circuit theory and technology ', Newnes publications, 4 t h Edition, 2010.
Reference Books	
1.	Allan R. Hambley, 'Electrical Engineering -Principles & Applications' Pearson Education, First Impression, 6/e, 2013.
2.	Simon Haykin, 'Communication Systems', John Wiley & Sons, 5 t h Edition, 2009.
3.	Charles K Alexander, Mathew N O Sadiku, 'Fundamentals of Electric Circuits', Tata McGraw Hill, 2012.
4.	Batarseh, 'Power Electronics Circuits', Wiley, 2003.
5.	W. H. Hayt, J.E. Kemmerly and S. M. Durbin, 'Engineering Circuit Analysis', 6/e, Tata McGraw Hill, New Delhi, 2011.
6.	Fitzgerald, Higgabogan, Grabel, 'Basic Electrical Engineering', 5t h edn, McGraw Hill, 2009.
7.	S.L.Uppal, 'Electrical Wiring Estimating and Costing ', Khanna publishers, NewDelhi, 2008.

Recommended by Board of Studies	29/05/2015		
Approved by Academic Council	37th AC	Date	16/06/2015

Course code	Applications of Differential and Difference Equations	L	T	P	J	C
MAT2002		3	0	2	0	4
Pre-requisite	MAT1011 - Calculus for Engineers	Syllabus Version				
		1.0				

Course Objectives (CoB): 1,2,3,4

The course is aimed at

[1] Presenting the elementary notions of Fourier series, which is vital in practical harmonic analysis

[2] Imparting the knowledge of eigenvalues and eigen vectors of matrices and the transform techniques to solve linear systems, that arise in sciences and engineering [3] Enriching the skills in solving initial and boundary value problems

[4] Impart the knowledge and application of difference equations and the Z-transform in discrete systems, that are inherent in natural and physical processes

Course Outcome (CO): 1,2,3,4,5

At the end of the course the student should be able to

[1] Employ the tools of Fourier series to find harmonics of periodic functions from the tabulated values

[2] Apply the concepts of eigenvalues, eigen vectors and diagonalisation in linear systems

[3] Know the techniques of solving differential equations

[4] understand the series solution of differential equations and finding eigen values, eigen functions of Strum-Liouville's problem

[5] Know the Z-transform and its application in population dynamics and digital signal processing

[6] demonstrate MATLAB programming for engineering problems

Module:1	Fourier series:	6 hours	CO: 1

Fourier series - Euler's formulae - Dirichlet's conditions - Change of interval - Half range series – RMS value – Parseval's identity – Computation of harmonics

Module:2	Matrices:	6 hours	CO: 2

Eigenvalues and Eigen vectors - Properties of eigenvalues and eigen vectors – Cayley-Hamilton theorem - Similarity of transformation - Orthogonal transformation and nature of quadratic form

Module:3	Solution of ordinary differential equations:	6 hours	CO: 3

Linear second order ordinary differential equation with constant coefficients – Solutions of homogenous and non-homogenous equations - Method of undetermined coefficients – method of variation of parameters – Solutions of Cauchy-Euler and Cauchy-Legendre differential equations

Module:4	Solution of differential equations through Laplace transform and matrix method	8 hours	CO: 3

Solution of ODE's - Nonhomogeneous terms involving Heaviside function, Impulse function - Solving nonhomogeneous system using Laplace transform – Reduction of *n*th order differential equation to first order system - Solving nonhomogeneous system of first

order differential equations $(X' = AX + G)$ and $X'' = AX$			
Module:5	**Strum Liouville's problems and power series Solutions:**	**6 hours**	**CO: 4**
The Strum-Liouville's Problem - Orthogonality of Eigen functions - Series solutions of differential equations about ordinary and regular singular points - Legendre differential equation - Bessel's differential equation			
Module:6	**Z-Transform:**	**6 hours**	**CO: 5**
Z-transform -transforms of standard functions - Inverse Z-transform: by partial fractions and convolution method			
Module:7	**Difference equations:**	**5 hours**	**CO: 5**
Difference equation - First and second order difference equations with constant coefficients - Fibonacci sequence - Solution of difference equations - Complementary function - Particular integral by the method of undetermined coefficients - Solution of simple difference equations using Z-transform			
Module:8	**Contemporary Issues**	**2 hours**	**CO: 2, 3, 5**
Industry Expert Lecture			
	Total Lecture hours:	**45 hours**	

Text Book(s)

1.	Advanced Engineering Mathematics, Erwin Kreyszig, 10th Edition, John Wiley India, 2015

Reference Books

1.	Higher Engineering Mathematics, B. S. Grewal, 43rd Edition, Khanna Publishers, India, 2015
2.	Advanced Engineering Mathematics by Michael D. Greenberg, 2nd Edition, Pearson Education, Indian edition, 2006

Mode of Evaluation

Digital Assignments (Solutions by using soft skills), Continuous Assessment Tests, Quiz, Final Assessment Test		**CO:6**
1.	Solving Homogeneous differential equations arising in engineering problems	2 hours
2.	Solving non-homogeneous differential equations and Cauchy, Legendre equations	2 hours
3.	Applying the technique of Laplace transform to solve differential equations	2 hours
4.	Applications of Second order differential equations to Mass spring system (damped, undamped, Forced oscillations), LCR circuits etc.	2 hours
5.	Visualizing Eigen value and Eigen vectors	2 hours
6.	Solving system of differential equations arising in engineering applications	2 hours
7.	Applying the Power series method to solve differential equations arising in engineering applications	2 hours

8.	Applying the Frobenius method to solve differential equations arising in engineering applications	2 hours
9.	Visualising Bessel and Legendre polynomials	2 hours
10.	Evaluating Fourier series-Harmonic series	2 hours
11.	Applying Z-Transforms to functions encountered in engineering	2 hours
12.	Solving Difference equations arising in engineering applications	2 hours
	Total Laboratory Hours	**24 hours**

Mode of Evaluation: Weekly Assessment, Final Assessment Test			
Recommended by Board of Studies	03-06-2019		
Approved by Academic Council	No. 55	Date	13-06-2019

Course code	Complex Variables and Partial Differential Equation	L	T	P	J	C
MAT3003		3	2	0	0	4
Pre-requisite	MAT2002 Applications of Differential and Difference Equations	Syllabus version				
		1.0				

Course Objectives (CoB):

The aim of this course is to present a comprehensive, compact and integrated treatment of two most important branches of applied mathematics for engineers and scientists namely the functions of complex variable and Partial differential equations in finite and infinite domains

Course Outcome (CO):1,2,3

At the end of the course the student should be able to

[1] construct analytic functions and find complex potential of fluid flow and electric fields
[2] find the image of straight lines by elementary transformations and
[3] able to express analytic functions in power series
[4] evaluate real integrals using techniques of contour integration
[5] analyze partial differential equations, and its applications, design the boundary value problems (one dimensional heat and wave equations) and find Fourier series, Fourier transform techniques in their respective engineering problems.

Module:1	Analytic Functions	6 hours	CO: 1

Complex variable-Analytic functions and Cauchy – Riemann equations - Laplace equation and Harmonic functions - Construction of Harmonic conjugate and analytic functions - Applications of analytic functions to fluid-flow and Field problems.

Module:2	Conformal and Bilinear transformations	5 hours	CO: 2

Conformal mapping - Elementary transformations-translation, magnification, rotation, inversion. Exponential and Square transformations ($w = e^z$, z^2) - Bilinear transformation - Cross-ratio-Images of the regions bounded by straight lines under the above transformations.

Module:3	Power series	4 hours	CO: 3

Functions given by Power Series - Taylor and Laurent series -singularities - poles – Residues.

Module:4	Complex Integration	5 hours	CO: 4

Integration of a complex function along a contour - Cauchy-Goursat theorem- Cauchy's integral formula -Cauchy's residue theorem - Evaluation of real integrals - Indented contour integral.

Module:5	Partial Differential equations of first order	6 hours	CO: 5

Formation and solution of partial differential equation - General, Particular, Complete and Singular integrals - Partial Differential equations of first order of the forms: F(p,q)=0, F(z,p,q)=0, F(x,p)=G(y,q) and Clairaut's form - Lagrange's equation: Pp+Qq = R.

Module:6	Applications of Partial Differential Equations	10 hours	CO: 5

Linear partial differential equations of higher order with constant coefficients. Solution of a

partial differential equation by separation of variables - Boundary Value Problems-one dimensional wave and heat equations- Fourier series solution.			
Module:7	**Fourier transforms**	**7 hours**	**CO: 5**
Complex Fourier transform and properties - Relation between Fourier and Laplace transforms - Fourier sine and cosine transforms – Convolution Theorem and Parseval's identity.			
Module:8	**Contemporary issues:**	**2 hours**	**CO: 2, 3**
Industry Expert Lecture			
	Total Lecture hours:	**45 hours**	
Tutorial	• A minimum of 10 problems to be worked out by students inventory Tutorial Class • Another 5 problems per Tutorial Class to be given as home work.	**30 hours**	**CO: 1, 2, 3**

Text Book(s)

1.	Advanced Engineering Mathematics, Erwin Kreyszig, 10th Edition, John Wiley & Sons (Wiley student Edison) (2015)

Reference Books

1	Higher Engineering Mathematics, B. S. Grewal, 43rd Edition (2019), Khanna Publishers, New Delhi
2	A first course in complex analysis with applications, G.Dennis Zill, Patrick D. Shanahan, 3rd Edition, 2013, Jones and Bartlett Publishers Series in Mathematics:
3	Advanced Engineering Mathematics, Michael, D. Greenberg, 2nd Edition, Pearson Education (2006)
4	Advanced Engineering Mathematics, Peter V. O' Neil, 7th Edition, Cengage Learning (2012)
5	Complex Analysis for Mathematics and Engineers, JH Mathews, R. W. Howell, 5th Edition, Narosa Publishers (2013)

Mode of Evaluation:

Digital Assignments(Solutions by using soft skill),Quiz, Continuous Assessments, Final Assessment Test.

Recommended by Board of Studies	03-06-2019		
Approved by Academic Council	No. 55	Date	13-06-2019

Course Code	Applied Numerical Methods	L	T	P	J	C
MAT3005		3	2	0	0	4
Pre-requisite	MAT2002 – Applications of Differential and Difference Equations	Syllabus Version				
		1.0				

Course Objectives (CoB): 1,2,3,4

The aim of this course
[1] is to cover certain basic, important computer oriented numerical methods for analyzing problems that arise in engineering and physical sciences.
[2] is to use MATLAB as the primary computer language to obtain solutions to a few problems that arise in their respective engineering courses.
[3] is to impart skills to analyse problems connected with data analysis,
[4] is to solve ordinary and partial differential equations numerically

Course Outcome (CO): 1,2,3,4,5

At the end of the course the student should be able to
[1] Observe the difference between exact solution and approximate solution.
[2] Use the numerical techniques (algorithms) to find the solution (approximate) algebraic equations and system of equations.
[3] Fit the data using interpolation technique and spline methods.
[4] Find the solution of ordinary differential equations , Heat and Wave equation numerically.
[5] Apply calculus of variation techniques to extremize the functional and also find approximate series solution to ordinary differential equations

Module:1	Algebraic and Transcendental Equations	5 hours	CO: 1

General iterative method- rates of convergence- Secant method - Newton – Raphson method- System of non-linear equations by Newton's method.

Module:2	System of Linear Equations and Eigen Value Problems	6 hours	CO: 2

Gauss –Seidel iteration method. Convergence analysis of iterative methods-LU Decomposition -Tri diagonal system of equations-Thomas algorithm- Eigen values of a matrix by Power and Jacobi methods.

Module:3	Interpolation	6 hours	CO: 3

Finite difference operators- Newton's forward-Newton's Backward- Central differences- Stirling's interpolation - Lagrange's interpolation - Inverse Interpolation-Newton's divided difference-Interpolation with cubic splines.

Module:4	Numerical Differentiation and Integration	6 hours	CO: 3

Numerical differentiation with interpolation polynomials-maxima and minima for tabulated values-Trapezoidal rule, Simpsons $1/3^{rd}$ and $3/8^{th}$ rules. –Romberg's method. Two and Three point Gaussian quadrature formula.

Module:5	Numerical Solution of Ordinary Differential Equations	8 hours	CO: 4

First and second order differential equations - Fourth order Runge – Kutta method. Adams-

Bashforth-Moulton predictor-corrector methods. Finite difference solution for the second order ordinary differential equations.			
Module:6	**Numerical Solution of Partial Differential Equations**	**6 hours**	**CO: 4**
Classification of second order linear partial differential equations-Laplace equation –Gauss-Seidal method-One dimensional heat equation- Schmidt explicit method-Crank-Nicolson implicit method.-One dimensional wave equation–Explicit method.			
Module:7	**Variational Methods**	**6 hours**	**CO: 5**
Introduction - functional –variational problems- extremals of functional of a single dependent variable and its first derivative- functional involving higher order derivatives- Isoperimetric problems- Galerkins- Rayleigh Ritz methods.			
Module:8	**Contemporary Issues**	**2 hours**	**CO: 4, 5**
Industry Expert Lecture			
	Total Lecture hours:	**45 hours**	
Tutorial	• A minimum of 10 problems to be worked out by students in every Tutorial Class. • Another 5 problems per Tutorial Class to be given for practise.	**30 hours**	**CO: 1, 2, 3, 4, 5**

Text Book(s)

1. Numerical Methods for Scientific and Engineering, M. K. Jain, S. R. K. Iyengar and R. K. Jain, New Age International Ltd., 6th Edition, 2012.
2. Applied Numerical Analysis, C. F. Gerald and P.V. Wheatley, Addition-Wesley, 7th Edition, 2004.

Reference Books

1. Introductory Methods of Numerical Analysis, S.S. Sastry, PHI Pvt. Ltd., 5th Edition, New Delhi, 2009.
2. Applied Numerical Methods Using MATLAB, W.Y. Yang, W. Cao, T.S. Chung and J. Morris, Wiley India Edn., 2007.
3. Numerical Methods for Engineers with Programming and Software Applications, Steven C. Chapra and Ra P. Canale, 7th Edition, Tata McGraw Hill, 2014.
4. Numerical Analysis, R.L. Burden and J. D. Faires, 4th Edition, Brooks Cole, 2012.
5. Numerical Methods: Principles, Analysis and Algorithms, Srimanta Pal, Oxford University Press India; 978-0195693751, 2009.

Mode of Evaluation

Digital Assignments (Solutions by using soft skills), Continuous Assessment Tests, Final Assessment Test

Recommended by Board of Studies	03-06-2019		
Approved by Academic Council	No. 55	Date	13-06-2019

Course Code	ENGINEERING DRAWING	L	T	P	J	C
MEE1001		1	0	4	0	3
Pre-requisite	NIL	Syllabus version				
		v. 2.2				

Course Objectives:

1. Understand and escalate the importance of basic concepts and principles of Engineering Drawing (components, sections, views, and graphical representation).
2. Enable the students with various concepts like dimensioning, conventions and standards related to working drawings in order to become professionally efficient.
3. Develop the ability to communicate with others through the language of technical drawing and sketching.
4. Ability to read and interpret engineering drawings created by others.
5. Ability to draw orthographic projections and sections.
6. Develop an understanding for size specification procedures and use of SI and traditional units of linear measure.

Course Outcome:

Upon successful completion of the course the students will be able to

1. Apply BIS and ISO Standards in Engineering Drafting.
2. Graphically construct mathematical curves in engineering applications.
3. Visualize geometrical solids in 3D space through Orthographic Projections
4. Construct isometric scale, isometric projections and views.
5. Draw sections of solids including cylinders, cones, prisms and pyramids.
6. Draw projections of lines, planes, solids, isometric projections and sections of solids including cylinders, cones, prisms and pyramids using Mini-Dafter and CAD.
7. Construct orthographic projections from pictorial views.

Module:1	Lettering and Dimensioning	1 hours

Introduction, lettering practice, Elements of dimensioning - systems of dimensioning.

Module:2	Geometric Constructions	2 hours

Free hand sketching, Conic sections, Special curves.

Module:3	Projection of Points and Projection of Lines	2 hours

Projection of Points: First and Third Angle Projections; Projection of points.

Projection of Lines: Projection of straight lines (First angle projection only); Projection of lines inclined to one plane and both planes, true length and true inclinations.

Module:4	Projection of Solids and Section of Solids	3 hours

Projection of solids: Classification of solids, Projection of solids in simple position, Projection of solids inclined to one plane.

Sections of Solids: Right regular solids and auxiliary views for the true shape of the sections.		
Module:5	**Development of Surfaces**	**2 hours**
Development of surfaces for various regular solids.		
Module:6	**Isometric Projection and Perspective Projection**	**2 hours**
Isometric Projection: Isometric scales, Isometric projections of simple and combination of solids; **Perspective Projection:** Orthographic representation of a perspective views – Plane figures and simple solids - Visual ray method.		
Module:7	**Orthographic Projection**	**2 hours**
Conversion of pictorial view into orthographic Projection.		
Module:8	**Contemporary issues**	**1 hours**
	Total Lecture hours:	**15 hours**

Text Book(s)	
1.	Venugopal K and Prabhu Raja V, "Engineering Graphics", New AGE International Publishers, 2015.
Reference Books	
1.	N. D. Bhatt, Engineering Drawing, Charotar publishing House, 2012.
2	Natarajan, K. V., A Text book of Engineering Graphics, Dhanalakshmi Publishers, 2012.
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar	

List of Challenging Experiments (Indicative)		
1.	Identifying the incorrect dimensioning and correct it as per BIS standards for Engineering Components.	4 hours
2.	Tutorials on free hand sketching of the plan view of stadium, garden, etc.,	4 hours
3.	Tutorials on geometric constructions like conics and special curves for projection of cricket ball, missile projection, etc.,	4 hours
4.	Representation of orthographic projection of points	4 hours
5.	Representation of orthographic projection of lines (First angle projection only) inclined to one plane and projection of lines inclined to both the planes- solving problems like electrical bulbs hanging from the roof, finding the shortest distance between fan to electrical switch board, etc.,	8 hours
6.	Sketching orthographic projection of solids in simple position and projection of solids inclined to one plane for household accessories and objects.	8 hours
7.	Drawing the auxiliary views, orthographic views and true shape of sectioned regular solids for household accessories and objects.	4 hours
8.	Development of lateral surfaces of the regular shapes and sectioned shapes for water cans, refrigerator, cylinder container, funnel, etc.,	4 hours
9.	Conversion of orthographic views to isometric views for engineering	8 hours

	components.	
10.	Tutorial problems on perspective projection of plane figures and simple solids for train with track, landscape, etc.,	4 hours
11.	Conversion of pictorial drawing into orthographic projection for engineering components, architectural structures, etc.,	8 hours
	Total Laboratory Hours	**60 hours**
Mode of assessment:		
Recommended by Board of Studies	17-08-2017	
Approved by Academic Council	47	Date 05-10-2017

Course code	ENGINEERING MECHANICS	L	T	P	J	C
MEE1002		2	2	0	0	3
Pre-requisite	NIL	Syllabus version				
		v. 2.2				

Course Objectives:

1. To enable students to apply fundamental laws and basic concepts of rigid body mechanics to solve problems of bodies under rest or in motion.
2. To enable the students to apply conditions of static equilibrium to analyse physical systems.
3. To compute the properties of areas and bodies.

Course Outcome:

Upon successful completion of the course the students will be able to

1. Compute the resultant of system of forces in plane and space acting on bodies.
2. Predict the support-reactions and the internal forces of the members of various trusses and frames.
3. Analyse equilibrium problems with friction.
4. Apply transfer theorems to determine properties of various sections.
5. Analyse equilibrium of connected bodies virtual work method.
6. Predict motion parameters of bodies under rectilinear, curvilinear and general plane motion.

Module:1	Basics of Statics	5 hours

Fundamental Principles – Coplanar forces – Resolution and Composition of forces and equilibrium of particles – Forces of a particle in space – Equivalent system of forces – Principle of transmissibility – Single equivalent force – Free body diagram – Equilibrium of rigid bodies in two dimensions and three dimensions.

Module:2	Analysis of Structures	4 hours

Types of supports and their reactions – Plane trusses and frames - Analysis of forces by method of joints and method of sections.

Module:3	Friction	3 hours

Characteristics of dry friction – simple contact friction – Wedges and Ladder friction.

Module:4	Properties of Surfaces and Solids	4 hours

Centroid - First moment of area – Second moment of area – Moment and product of inertia of plane areas – Transfer Theorems - Polar moment of inertia – Principal axes – Mass moment of inertia.

Module:5	Virtual Work	4 hours

Virtual work – Principle of virtual work – System of connected rigid bodies – Degrees of freedom

– Conservative forces – Potential energy – Potential energy criteria for equilibrium.		
Module:6	**Kinematics**	**4 hours**
Displacements, Velocity and Acceleration – Rectilinear motion – Curvilinear motion – Tangential and Normal components – Radial and Transverse components.		
Module:7	**Energy and Momentum Methods**	**4 hours**
Principle of work and energy for a particle and a rigid body in plane motion – Conservation of energy - Principle of impulse and momentum for a particle and a rigid bodies in plane motion – Conservation of momentum.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)	
1.	Beer, Johnston, Cornwell and Sanghi, Vector Mechanics for Engineers: Statics and Dynamics, 10th Edition, McGraw-Companies, Inc., New York, 2013.
Reference Books	
1.	Russell C Hibbeler and Ashok Gupta, Engineering Mechanics: Statics and Dynamics (11th Edition), Pearson Education Inc., Prentice Hall, 2010.
2.	Meriam J.L and Kraige L.G., Engineering Mechanics, Volume I - Statics, Volume II - Dynamics, 7th Edition, John Wiley & Sons, New York, 2012.
3.	Rajasekaran S and Sankarasubramanian G, Fundamentals of Engineering Mechanics, 3rd Edition, Vikas Publishing House Pvt Ltd., India, 2013.
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar	
Mode of assessment:	

Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-10-2017

Course code	ENGINEERING THERMODYNAMICS	L	T	P	J	C
MEE1003		2	2	0	0	3
Pre-requisite	NIL	Syllabus version				
		v. 2.2				

Course Objectives:

1. Familiarize with the concepts of 1st and 2nd Laws of Thermodynamics.
2. Evaluate the properties of pure substances and mixtures.
3. Understand and analyze power and refrigeration cycles.

Course Outcome:

Upon successful completion of the course the students will be able to

1. Identify thermodynamics systems, point functions and path functions.
2. Solve engineering problems using zeroth and first laws of thermodynamics.
3. Analyse the heat and work interactions by applying the concepts of entropy principles and exergy.
4. Analyse thermodynamic systems involving pure substances and mixtures.
5. Calculate thermodynamics properties based on thermodynamics relations.
6. Analyse basic thermodynamic cycles of various systems.

Module:1	Basic Concepts in Thermodynamics	3 hours

Basic concepts of Thermodynamics - Thermodynamics and Energy - Closed and open systems - Properties of a system - State and equilibrium - Processes and cycles - Forms of energy - Work and heat transfer - Temperature and Zeroth law of thermodynamics.

Module:2	First law of thermodynamics	3 hours

Energy balance for closed systems - First law applied to steady – flow engineering devices

Module:3	Second Law of Thermodynamics and Exergy	6 hours

Limitations of the first law of Thermodynamics - Kelvin-Planck and Clausius statements and its equivalence- Refrigerators, Heat Pump–COP - Perpetual Motion Machines - Reversible and Irreversible process Carnot's Theorem - Entropy - The Clausius inequality - Availability and irreversibility - Second law efficiency-Quality of Energy

Module:4	Properties of Pure Substance and Mixtures	5 hours

Property diagram for water-phase change processes-refrigerants-real gases-Compressibility factor-Composition of gas mixtures - Mass and mole fractions - Dalton's law of additive pressures - Amagat's law of additive volumes - Evaluating properties of gas mixtures

Module:5	Thermodynamic relations	2 hours

Gibbs and Helmholtz function-Maxwell's relations-Clapeyron equations-general relations of properties

Module:6	**Gas power cycles**	**4 hours**
Air standard assumptions - Otto cycle - Diesel and Dual cycles - Brayton cycle		
Module:7	**Vapor and Refrigeration Cycles**	**5 hours**
Rankine cycle-reheat-regeneration- Vapor compression refrigeration cycle		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)	
1.	Yunus A. Cengel, Thermodynamics: An Engineering Approach, 8th Edition, McGraw - Hill Education, 2017.
Reference Books	
1.	P. K. Nag, Engineering Thermodynamics, 6th Edition, McGraw - Hill Education, 2017.
2.	Michael Moran and Howard Shapiro, Principles of Engineering Thermodynamics, 8th Edition, Wiley, 2015.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar			
Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-10-2017

Course code	FLUID MECHANICS	L	T	P	J	C
MEE1004		2	2	2	0	4
Pre-requisite	NIL	Syllabus version				
		v. 2.2				

Course Objectives:

1. To apply hydrostatic law, principle of mass and momentum in fluid flows, concepts in Euler's and Bernoulli equations.
2. To provide fundamental knowledge of fluids, its properties and behaviour under various conditions of internal and external flows.
3. To determine the losses in a flow system, flow through pipes, boundary layer concepts.

Course Outcome:

Upon successful completion of the course the students will be able to

1. Analyse various hydraulic systems by applying the fundamental laws of fluid statics.
2. Solve the fluid flow governing equations by taking suitable constraints and assumptions
3. Evaluate major and minor losses in pipes
4. Analyse the practical significance of open channel flows
5. Perform dimensional analysis on any real life problems
6. Interpret the boundary layer aspects of laminar and turbulent flows
7. Experimentally determine the fluid properties and flow parameters using various experimental setups.

Module: 1	Introduction to Fluid Statics	4 hours

Definition of fluid, Concept of continuum, Fluid properties, Classification of fluids, Pascal's Law and Hydrostatic Law, Pressure and its variation in a static Fluid, Measurement of static fluid pressure: Manometers.

Module: 2	Hydrostatic Forces and Buoyancy	4 hours

Hydrostatic forces on Plane –Inclined and Curved surfaces, Buoyancy, Condition of Equilibrium for Submerged and Floating Bodies, Centre of Buoyancy, Metacentre–Determination of Metacentric Height.

Module: 3	Fluid Kinematics and Dynamics	6 hours

Fluid kinematics: Description of fluid motion – Lagrangian and Eulerian approach, Types of flows, Control volume, Material derivative and acceleration, Streamlines, pathlines and streaklines, Stream function and velocity potential function, Reynolds transport theorem.

Fluid dynamics: Continuity equation, Euler and Bernoulli's equations – orificemeter, venturimeter, Momentum equation, Application of momentum equation – forces on curved pipes, Navier–Stokes Equations.

Module: 4	Flow through pipes	4 hours

Measurement in pipe flow- Major loss, Darcy–Weisbach equation, Moody's diagram, Minor losses,

Multi reservoir problems, pipe network design, Hagen Poiseuille equation, Turbulent flow.		
Module: 5	**Open channel flow**	**3 hours**
Types of open channel flows, Specific Energy, Specific force, Critical flow, Hydraulic jumps/Surges and gradually varying flow concepts, Measurement of discharge in open channels.		
Module: 6	**Dimensional Analysis**	**3 hours**
Dimensional homogeneity, Rayleigh's method, Buckingham π theorem, Non-dimensional numbers, Model laws and distorted models, Modelling and similitude.		
Module: 7	**Boundary layer flow**	**4 hours**
Boundary layers, Laminar flow and turbulent flow, Boundary layer thickness, Momentum integral equation, Drag and lift, Separation of boundary layer, Methods of preventing the boundary layer separation.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)	
1.	Robert W. Fox, Alan T. McDonald, Philip J. Pirtchard John W. Mitchell, Introduction to Fluid Mechanics, 9th Edition, Wiley Publications, 2015.
Reference Books	
1.	P.N.Modi and S.M.Seth, Hydraulics and Fluid Mechanics including Hydraulic Machines, 17th Edition, 2011.
2.	Yunus A. Çengel, John M. Cimbala, Fluid Mechanics: Fundamentals And Applications, McGraw-Hill, 3rd Edition, 2013.
3.	Dr.R.K.Bansal, A Textbook of Fluid Mechanics and Hydraulic Machines, 5th Edition, Laxmi Publication, 2012.
4.	Donald F. Elger, Barbara C. Williams, Clayton T. Crowe, John A. Roberson, Engineering Fluid Mechanics, John Wiley & Sons, 10th Edition, 2013.
5.	V.L. Streeter, Fluid Mechanics, McGraw Hill Book Co., 2010.
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar	

List of Challenging Experiments (Indicative)		
1.	Estimation of discharge from a given tank using orifice (constant head method)	3 hours
2.	Estimation of discharge from a given tank using mouthpiece (variable head method)	3 hours
3.	Determination of discharge in an open channel using rectangular Notch	3 hours
4.	Determination of discharge of a given pipe flow using venturimeter	3 hours
5.	Determination of discharge of a given pipe flow using orifice meter	3 hours
6.	Estimation of friction factor and major loss for a given flow system	3 hours

7.	Estimation of minor losses for a given pipe line	3 hours
8.	Determination of state of flow in a closed conduit using Reynold's experiment	3 hours
9.	Verification of conservation of energy principle for a given flow system using Bernoulli's Theorem	3 hours
10.	Estimating the flow rate in a pipe line using water meter	1.5 hours
11	Study and calibration of a pitot static tube	1.5 hours
	Total laboratory hours	**30 hours**

Mode of assessment:			
Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-10-2017

Course code	MATERIALS ENGINEERING AND TECHNOLOGY	L	T	P	J	C
MEE1005		3	0	2	0	4
Pre-requisite	NIL	Syllabus version				
		v. 2.2				

Course Objectives:

1. To develop the knowledge on structure of materials including crystallography, microstructure, defects and phase diagrams
2. To provide an understanding to students on the correlation between structure, processing, mechanical properties and performance of materials
3. To develop the knowledge on mechanical properties of materials and strengthening mechanism
4. To give insight in to advanced materials such as polymers, ceramics and composite and their applications

Course Outcome:

Upon successful completion of the course the students will be able to

1. Suggest suitable engineering materials for different application
2. Identify various phases of metals and alloys through appropriate phase diagrams
3. Apply suitable heat treatment process based on material properties
4. Evaluate the effect of alloying elements, properties and application of ferrous and non-ferrous metals
5. Evaluate the mechanical behavior of materials for different applications
6. Apply advanced materials such as polymers, ceramics and composites in product design
7. Correlate the structure-property relationship in metals/alloys in as-received and heat treated conditions

Module:1	Structure of Materials	8 hours

Introduction to engineering materials – significance of structure property correlations in all classes of engineering materials, Unit Cells, Metallic Crystal Structures, Density Computations, Crystal Systems, Crystallographic Points, Crystallographic Directions, Crystallographic Planes, Linear and Planar Densities, Close-Packed Crystal Structures, Crystalline and Non-crystalline Materials, Single Crystals, Polycrystalline Materials, Imperfection in solids – Point, Line, Surface and Volume defects - Polymorphism and Allotropy.

Module:2	Constitution of Alloys	7 hours

Mechanism of Crystallization- Nucleation-Homogeneous and Heterogeneous Nucleation- Growth of crystals- Planar growth – dendritic growth – Cooling curves - Diffusion - Construction of Phase diagram -Binary alloy phase diagram – Cu-Ni alloy; Cu-Zn alloy and Pb-Sn alloy; Iron-Iron carbide phase diagram – Invariant reactions – microstructural changes of hypo and hyper-eutectoid steel-TTT and CCT diagram.

Module:3	Heat Treatment and Surface Heat treatment	5 hours
Heat treatment – Overview – Objectives – Annealing and types, normalizing, quenching, austempering and martempering – microstructure changes –Surface hardening processes - Carburizing – nitriding – cyaniding and carbonitriding, induction and flame hardening, Laser and Electron beam hardening– principles and case depths.		
Module:4	**Ferrous Metals**	**6 hours**
Steels – Types of Steels - HSLA – TRIP - White, Grey, Malleable and Nodular - Properties and application of cast irons, Effect of alloying elements on structure and properties of steels - Properties and uses of Silicon and Hadfield Manganese steels, High speed steels - Stainless steel and Types.		
Module:5	**Non Ferrous metals**	**6 hours**
Properties and Applications of Aluminum, Magnesium, Copper, Nickel, Titanium and their alloys.		
Module:6	**Mechanical behavior of Materials**	**7 hours**
Strengthening mechanisms – Hardness measurements – Hardenability - Tensile properties of the materials – Fracture of metals – Ductile Fracture, Brittle Fracture, Ductile to Brittle Transition Temperature (DBTT) –Fatigue – Endurance limit of ferrous and non-ferrous metals -Fatigue test, S-N curves, factors affecting fatigue, structural changes accompanying fatigue; Creep and stress rupture– mechanism of creep – stages of creep and creep test.		
Module:7	**Introduction to Advanced Materials**	**4 hours**
Properties and Applications of Engineering polymers- Ceramics – properties and applications of various ceramics – Composites – and their types; properties and processing of composites – Manufacture of fibers.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	W.D. Callister, David G. Rethwisch, Materials Science and Engineering: An Introduction, 9th ed., Wiley & Sons, 2013.

Reference Books

1.	Donald R. Askeland, Pradeep P. Fulay, Wendelin J. Wright, The Science and Engineering of Materials 6th Edition, Cenage Publications, 2010.
2.	G. F. Carter, Giles F. Carter and Donald E. Paul, Materials Science and Engineering, Digital Printing Edition, ASM International, 2011.
3.	William D. Callister, Jr., David G. Rethwisch, Fundamentals of Materials Science and Engineering: An Integrated Approach, 5th Edition International Student Version, Wiley & Sons, 2016.

4.	W Bolton, Materials for Engineering, 2nd Edition, Routledge Publishers, USA, 2011.	
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar		
List of Challenging Experiments (Indicative)		
1.	Overview of Materials Characterization – Optical Microscopy, Scanning Electron Microscopy, X-Ray Diffraction and Energy Dispersive X-ray analysis.	2 hours
2.	Perform the metallographic studies and identify the given ferrous/non-ferrous samples.	7 hours
3.	Use metallographic analysis software to establish the phases and average grain size of the given samples.	2 hours
4.	Design the heat treatments that result in the following microstructures (a) Coarse pearlite (b) Medium/Fine pearlite (c) 100% Martensite (d) Martensite and retained austenite.	2 hours
5.	Compare the microstructures of the given steel sample before and after heat treatment. Also measure the hardness of the samples.	3 hours
6.	Perform the hardness examination on the given samples using Rockwell Hardness Tester and find out the equivalent Vickers hardness in HV.	2 hours
7.	Perform the phase analysis using XRD.	2 hours
8.	Conduct the tensile studies on the given sample and infer whether the given sample is ductile or brittle. Evaluate the elastic and plastic properties of the given sample.	2 hours
9.	A fractured sample is given for assessment to interpret the reasons for fracture. What are the various metallurgical tests to be carried out to infer the same?	2 hours
10.	Conduct the corrosion studies on the given sample using electrochemical cell. What is the inference drawn from the polarization curves?	3 hours
11.	Perform high temperature corrosion studies on the given sample at 500°C in air oxidation and analyze the microstructure before and after corrosion.	3 hours
	Total laboratory hours	**30 hours**

Mode of assessment:			
Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-10-2017

Course code	MANUFACTURING PROCESSES	L	T	P	J	C
MEE1007		2	0	2	0	3
Pre-requisite	NIL	Syllabus version				
		v. 2.2				

Course Objectives:

1. To identify and explain manufacturing concepts.
To impart students, knowledge on fundamentals concepts in metal casting, welding, and forming processes.
To enable students understand basics of digital printing, powder metallurgy process and fabrication methods for polymer products and glass products.

Course Outcome:

Upon successful completion of the course the students will be able to

1. Develop suitable casting processes for various materials and components
2. Identify a suitable welding process & Process Parameters for an application
3. Design a suitable metal forming system for making an industrial product
4. Analyse the influence of Process Parameters on the powder metallurgy process
5. Select fabrication method for glass and polymer products
6. Identify suitable manufacturing process for product realisation
7. Fabricate simple components by various manufacturing processes

Module:1	Manufacturing	3 hours

Manufacturing – Role of Manufacturing in the development of a country – classification of manufacturing processes.

Module:2	Casting Processes	3 hours

Casting: Fundamentals of metal casting – Types of patterns – sand mold making –different casting techniques – types of furnaces – Defects in castings – Testing and inspection of castings.

Module:3	Joining processes	6 hours

Fusion welding processes – solid state welding processes – other welding techniques – Welding defects – Testing of welded joints.

Module:4	Metal forming processes	6 hours

Cold and hot working of metals – Bulk metal forming- Sheet metal forming- High Energy Rate Forming processes: Explosive forming- Electro hydraulic forming – Electromagnetic forming.

Module:5	Processing parts made of metal powders, ceramics and glass	3 hours

Powder metallurgy-production of metal powders-stages in powder metallurgy – production of ceramic parts-production of glass parts.

Module:6	**Shaping methods for polymer parts**	**3 hours**
Injection molding-Blow molding – compression molding-transfer molding-thermoforming.		
Module:7	**Process selection**	**4 hours**
Systematic process selection for given parameters – Process selection charts-economic quantity selection.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)	
1.	Serope Kalpakjian; Steven R. Schmid, Manufacturing Engineering and Technology, 6th Edition, Publisher: Prentice Hall, ISBN-10 0-13-608168-1, ISBN- 13 978-0-13-608168-5, 2013.
Reference Books	
1.	P. N. Rao, Manufacturing Technology (Volume 1) – Foundry, Forging and Welding, 4th Edition, Tata McGraw Hill Education, New Delhi, 2013.
2.	Mikell P. Groover, Fundamentals of Modern Manufacturing Materials, Processes and Systems, Publishers: Wiley India, 2012.
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar	

List of Challenging Experiments (Indicative)		
1.	Estimation of molding sand properties.	4 hours
2.	Fabrication of Pattern for sand moulding-through conventional, digital manufacturing method.	2 hours
3.	Evaluation of 3D printed pattern over conventional pattern for complex profiles	3 hours
4.	Investigation of casting properties of 3D printed pattern	3 hours
5.	Preparation of sand mould for the given engineering part and investigating the mould properties	2 hours
6.	Comparison of 3D printed pattern and wax pattern for Investment Casting	2 hours
7.	Edge preparation for Butt joint (V, J) & Welding practice by SMAW process and heat input basic calculations.	2 hours
8.	Welding practice on T/Butt joint using MIG/GTAW welding through manual and automation	2 hours
9.	Evaluation of welded joint using NDT and DT	3 hours
10.	Deformation behavior during Rolling	2 hours
11.	Recovery, recrystallization, grain growth & grain size measurement by Quantitative metallography.	2 hours
12.	Ericson cupping test to measure the ductility	3 hours
	Total laboratory hours	**30 hours**
Mode of assessment:		

Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-10-2017

Course code	MACHINE DRAWING	L	T	P	J	C
MEE2001		1	0	4	0	3
Pre-requisite	MEE1001	Syllabus version				
		v. 2.2				

Course Objectives:

1. To understand and apply national and international standards while drawing machine component.
2. To understand the concept of various tolerances and fits used for component design
3. To familiarize in drawing assembly, orthographic and sectional views of various machine components.

Course Outcome:

Upon successful completion of the course the students will be able to

1. Apply the national and international standards in machine drawing.
2. Apply limits and tolerances to assemblies and choose appropriate fits.
3. Prepare production drawings with geometrical dimensioning and tolerances
4. Assign machining and surface finish symbols.
5. Prepare production drawings with geometrical dimensioning and tolerances
6. Illustrate various machine components through drawings.

Module:1	Basics of Machine Drawing	4 hours

Introduction – Projections - Classifications of machine drawing- BIS specifications - Sectioning – Dimensioning methods: Counter Sink, Counter Bores, Spot Faces, Chamfers, Screw Threads, Tapered Features, Title block of Industrial drawing and Bill of Materials.

Module:2	Limits and Fits	2 hours

Classifications and of Fits, Selection of Fits, Representation on Drawings, Tolerance Grade, Computations of Tolerance, Positions of Tolerance, Fundamental of Deviations, Shaft and Hole Terminology, Method of placing limit dimensions.

Module:3	Geometrical Tolerances	2 hours

Need of Geometrical Tolerance, Geometrical Characteristics of Symbols, Indication of MMC, LMC, Interpretation and Indication of Geometrical Tolerance and Dimensioning.

Module:4	Conventional Representations	2 hours

Materials - Interrupted views and Braking of Shaft, Pipe, Bar - Surface finishing & Machining Symbols.

Module:5	Screwed Fastenings and Joints	3 hours

Screwed Fastenings - Screw Thread Nomenclature and types, Joints: Bolts and Nuts, Key, Cotter, Riveted, Pin, Welded joints. Pulleys and Couplings.

Module:6	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**15 hours**

Text Book(s)	
1.	Bhatt, N.D., Machine Drawing, 50th edition, Charotar Publishing House Pvt. Ltd., India, 2014.
Reference Books	
1.	Ajeet Singh, Machine drawing, 2nd edition, Tata McGraw Hill, India, 2012.
2.	K.L. Narayana, Machine Drawing, 4th edition, New Age International publisher, India, 2014.
3.	K.C. John, Text book on Machine Drawing, 2nd edition, PHI Learning Pvt, Ltd, India, 2010.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

List of Challenging Experiments (Indicative)		
1.	Introduction to CAD Packages and demonstration of part modeling, assembly and detailed with simple examples to familiarize CAD Packages. Sketcher constraints, basic 3D commands to be used for drawing machine components.	4 hours
2.	Visualization of machine components and its assemblies.	2 hours
3.	CAD modeling of shaft, bearings, fasteners, couplings, gears, keys, rivets, springs and pulleys –user defined, customization using catalogues.	4 hours
4.	Part modeling, assembling and detailed drawing of Shaft joints: Cotter joint and Knuckle joint.	8 hours
5.	Part modeling, assembling and detailed drawing of Keys and Shaft coupling: Flanged and Universal coupling.	8 hours
6.	Part modeling, assembling and detailed drawing of Shaft Bearing: Plummer block and Footstep bearing.	8 hours
7.	Part modeling, assembling and detailed drawing of Pulleys: Belt pulley, V belt pulley, Fast and loose pulley and Speed cone pulley.	8 hours
8.	Part modeling, assembling and detailing of machine components: Tailstock and Bench Vice.	8 hours
9.	Part modeling, assembling and detailing of I.C engine connecting rods.	6 hours
10.	Part modeling, assembling and detailing of Real time machine components.	4 hours
	Total Laboratory Hours	**60 hours**

Mode of assessment:			
Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	47	47

Course code	**STRENGTH OF MATERIALS**	**L**	**T**	**P**	**J**	**C**

MEE2002		2	2	2	0	4
Pre-requisite	**MEE1002**	**Syllabus version**				
		v. 2.2				

Course Objectives:

1. To study about stresses, strains and deformation of various simple mechanical components under load
2. To study about theories of failure and the criteria for failure
3. To experimentally determine the mechanical properties of materials

Course Outcome:

Upon successful completion of the course the students will be able to

1. Compute Stress, Strain and Deformation in Axially loaded members
2. Analyse the effect of axial and shear stresses acting in various directions on different planes
3. Draw the shear force and bending moment diagrams for various beams and compute bending stress, and shear stress at various points in beams
4. Compute slope and deflection at various points of a beam
5. Analyse stresses and deformation induced in circular shafts due to torsion
6. Analyse stresses and deformation of columns and thin shells
7. Experimentally determine various mechanical properties of materials

Module:1	**Simple Stresses and strains**	**4 hours**

Definition/derivation of normal stress, shear stress, and normal strain and shear strain – Stress-strain diagram for brittle and ductile materials - Poisson's ratio & volumetric strain – Elastic constants – relationship between elastic constants and Poisson's ratio – Generalised Hook's law – Deformation of simple and compound bars – Strain energy – Resilience – Gradual, sudden, impact and shock loadings – thermal stresses.

Module:2	**Bi-axial Stress system**	**4 hours**

Introduction – Stresses on an inclined section of a bar under axial loading – compound stresses – Normal and tangential stresses on an inclined plane for biaxial stresses – Two perpendicular normal stresses accompanied by a state of simple shear – Mohr's circle of stresses – Principal stresses and strains – Analytical and graphical solutions, Theories of Failure.

Module:3	**Shear Force and Bending Moment**	**4 hours**

Definition of beam – Types of beams – Concept of shear force and bending moment – S.F and B.M diagrams for cantilever, simply supported and overhanging beams subjected to point loads, uniformly distributed loads, uniformly varying loads and combination of these loads – Point of contra flexure – Relation between S.F., B.M and rate of loading at a section of a beam.

Module:4	**Stresses in beams**	**4 hours**

Theory of simple bending – Assumptions – Derivation of bending equation - Neutral axis –

Determination of bending stresses – section modulus of rectangular and circular sections (Solid and Hollow), I, T, Angle and Channel sections – Design of simple beam sections, Shear Stresses: Derivation of formula – Shear stress distribution across various beams sections like rectangular, circular, triangular, I, T angle sections.		
Module:5	**Deflection of beams**	**4 hours**
Deflection of beams by Double integration method – Macaulay's method – Area moment theorems for computation of slopes and deflections in beams – Conjugate beam method.		
Module:6	**Torsion**	**4 hours**
Introduction to Torsion – derivation of shear strain – Torsion formula – stresses and deformations in circular and hollow shafts – Stepped shafts – shafts fixed at the both ends – Design of shafts according to theories of failure, Stresses in helical springs.		
Module:7	**Columns, Thin and thick cylinders**	**4 hours**
Theory of columns – Long column and short column - Euler's formula – Rankine's formula.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)	
1.	Ferdinand P. Beer, E. Russell Johnston, John T. Dewolf, David F. Mazurek, Mechanics of Materials, 6th edition, McGraw-Hill, New York, 2012.
Reference Books	
1.	S. S. Rattan, Strength of Materials, 2nd edition, McGraw Hill Education (India) Private Limited, New Delhi, 2011.
2.	W. A. Nash and M. C. Potter, Strength of Materials, 5th Edition, Schaum's Outline Series, McGraw-Hill, New York, 2011.
3.	James M. Gere, Barry J. Goodno, Mechanics of Materials, Brief edition, Cengage Learning, United States, 2011.
4.	R.C. Hibbeler, Mechanics of Materials, 8th edition, Prentice Hall, New York, 2011.
5.	R.K. Bansal, Strength of Materials, Laxmi Publications, India, 2010.
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar	

List of Challenging Experiments (Indicative)		
1.	Evaluation of Engineering Stress/Strain diagram on different materials (ductile and brittle) and different shapes in geometry (bars and flat) under tension.	
2.	Comprehension of different cross sections of beam on bending stress.	
3.	Deflection test – Verification of Maxwell theorem.	

4.	Comparison of hardness values of Steel, Copper and Aluminium using Rockwell, Brinell and Vickers hardness measuring machines.	
5.	Estimation of Spring constant under Tension and Compression.	
6.	Estimation of Notch Toughness of Steel using Charpy and Izod Impact Testing Machines.	
7.	Torsion Test on Mild Steel Rod.	
8.	Double shear test in U.T.M.	
9.	Fatigue test on Steel.	
10.	Strain measurement using Rosette Strain Gauge.	
	Total Laboratory Hours	**30 hours**

Mode of assessment:			
Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-10-2017

Course code	THERMAL ENGINEERING SYSTEMS	L	T	P	J	C
MEE2003		2	2	2	0	4
Pre-requisite	MEE1003	Syllabus version				
		v. 2.2				

Course Objectives:

1. To guide the students to apply the laws of thermodynamics in applications of thermal systems.
2. To help students gain essential and basic knowledge of various types of internal and external combustion engines, so as to equip them with knowledge required for the design of engines and power plants.
3. To train the students with the procedures for the testing of engines and fuels.
4. To equip the students to analyse various components of thermal power plant.
5. To impart knowledge in the design of refrigeration and air –conditioning systems.

Course Outcome:

Upon successful completion of the course the students will be able to

1. Apply the laws of thermodynamics to the working of I.C engines.
2. Conduct engine tests and analyze different performance parameters.
3. Design a steam nozzles for thermal power plant
4. Analyze different subsystems of thermal power plants and performance of reciprocating compressors.
5. Analyze various refrigeration systems and suggest for better modifications.
6. Evaluate the cooling load requirements for conditioned space.
7. Experimentally determine the performance indicators of IC Engines, R&AC systems and compressors

Module:1	IC Engines	4 hours

Working principle of 2 stroke and 4 stroke SI and CI engines with PV and Valve Timing Diagrams, Combustion process - Knocking and detonation, Cetane number and Octane number, Comparison of fuel system of diesel and petrol engines, Cooling system, Lubrication system, Ignition system - Battery, Magneto and Electronic systems.

Module:2	IC Engines Performance	4 hours

Performance test - Measurement of Brake power, Indicated power, Fuel consumption, Air consumption; Heat balance test, Morse test and Retardation test on IC engine.

Module:3	Steam Boilers	4 hours

Types of boilers, Reheating - Regeneration - Modern features of high-pressure boilers - Heat Recovery Boilers - Mountings and Accessories. Steam Nozzles – One-dimensional steady flow of steam through a convergent and divergent nozzle.

Module:4	Steam Turbine and Gas Turbine	4 hours

Steam Turbine – Impulse and Reaction principle.
Gas Turbine – Open and Closed cycle gas turbine, Reheating, Regeneration and Intercooling.

Module:5	Positive Displacement Compressors	4 hours

Reciprocating compressors - Construction - Working - Effect of clearance volume – Multi-staging - Volumetric efficiency - Isothermal efficiency.

Module:6	**Refrigeration and Cryogenic Engineering**	**4 hours**
Refrigeration: Vapour compression system - Components - Working - P-H and T-S diagrams - Calculation of COP - Effect of sub-cooling and super-heating - Vapour absorption system - NH_3 - water system, Vapour adsorption system. **Cryogenic engineering:** Introduction, Application, Cryo-coolers.		
Module:7	**Air-conditioning**	**4 hours**
Types, Working Principles - Psychrometry, Psychrometric chart, cooling load calculations.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)

1. Rajput R.K, Thermal Engineering, 10th Edition, Laxmi Publications (P) Ltd, 2017.

Reference Books

1. Ganesan V, Internal Combustion Engines, 4th Edition, McGraw Hill Education, 2012.
2. Manohar Prasad, Refrigeration and Air Conditioning, 3rd Edition, New Age International, 2015.
3. Soman.K, Thermal Engineering, PHI Learning Private Ltd, 2011.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

List of Challenging Experiments (Indicative)

1.	Compare the performance of a single cylinder CI engine connected with different dynamometers and suggest a suitable dynamometer for better accuracy of the results.	2 hours
2.	Compare the energy distribution of a single cylinder CI engine connected with different dynamometers and suggest a suitable dynamometer for better accuracy of the results.	2 hours
3.	Do the performance test on a single cylinder SI engine and compare your results with the engine specifications. Suggest a suitable method to improve the accuracy of your results.	2 hours
4.	Determine the friction power of a given four cylinder petrol engine by performing Morse test and compare the results with Willian's line method.	2 hours
5.	Determine the friction power of a given single cylinder diesel engine by performing retardation test and compare the results with Willian's line method.	2 hours
6.	Compare the properties of different fuels by performing flash point, fire point, viscosity and calorific value tests and find out which is suitable for the better performance of the given engine.	2 hours
7.	Determine the actual index of compression and compare with the isentropic compression for a given reciprocating air compressor.	2 hours
8.	Compare the performance of air blower with different vane profiles.	2 hours
9.	Calculate the COP of the given vapor compression refrigeration system and compare with the theoretical calculation.	2 hours
10.	Calculate the COP of the given air-conditioning test rig and compare with	2 hours

	the theoretical calculation.	
11.	Compare the boiler efficiency for different load levels for the given boiler.	3 hours
12.	Compare the power output for the steam turbine at different load conditions.	3 hours
13.	Draw the valve timing and port timing diagrams for the given engines, compare with the theoretical value and give your comments.	4 hours
	Total Laboratory Hours	**30 hours**

Mode of assessment:			
Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-10-2017

Course code	MECHANICS OF MACHINES	L	T	P	J	C
MEE2004		2	2	2	0	4
Pre-requisite	MEE1002	Syllabus version				
		v. 2.2				

Course Objectives:

1. To impart students' knowledge about forces acting on machine parts.
2. To enable students to understand the fundamental concepts of machines.
3. To facilitate students to understand the functions of cams, gears and fly wheels.
4. To make students to get an insight into balancing of rotations and reciprocating masses and the concepts of vibration.

Course Outcome:

Upon successful completion of the course the students will be able to

1. Apply different mechanisms for designing machines.
2. Compute velocity and acceleration of various plan mechanisms.
3. Apply the principles for analyzing cams, gears and gear trains.
4. Synthesize mechanisms for doing useful work.
5. Analyze dynamic fores acting on mechanism.
6. Balance rotating and reciprocating masses and reduce vibrations.
7. Analyze gyroscopic effects on aeroplanes, ships and automobiles.
8. Measure and analyze free, forced and damped vibrations of mechanical systems.

Module:1	Basics of Mechanisms	3 hours

Introduction - Terminologies, Degree of Freedom - Study of planar mechanisms and their inversions.

Module:2	Velocity and Accelerations in Mechanisms	5 hours

Velocity and accelerations in planar mechanisms, Coriolis component of acceleration

Module:3	Kinematics of Cams, Gears and Gear Trains	4 hours

Cams with different Follower Motion, Gear terminologies - Law of gearing - Interference and undercutting - Epicyclic gear train

Module:4	Synthesis of mechanisms	3 hours

Two position and Three position synthesis of planar mechanism - Graphical and analytical methods - Freudenstein equation

Module:5	Dynamic Force Analysis	5 hours

D'Alembert's Principle, Dynamic Analysis of planar Mechanism. Turning Moment Diagrams - Fly Wheels - Applications.

Module:6	**Balancing and Vibration**	**5 hours**
Static and Dynamic Balancing of Rotating Masses, Balancing of Reciprocating Masses, Introduction to vibration - Terminologies - Single degree of freedom- damped and undamped- free and forced vibration		
Module:7	**Mechanisms for Control & Gyroscope**	**3 hours**
Governors- types and its characteristics, Gyroscopic Effects on the Movement of Air Planes and Ships – Gyroscope Stabilization		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)	
1.	S. S. Rattan, "Theory of Machines", Tata McGraw Hill, 2015
Reference Books	
1.	Joseph Edward Shigley and John Jospeh Uicker JR, Theory of Machines and Mechanisms SI Edition, Oxford University Press, 2014
2.	R L Norton, Kinematics and Dynamics of Machinery, McGraw-Hill Education, 2017
3.	R L Norton, Design of Machinery: An Introduction to the Synthesis and Analysis of Mechanisms and Machines, McGraw-Hill Higher Education, 2011

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

List of Challenging Experiments (Indicative)		
1.	Identification of kinematic links, pairs and chains in a mechanism	3 hours
2.	Determination of moment of inertia and angular acceleration of the flywheel	3 hours
3.	Static and dynamic analysis on geared system and gear train system	3 hours
4.	Analysis of Cam and plotting the Cam profile for different cam and follower	3 hours
5.	Free vibration of spring mass system and simple pendulum	3 hours
6.	Determination of Gyroscopic couple on a rotating disc	3 hours
7.	Determination of equilibrium speeds on Governors - Watt's, Porter and Proell Governor	3 hours
8.	Balancing of Rotating and reciprocating masses	3 hours
9.	Radius of Gyration of bifilar system	3 hours
10.	Whirling in different horizontal shafts with different fixings	3 hours
	Total Laboratory Hours	**30 hours**

Mode of assessment:			
Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-10-2017

Course code	HEAT TRANSFER	L	T	P	J	C
MEE2005		2	2	2	0	4
Pre-requisite	MEE1003	Syllabus version				
		v. 2.2				

Course Objectives:

1. To impart a comprehensive knowledge of various modes of heat transfer.
2. To empower the students for solving heat transfer problems in the industry.
3. To equip the student in the design of heat exchangers.

Course Outcome:

Upon successful completion of the course the students will be able to

1. Apply the basic laws of heat transfer.
2. Solve problems of steady and unsteady state heat conduction for simple geometries.
3. Analyse natural and forced convective heat transfer process.
4. Solve radiation heat transfer problems.
5. Design of heat exchangers by LMTD and NTU methods.
6. Conduct experiments, interpret the data and analyse the heat transfer problems.

Module:1	Fundamental Concepts	2 hours

Basic principles of heat conduction, convection and thermal radiation; Fundamental laws; Identification of significant modes of heat transfer in practical applications.

Module:2	Conduction I	6 hours

General equation of heat conduction in Cartesian, cylindrical and spherical coordinates; One dimensional steady state conduction in simple geometries - plane wall, cylindrical and spherical shells; Electrical analogy; Conduction in composite walls and shells; Critical thickness of insulation; Thermal contact resistance; Overall heat transfer coefficient; One dimensional steady conduction heat transfer with internal heat generation in plane walls, cylinders and spheres.

Module:3	Conduction II	6 hours

Steady state heat conduction in 2D systems - graphical and numerical methods of solution; Conduction shape factor; Unsteady state heat transfer – Systems with negligible internal resistance - lumped heat capacity analysis; Infinite bodies – flat plate, cylinder and sphere; Semi-infinite bodies – chart solutions.

Module:4	Convection I	5 hours

Review of fluid mechanics concepts; Equations of conservation of mass, momentum and energy. Forced convection: External flow over flat plate, cylinder, sphere and bank of tubes; Internal flow through circular pipes; Boundary layers for flow over a flat plate, curved objects and flow through circular pipes.

Module:5	**Convection II**	**4 hours**
Natural convection: Steady one dimensional flow over vertical, horizontal and inclined plates; Steady one dimensional flow over cylinders and spheres; Combined free and forced convection; Introductory concepts of boiling and condensation.		
Module:6	**Radiation**	**3 hours**
Terminology and laws; Black body; Radiation from real surfaces; Effect of orientation - view factor; Electrical analogy - surface and space resistances.		
Module:7	**Practical applications**	**2 hours**
Extended surfaces (fins); Heat exchangers; Radiation shields.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)

1.	Yunus A Cengel and Afshin J Ghajar,Heat and Mass Transfer: Fundamentals and Applications, 5th edition, McGraw-Hill, 2015.
2.	R C Sachdeva, Fundamentals of Engineering Heat and Mass Transfer, 5th edition, New Age International, 2017.

Reference Books

1.	Theodore L. Bergman, Adrienne S. Lavine, Frank P. Incropera, David P. DeWitt, Fundamentals of Heat and Mass Transfer, 7th edition, Wiley, 2011.
2.	J P Holman and Souvik Bhattacharyya, Heat Transfer, 10th edition, McGraw-Hill, 2016.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

List of Challenging Experiments (Indicative)

	Introduction to laboratory, experiments, evaluation plan etc.	2 hours
1.	Determination of the thermal conductivity of a given metal sample and comparison with tabulated values.	2 hours
2.	Determination of the thermal conductivity of a given liquid and comparison with tabulated values.	2 hours
3.	Heat conduction in spherical coordinate system.	2 hours
4.	Study of heat conduction by electrical analogy: experiment on a composite wall.	2 hours
5.	Determination of rate of heat transfer in natural convection from a cylinder and comparison with theoretical calculations.	2 hours
6.	Determination of rate of heat transfer in forced convection from a heated pipe and comparison with theoretical calculations.	2 hours
7.	Prediction of temperature distribution and efficiency of a pin fin under forced and free convection and comparison with theoretical calculations.	4 hours

8.	Study of the regimes of pool boiling and determination of critical heat flux.	2 hours
9.	Determination of emissivity of a given surface.	2 hours
10.	Determination of Stefan-Boltzmann constant and comparison with reference value.	2 hours
11.	Demonstration of condenser, heat pipe and mass transfer apparatus.	2 hours
	Laboratory examinations (model and final)	4 hours
	Total Laboratory Hours	**30 hours**

Mode of assessment:			
Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-10-2017

Course code	MACHINING PROCESSES AND METROLOGY	L	T	P	J	C
MEE2006		2	0	2	0	3
Pre-requisite	MEE1007	Syllabus version				
		v. 2.2				

Course Objectives:

1. To create awareness on the basic concepts of machining Processes.
2. To give an insight on conventional machining principles and operations.
3. To impart students the fundamental knowledge of unconventional machining and finishing processes.
4. To familiarize the students with basic and advanced metrology concepts.

Course Outcome:

Upon successful completion of the course the students will be able to

1. Understand the mechanism of chip formation in machining.
2. Understand the various machining processes such as turning, drilling, boring, shaping, slotting, milling and grinding.
3. Understand the principle of gear generation and non-traditional machining processes.
4. Identify and suggest correct manufacturing process for particular application.
5. Know the principle of different metrology instruments.
6. Reduce various components on machine tools and carryout dimensional measurement.

Module:1	Metal Cutting	4 hours

Mechanics of metal cutting - cutting tool materials, temperature, wear, and tool life considerations, geometry and chip formation, surface finish and machinability, optimization.

Module:2	Basic Machine Tools	4 hours

Lathe and its types - Constructional details including accessories and attachments, operations, types of lathe, Contructional and operational details of Shaping - Planing - Slotting – Drilling - Boring – Reaming – Tapping – Broaching.

Module:3	Milling machine and Gear Generation	4 hours

Cutters - Milling operations - Indexing.
Gear generating principles - Gear Hobber - Gear finishing methods - Bevel gear generator.

Module:4	Grinding machine	4 hours

Operations and applications of surface, cylindrical and centreless grinding processes, dressing, truing and balancing of grinding wheels, grading and selection of grinding wheels, micro-finishing (honing, lapping, super-finishing).

Module:5	Unconventional methods	4 hours

Electro-chemical, electro-discharge, ultrasonic, LASER, electron beam, water jet machining.

Module:6	**Introduction to Metrology**	**4 hours**
Linear and angular measurements – taper measurement, threads, surface finish, inspection of straightness, flatness and alignment–– Comparators - Gear testing.		
Module:7	**Advances in Metrology**	**4 hours**
Precision Instrumentation based on Laser Principals, Coordinate measuring machines, Optical Measuring Techniques: Tool Maker's Microscope, Profile Projector. Nano-measurements: Scanning Electron Microscope-Atomic Force Microscopy-Transmission Electron Microscopy.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)	
1.	Serope Kalpakjian; Steven R. Schmid (2013), Manufacturing Engineering and Technology, 6th Edition, Publisher: Prentice Hall, ISBN-10 0-13-608168-1, ISBN- 13 978-0-13-608168-5.
Reference Books	
1.	P.N.Rao, Manufacturing Technology, McGraw Hill Education, New Delhi, 2013.
2	R.K. Rajput, A Textbook of Manufacturing Technology, Laxmi publications, New Delhi, 2015.
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar	

List of Challenging Experiments (Indicative)		
MACHINING EXPERIMENTS		
1.	Determination of cutting force measurement using Lathe Tool Dynamometer.	1.5 hours
2.	Prepare the part shown in the sketch from a mild steel rod on a Lathe.	1.5 hours
3.	Prepare and check the dimensions of the sample by Surface Grinding.	1.5 hours
4.	Machine the hexagonal head shown in the sketch on the specimen.	1.5 hours
5.	Machining a keyway by using slotting machine.	1.5 hours
6.	Machining a V-block by using shaper.	1.5 hours
7.	Gear cutting using milling and gear hobbing machines.	1.5 hours
8.	Grinding of single point cutting tool as per given specifications (to check the tool angles) in a Tool and Cutter Grinder	1.5 hours
METROLOGY EXPERIMENTS		
9.	Calibration of Micrometer, Mechanical Comparator, Vernier Caliper and Dial Gauge.	2 hours
10.	Measurement of taper angle using Bevel Protractor, Dial Gauge and Sine-Bar.	2 hours
11.	Measure the flatness of the object using dial gauge.	2 hours
12.	Measurement of bores by using Micrometer and Dial bore indicator.	2 hours
13.	Measurement of Screw threads Parameters using Three-wire method and	2 hours

	Profile Projector.	
14.	Measurement of Gear tooth thickness by using Gear tooth Vernier.	2 hours
15.	Surface roughness measurement of machined component.	2 hours
16.	Measurement of single point tool by using Tool Makers Microscope.	2 hours
	Total Laboratory Hours	**30 hours**

Mode of assessment:			
Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-10-2017

Course code	DESIGN OF MACHINE ELEMENTS	L	T	P	J	C
MEE3001		2	2	0	0	3
Pre-requisite	MEE2002 / MEE1032	Syllabus version				
		v. 2.2				

Course Objectives:

1. Develop an ability to apply knowledge of mechanics and materials
2. Develop an ability to design a system / component to meet desired needs within realistic constraints using suitable design methodology.
3. Utilize various standards and methods of standardization.
4. Apply the concept of design and validation by strength analysis.

Course Outcome:

Upon successful completion of the course the students will be able to

1. Analyse machine components using theories of failure
2. Design machine parts against fatigue failures of components subjected to variable and cyclic loads
3. Design springs for withstanding static and fatigue loads
4. Design welded, riveted and bolted joints
5. Design keys, cotter and knuckle joints
6. Design shafts and different types of couplings using computers
7. Design engine components like piston, connecting rod, crankshaft and flywheel

Module:1	Introduction to Design Process	4 hours

Introduction to Design process – Factors – Materials selection - direct - Bending and Torsional stress equation - Impact and Shock loading - Factor of safety - Design stress - Theories of failures – Problems.

Module:2	Fatigue strength	4 hours

Stress concentration - theoretical stress concentration factor - Size factor - Surface limits factor - fatigue stress concentration factor - notch sensitivity - Variable and cyclic loads – Fatigue strength – S-N curve – Continued cyclic stress – Soderberg and Goodman equations.

Module:3	Design of Mechanical Springs	4 hours

Stresses and deflections of helical springs – extension -compression springs – springs for fatigue loading, energy storage capacity – helical torsion springs – Flat Spiral Springs - leaf springs. Computer aided design of springs.

Module:4	Design of Riveted, Welded and Bolted Joints	4 hours

Riveted, Welded and Bolted Joints, Computer aided design of joints.

Module:5	Design of Keys, cotters and knuckle joints	4 hours

Design of keys-stresses in keys-cotter joints-spigot and socket, sleeve and cotter, jib and cotter joints- knuckle joints.		
Module:6	**Design of Shafts and Couplings**	**6 hours**
Design of solid and hollow shafts for strength and rigidity – design of shafts for combined bending and axial loads – shaft sizes. Computer aided design of shafts and analysis- Design of couplings – Rigid – Muff, Split muff and Flange couplings - Flexible – Oldham, Universal couplings. Computer aided design of Couplings.		
Module:7	**Design of Engine Components**	**2 hours**
Design of Piston – Connecting rod – Crankshaft – Flywheel.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)

1.	Keith J Nisbett and Richard G Budynas, Shigley's Mechanical Engineering Design, McGraw-Hill Education, 10th Edition, 2014.

Reference Books

1.	V.B. Bhandari, Design of Machine elements, Tata Mc Graw Hill, 3rd Edition, 2010.
2.	P.C.Sharma & D.K.Aggarwal, A Text Book of Machine Design, S.K.Kataria & Sons, New Delhi,12th edition, 2012.
3.	Jack A.Collins, Henry Busby, George Staab, Mechanical Design of Machine Elements and Machines, 2nd Edition, Wiley India Pvt. Limited, 2011.
4.	Steven R. Schmid, Bernard J. Hamrock, Bo. O. Jacobson, Fundamentals of Machine Elements, CRC Press, Third Edition, 2014.
5.	Juvinal, R.C and Kurt M.Marshek, Machine component design, John Wiley, 2012.
6.	Design Data – PSG College of Technology, DPV Printers, Coimbatore, 2012.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar			
Mode of assessment:			
Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-10-2017

Course code	FUELS AND COMBUSTION	L	T	P	J	C
CHE2006		3	0	0	0	3
Pre-requisite	NIL	Syllabus version				
		1.2				

Course Objectives:

1. Develop the understanding levels of fuels and combustion fundamentals
2. Classify and introduce different types of fuel and fuel analysis techniques that assists the students to choose most convenient fuel for a process involving combustion
3. Engage the students in designing various control techniques for handling various environmental issues resulting from combustion of fuels

Course Outcomes (CO):

1. Classify the various types of fuels like liquid, solid and gaseous fuels available for firing in boilers and furnaces
2. Compare various fuel properties and its efficient use
3. Choose the right type of fuel depends on various factors such as availability, storage, handling, pollution and cost of fuel
4. Differentiate the properties of exhaust and flue gases
5. Execute basic engineering and science concepts for the design of various combustion equipment
6. Interpret various air pollution controlling techniques for reducing the pollution generated from combustion of various fuels

Module:1	Classification and Properties of Fuels	5 hours	CO:1

Fuels-Types and characteristics of fuels-Determination of properties of fuels-Fuel analysis-Proximate and ultimate analysis-Calorific value (CV)-Gross and net calorific values (GCV,NCV)-Bomb Calorimetry-empirical equations for CV estimation

Module:2	Solid Fuels	6 hours	CO:2

Origin of coal-Ranking of coal-Washing, cleaning and storage of coal-Renewable Solid Fuels-comparative study of Solid, liquid and gaseous fuels-selection of coal for different industrial applications-carbonization of coal

Module:3	Liquid fuels	6 hours	CO:2,3

Origin of crude oil-composition of crude petroleum-classification of crude petroleum-Removal of salt from crude oil-processing of crude petroleum-Fractionation distillation-ADU and VDU-Cracking-Hydrotreatment and Reforming

Module:4	Gaseous fuels	6 hours	CO:2,3

Rich and lean gas-Wobbe index-Natural gas-Dry and wet natural gas-Foul and sweet NG-LPG-LNG-CNG-Methane-Producer Gas-Water gas-Coal Gasification-Gasification Efficiency

Module:5	Combustion	7 hours	CO:5

General principles of combustion-types of combustion processes-Combustion chemistry-Combustion equations-Kinetics of combustion-combustion of solid fuels-Combustion calculations-air fuel ratio-Excess air calculations

Module:6	Combustion Equipment	7 hours	CO:4

Analysis of flue gases by Orsat apparatus-Combustion of solid fuels-grate firing and pulverized fuel firing system-Fluidized bed combustion-Circulating fluidized bed boiler-Burners-Factors affecting burners and combustion			
Module:7	**Air Pollution**	**6 hours**	**CO:6**
Types of pollution-Combustion generated air pollution-Effects of air pollution-Pollution of fossil fuels and its control-Pollution from automobiles and its control			
Module:8	**Contemporary issues**	**2 hours**	
	Total Lecture hours:	**45 hours**	

Text Books	
1.	Kenneth K.K., Principles of Combustion, 2nd ed., Wiley Publications, USA, 2012
2.	Phillips H.J., Fuels-solid, liquid and gases–Their analysis and valuation, 1st ed., Foster Press, USA, 2010
Reference Books	
1.	Speight J.G., The Chemistry and Technology of Coal, 3rd ed., Taylor and Francis Ltd., USA, 2016
2.	Sarkar S., Fuels and combustion, 3rd ed., Universities Press, India, 2009

Mode of evaluation: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test			
Recommended by Board of Studies	15-04-2019		
Approved by Academic Council		Date	

Course code	Electronics and Microcontroller	L	T	P	J	C
EEE2007		2	0	0	4	3
Pre-requisite	EEE1001	Syllabus version				
		v. 2.2				

Course Objectives:

1. To understand different methods for design and implementation of Digital circuits.
2. To apply the knowledge of solid state devices principles to analyze electronic circuits
3. To provide essential knowledge on various operating modes of I/O ports Timers/Counters, control registers and various types of interrupts.
4. To teach various interfacing techniques

Course Outcome:

1. To analyze and design combinational logic circuits.
2. To analyze and design sequential logic circuits.
3. Understand the difference between different microcontrollers.
4. To analyze and design microprocessor and microcontroller
5. Understand the Assembly language programming 6. Understand the Interfacing with PIC

Module:1	Number System and Codes	3 hours

Introduction to Digital Systems-Number representation-Binary, Octal, Decimal, Hexadecimal-Number Base conversion-Complements:1's and 2's-Signed binary numbers - ASCII,BCD,Excess3andGrayCodes -Parity

Module:2	Digital Electronics	4 hours

Calorific Value - Gross and Net Calorific Values - Calorimetry - DuLong's Formula for CV Estimation - Flue gas Analysis - Orsat Apparatus - Fuel and Ash Storage and Handling.

Module:3	Combinational circuits	4 hours

Combinational circuits – Analysis and design procedures - Circuits for arithmetic operations - Code conversion. Decoders and encoders - Multiplexers and demultiplexers

Module:4	Sequential circuits	4 hours

Origin of petroleum fuels - Production – Composition -Petroleum refining - Various grades of petro Products - Properties and testing – Alcohol shale oil - Gasification of liquid fuels – Synthetic fuels Storage and handling of liquid fuels.

Module:5	Introduction to microprocessor	4 hours

Introduction to microprocessor and microcontroller- Internal architecture of PIC18-Comparison of PIC with other CISC & RISC based systems and microprocessor-PIC family-features.

Module:6	Assembly language programming	6 hours

Flag Register, stack- addressing modes, loop, jump, call instructions, arithmetic and logic instructions, Programming I/O ports- timers, counters, interrupts, serial communication		
Module:7	**Interfacing with PIC**	**4 hours**
Mechanism of Combustion – Ignition and Ignition Energy - Spontaneous Combustion - Flame Propagation - Solid - Liquid and Gaseous Fuels Combustion - Flame Temperature - Theoretical - Adiabatic and Actual - Ignition Limits – Limits of Inflammability.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)	
1.	Donald G. Givone “Digital principles and Design” Tata McGraw Hill 2003.
2.	Mohamed Ali Mazidi, Rolin D.McKinlay, Danny Causey,”Pic Microcontroller And Embedded Systems: Using Assembly And C For Pic 18”,Pearson Education,2016.
Reference Books	
1.	M. Morris Mano, "Digital Design", 4th Edition, Prentice Hall of India Pvt. Ltd., 2017.
2.	Charles H. Roth, Jr., "Fundamentals of Logic Design", 6th Edition, Brooks/Cole, 2014
3.	Thomas L. Floyd & R P Jain, “Digital Fundamentals”, PHI, 10th Edition, 2016
4.	Barry B. Brey, “Applying PIC18 Microcontrollers”, Pearson/Prentice Hall, 2008
5.	Sid Katzen, “The Essential PIC18® Microcontroller”, Springer, 2010

Mode of assessment: CAT / Assignment / Quiz / FAT / Project / Seminar			
Recommended by Board of Studies			
Approved by Academic Council	37	Date	16.06.2015

Course code	Control Systems	L	T	P	J	C
EEE3001		3	0	2	0	4
Pre-requisite	EEE2001, MAT2002/EEE1001	Syllabus version				
		v. 2.2				

Course Objectives:

1. To present a clear exposition of the classical methods of control engineering, physical system modelling, and basic principles of frequency and time domain design techniques.
2. To teach the practical control system design with realistic system specifications.
3. To provide knowledge of state variable models and fundamental notions of state feedback design

Course Outcome:

On the completion of this course the student will be able to:

1. Formulate mathematical model and transfer function of the physical systems
2. Analyze the system performance by applying various input signals
3. Determine the stability of linear systems in time domain
4. Perform frequency domain analysis using bode and polar plot
5. Analyze the stability of linear system in the frequency domain
6. Design compensators and controllers for the given specifications
7. Formulate and design state-space analysis
8. Design and Conduct experiments, as well as analyze and interpret data

Module:1	Systems and their Representations	6 hours

Basic elements in control systems □ open loop & closed loop □ Transfer functions of mechanical, electrical and analogous systems. Block diagram reduction □ signal flow graphs.

Module:2	Time Response Analysis	6 hours

Standard test signals, Time response of first and second order system, Time domain specifications, Steady state error, error constants, generalized error coefficient.

Module:3	Stability Analysis and Root Locus	6 hours

Stability □ concept and definition, Characteristic equation – Location of poles – Routh Hurwitz criterion □ Root locus techniques: construction, properties and applications.

Module:4	Frequency Response Analysis	6 hours

Bode plot □ Polar plot □ Correlation between frequency domain and time domain specifications

Module:5	Stability in Frequency Domain	5 hours

Relative stability, Gain margin, Phase margin, stability analysis using frequency response methods, Nyquist stability criterion.

Module:6	Compensator and Controller	7 hours

Realization of basic compensators, cascade compensation in time domain and frequency domain,

feedback compensation Design of lag, lead, lag-lead series compensator (using Bode plot), P, PI and PID controllers in frequency domain.		
Module:7	**State Space Analysis**	**6 hours**
Concepts of state variable and state model, Solution of state equation, State space to transfer function conversion, Controllability, Observability, Pole placement control		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Norman S. Nise, "Control System Engineering", John Wiley & Sons, 6th Edition, 2011.
2.	Benjamin C Kuo "Automatic Control System" John Wiley & Sons, 8th Edition, 2007.
Reference Books	
1.	K. Ogata, "Modern Control Engineering", Pearson, 5th Edition, 2010.
2.	R.C. Dorf & R.H. Bishop, "Modern Control Systems", Pearson Education, 11th Edition, 2008.
3.	M. Gopal, "Control Systems Principles And Design", Tata McGraw Hill –4th Edition, 2012.
4.	Graham C. Goodwin, Stefan F. Graebe, Mario E. Sagado, " Control System Design", Prentice Hall, 2003'
5.	J.Nagrath and M.Gopal," Control System Engineering", New Age International Publishers, 4th Edition, 2006.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

List of Challenging Experiments (Indicative)		
1.	Block Diagram Reduction	2 hours
2.	Determination of Time Domain Specifications	2 hours
3.	Stability analysis of linear systems	2 hours
4.	PID Controller Design using Bode Plot	2 hours
5.	PID Controller Design using Root Locus	2 hours
6.	Compensator Design in Frequency and Time Domains	2 hours
7.	Transfer Function to State Space Conversion with Controllability and Observability Tests	2 hours
8.	Lag compensator design for linear servo motor for speed control application	2 hours
9.	Pole placement controller design for inverted pendulum	2 hours
10.	PD controller design for position control of servo plant	2 hours
11.	Cascade control design for ball and beam system	2 hours
12.	PID controller design for magnetic levitation system	2 hours
13.	Transfer function of Separately excited DC generator	2 hours
14.	Transfer function of Field Controlled DC Motor	2 hours
15.	Study of First and Second order systems	2 hours
	Total Hours	**30 hours**

Mode of assessment:			
Recommended by Board of Studies	30/11/2015		
Approved by Academic Council	39 AC	Date	17/12/2015

Course code	MEMS	L	T	P	J	C
MEE1008		3	0	0	0	3
Pre-requisite	NIL	Syllabus version				
		v. 2.2				

Course Objectives:

1. Introduce the fundamental elements of MEMS & Microsystem and their relevance to
2. current industry/scientific needs
3. Identify the materials and the fabrication processes that are used in MEMS devices
4. Outline the basic principle of micro sensors and micro-actuators
5. Discuss the essential components of microfluidics
6. Project the design, fabrication, limitation and challenges of micro devices through various
7. case studies

Course Outcome:

Upon successful completion of the course the students will be able to

1. Apply MEMS & Microsystems to engineering applications
2. Apply physical, chemical, biological and engineering principles to design micro devices
3. Fabricate micro devices in silicon, polymer, metal and other materials.
4. Fabricate using various micro fabrication techniques
5. Design MEMS components using micro sensors and micro actuators
6. Apply micro pumps and micro dispensers
7. Design MEMS for smart homes and for visually impaired

Module:1	Introduction to MEMS	4 hours

Unique characteristics of MEMS, Microsystems Technology- An Overview, typical MEMS and Microsystem Products.

Module:2	Laws and Application of MEMS	4 hours

Scaling effects - scaling laws in miniaturization- Application of MEMS and Microsystems- Future Directions of MEMS.

Module:3	Materials for MEMS and Manufacturing	6 hours

Structure of silicon and other materials - Silicon wafer processing - Bulk micromachining and Surface micromachining, Wafer-bonding. Thin-film deposition, Lithography, wet etching and dry etching.

Module:4	Other Microfabrication techniques	5 hours

LIGA and other moulding techniques- Soft lithography and polymer processing- Thick-film processing; Low temperature co-fired ceramic processing- Smart material processing.

Module:5	MEMS components-micro sensors and Micro-actuators	11 hours

Micro sensors - Basic principles and working of micro sensors- Acoustic wave micro sensors- Bio-medical micro sensors- Bio-sensors- Chemical micro sensors – Optical Sensors – Pressure micro sensors- Thermal micro sensors-acceleration micro sensors; Micro actuators - Basic principles and working of micro actuators- Electrostatic micro actuators- Piezoelectric micro actuators- Thermal micro actuators- SMA micro actuators- Electromagnetic micro actuators, micro valves, micro pumps.		
Module:6	**Microfluidics**	**5 hours**
Fundamentals of fluid mechanics- Basic components of a micro fluidic system- Micro flows- Micro pumps- Capillarity and Surface Tension- Micro pumping methods- Micro dispensers- Micro nozzles.		
Module:7	**Case studies**	**8 hours**
MEMS as Gas sensors – MEMS Accelerometer - Development of Proximity Sensor - MEMS based Current sensors - MEMS for Smart homes - MEMS for Visually impaired -MEMS Sensors for object detection - MEMS based touch sensor - Synthesis and characterization of Micro fluids - Development of thin film MEMS layers.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	Tai-Ran-Hsui, MEMS & Microsystems: Design and Manufacture, 17th Edition (Reprint), McGraw Hill, 2013.

Reference Books

1.	Vijay K.Varadan, K.J.Vinoy, S.Gopalakrishnan, Smart Material Systems and MEMS: Design and Development Methodologies Paperback,2011.
2.	Volker Kempe, Inertial MEMS: Principles and Practice, Cambridge University Press New York, NY, USA, 2011.
3.	Laurent A. Francis, Krzysztof Iniewski, Novel Advances in Microsystems Technologies and Their Applications, CRC Press, 2017.
4.	Baltes H.,Brand O.,Fedder,.G.K. Herold C.,Korvink J.G.,Tabata O.,Enabling Technologies for MEMs and Nanodevices: Advanced Micro and Nanosystems,Wiley VCH,Germany, 2013.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

Mode of assessment:

Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-10-2017

Course code	NEW PRODUCT DEVELOPMENT	L	T	P	J	C
MEE1009		2	0	0	4	3
Pre-requisite	NIL	Syllabus version				
		v. 2.2				

Course Objectives:

1. To understand the new product development process.
2. To Design and analysis concepts and tools necessary for product development through case examples and assignments.
3. To familiarize Intellectual Property Rights pertaining to New Products.

Course Outcome:

Upon successful completion of the course the students will be able to

1. Demonstrate key concepts and principles concerning the role of product innovation and their contribution to generate competitive advantage in firms.
2. Identify key concepts and principles concerning the activities and competencies involved in new product development.
3. Evaluate key concepts and principles concerning- the range of tools and methods that are used to manage new product development.
4. Apply the methods of generating, evaluating and testing product concepts.
5. Analyse the set of potential innovation triggers and strategically select those opportunities that fit with the organisational resources and strategies.
6. Create awareness of patents and copyrights for the new products developed.

Module:1	New Product Development	4 hours

Introduction to New Product Development, Need for developing new products – Evolution of design, types of design – the design process –product life cycle – generic product development process – Strategic Planning and Opportunity Identification for new products – Identifying Market Opportunities.

Module:2	Translation of needs into Specifications	4 hours

Understanding Customer and User Needs – customer survey – need gathering methods – clarification - search-externally and internally - Explore systematically - needs importance - establishing product specification -competitive benchmarking. Case Studies-I.

Module:3	Creativity and Innovation	4 hours

Need for design creativity - Creative thinking – creativity and problem solving - creative thinking methods- generating design concepts - systematic methods for designing –morphological methods - TRIZ methodology of Inventive Problem Solving. Case Studies-II.

Module:4	Concept Development	3 hours

Concept Generations- Concept Screening- Concept Scoring - Concept Testing methods. Case

Studies-III.		
Module:5	**Embodiment Design**	**4 hours**
Introduction to embodiment design – product architecture – types of modular architecture –steps in developing product architecture Industrial design – human factors design –user friendly design – Case Studies-IV.		
Module:6	**Design for X**	**6 hours**
Design for serviceability – design for environment – prototyping and testing – Cost evaluation – categories of cost – overhead costs – activity based costing. Case Studies-V. Design for Quality - Reliability - Failure Mode and Effect Analysis - Test and Inspection – Maintenance - Warranty.		
Module:7	**Patents and Intellectual Property**	**3 hours**
Patent – trademark - trade secret – copyright - preparing a disclosure.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)

1.	Karl T. Ulrich, Steven D. Eppinger, Product Design and Development, Sixth Edition, McGraw-Hill, 2015.

Reference Books

1.	Robert G. Cooper, Winning at New Products: Creating Value Through Innovation, Hachette Book Group, Newyork, 2017.
2.	John Starc, Product Lifecycle Management (Decision Engineering), Springer Publications, 2015.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

Challenging Projects	
Guidelines • Generally a team project [Maximum of 3 members only] • Concepts studied should have been used. • Down to earth application and innovative idea should have been attempted Assessment on a continuous basis with a minimum of 3 reviews. **Sample projects:** • New product development starting from customer survey, product specification, concept generation, concept selection, concept testing and prototyping. • Redesign of an existing product from customer survey, product specification, concept generation, concept selection, concept testing and	**60** [Non-contact hours]

prototyping. Design modification of an existing product from customer survey, product specification, concept generation, concept selection, concept testing and prototyping			
Mode of assessment:			
Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-10-2017

Course code	RENEWABLE ENERGY SOURCES	L	T	P	J	C
MEE1011		2	2	2	0	4
Pre-requisite	NIL	Syllabus version				
		v. 2.2				

Course Objectives:

1. To help students gain essential knowledge on the importance of various renewable energy sources
2. To familiarize the students with principles of energy conversion for various renewable energy sources
3. To do practical experiments for energy resource performance under different operating conditions
4. To understand the method for assessment of various input energy resources for meeting the specific requirements.
5. To know the limitations in renewable energy conversion techniques

Course Outcome:

Upon successful completion of the course the students will be able to

1. Explain the current energy scenario and requirement of migration to renewable energy sources
2. Demonstrate the knowledge of various solar thermal energy applications
3. Design solar PV systems under stand-alone mode and analyze the performance of solar cells
4. Design a bio-gas digester
5. Analyze the performance of wind mills
6. Assess the power potential of a given site and choose adequate hydro turbine
7. Explain various methods for harvesting the ocean energy
8. Experimentally determine performance of various renewable energy conversion devices working under different operating conditions

Module:1	Classification of Energy	5 hours

Energy chain and common forms of usable energy - Present energy scenario - World energy status - Energy scenario in India - Introduction to renewable energy resources - Introduction to Solar Energy - Energy from Sun - Spectral distribution of Solar radiation - Instruments for measurement of solar radiation - Solar radiation data analysis

Module:2	Applications of Solar Energy	6 hours

Thermal applications - Introduction to Solar thermal collectors - Types - Principle of operation of different collectors - Flat plate - Evacuated tube collectors - Compound parabolic collectors - Solar air heaters - Solar dryers -solar cookers - solar stills - Solar ponds - concentrating collectors - line type - point type - Methods of Solar power generation - Power towers

Module:3	Introduction to Solar Photovoltaics	5 hours

Physics of solar cells - Cell and module.

Manufacturing Process– Characteristics of cells and module - Performance parameters -BoS- PV System applications - Stand alone- Grid connected systems.		
Module:4	**Bio Energy Sources**	**4 hours**
Energy through various processes - Energy through fermentation - Gasification - various types of gasifiers -Pyrolysis - Fixed bed and fast Pyrolysis - Bio energy through digestion - Types of Digesters- Factors affecting the yield of products.		
Module:5	**Wind Energy**	**4 hours**
resource assessment - types of wind turbines - selection of components - blade materials - power regulation - various methods of control - wind farms - site selection - off shore wind farms - Solar Wind Hybrid energy systems.		
Module:6	**Small Hydro Power Systems**	**2 hours**
Introduction - types - system components, discharge curve and estimation of power potential - Turbines for SHP.		
Module:7	**Ocean Energy**	**2 hours**
Power generation through OTEC systems - various types - Energy through waves and tides - Energy generation through geothermal systems – types.		
Module:8	**Contemporary issues:**	**2 hours**
Discussion on Recent developments in the area of renewable energy systems and their integration		
	Total Lecture hours:	**30 hours**

Text Book(s)	
1.	John Andrews, Nick Jelley (2013), Energy Science: Principles, technologies and impacts, Oxford Universities press.
Reference Books	
1.	Fang Lin You, Hong ye (2012), Renewable Energy Systems, Advanced conversion technologies and applications, CRC Press
2	John.A.Duffie, William A.Beckman (2013), Solar Engineering of Thermal processes, Wiley
3	A.R.Jha (2010), Wind Turbine technology, CRC Press.
4	Godfrey Boyle (2012), Renewable Energy, power for a sustainable future, Oxford University Press..

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar		
List of Challenging Experiments (Indicative)		
1.	1. Estimation of Solar radiation: Pyranometer, pyrheliometer. 2. Testing the yield of a Solar still in outdoor conditions (Multiple sessions).	30 x 14

	3. Wind Energy Experimental Set up – I. 4. Wind Energy Experimental Set up – II. 5. Testing of Solar PV system in PV training Kit. 6. Fuel Cell Experiment. 7. Performance of Biomass stove. 8. Production of Bio-diesel by Transesterification process. 9. Flash Point and Fire point comparison for conventional fuels and alternate fuels. 10. Production of Hydrogen from Electrolysis with PV system. 11. Estimation of Figures of Merit in a Solar cooker. 12. Performance characteristics of a Solar thermal collector. 13. Exergy analysis of a Solar cabinet dryer.	
		Total Laboratory Hours 17 hours

Mode of assessment:			
Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	No. 47	Date	05-10-2017

Course code	ALTERNATIVE FUELS	L	T	P	J	C
MEE1012		3	0	0	0	3
Pre-requisite	NIL	Syllabus version				
		v. 2.2				

Course Objectives:

1. To provide the students with sufficient background to understand the need for alternative fuels.
2. To enable the students to understand different sources of alternative fuels, production and storage methods.
3. To teach students how to use alternative fuels in internal combustion engines and their performance and emission characteristics.
4. To provide the knowledge of zero emission vehicles using clean technologies.

Course Outcome:

Upon successful completion of the course the students will be able to

1. Explicate the importance of alternative fuels and reserve status of fossil fuels.
2. Comprehend the important properties, production and storage of hydrogen and other gaseous fuels and address the implications during their use in IC engines.
3. Comprehend the important properties, production and storage of liquid fuels and solid and address the implications during their use in IC engines.
4. Evaluate the performance of clean propulsion technologies.
5. Predict the behavior of engines during the usage of alternative fuels.
6. Identify the optimal alternative fuels for local usage based on the availability of raw materials.

Module:1	Introduction	2 hours

Status of petroleum reserves, economics; Need for alternative fuels; Review of fuel properties.

Module:2	Hydrogen – Production and Storage	6 hours

Properties; Production and storage methods; Safety aspects; Use in SI and CI engines; Engine modifications required; Performance and emissions.

Module:3	Organic gaseous fuels	10 hours

Natural Gas, LPG, biogas, producer gas, syngas etc.; Properties; Production and storage methods - CNG and LNG, gasification, digesters; Use in SI and CI engines; Performance and emission characteristics; Modes of operation in internal combustion engines.

Module:4	Alcohols and ethers	10 hours

Methanol and ethanol; DME and DEE; Properties; Production methods; Use in SI and CI engines –Fuel and engine modifications required; Performance and emissions.

Module:5	Vegetable oils	10 hours

Types, composition and properties; Challenges of use in CI engines, solutions - preheating,

blending; Transesterification; Pyrolysis; Performance and emissions; Oils from waste - cooking oil, wood, rubber, plastic etc.		
Module:6	**Solid fuels**	**2 hours**
Biomass - processing and usage, forms - municipal solid waste, wood.		
Module:7	**Clean technology**	**3 hours**
Fuel cells - types, working; Hybrid and electric vehicles; Solar power; Challenges; Engine modifications; Performance.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Thipse S. S., Alternative Fuels: Concepts, Technologies and Developments, Jaico Publishing House, 2010.
Reference Books	
1.	Ganesan V, Internal Combustion Engines, McGraw-Hill Education India Pvt. Ltd, 2012.
2.	Michael F. Hordeski, Alternative Fuels: The Future of Hydrogen, The Fairmont Press, Inc, 2013.
3.	Sunggyu Lee, James G. Speight, Sudarshan K. Loyalka, Handbook of Alternative Fuel Technologies, 2nd edition, CRC Press, 2014.
4.	James Larminie, John Lowry, Electric Vehicle Technology Explained, 2nd edition, John Wiley & Sons, Ltd, 2012.
5.	Richard L.Bechtold, Alternative Fuels Guidebook, Society of Automotive Engineers (SAE), 2014.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar			
Mode of assessment:			
Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-10-2017

Course code	INDUSTRIAL ENGINEERING AND MANAGEMENT	L	T	P	J	C
MEE1014		3	0	0	0	3
Pre-requisite	NIL	Syllabus version				
		v. 2.2				

Course Objectives:

1. To analyze different planning activities needed during the operations stage of a manufacturing or a service industry.
2. To apply productivity techniques for achieving continuous improvement.

Course Outcome:

Upon successful completion of the course the students will be able to

1. Analyze the way price of a product affects the demand for a product for consequent actions and predict demand for a product by making use of different demand forecasting techniques.
2. Explain Break even analysis to determine safe production levels and costing of industrial products.
3. Apply productivity techniques for continuous improvement in different functionalities of an industry.
4. Analyze the existing operations that happen in factories for establishing time standards for different activities.
5. Demonstrate the knowledge of selection of location for the new plant & optimizing the layout within the plant for smooth production.
6. Apply cellular manufacturing concepts in industry.
7. Compute material requirement needed to satisfy the Master Production Schedule of a factory by having thorough understanding of MRP logic.

Module:1	Introduction to macro and micro economics	6 hours

Macro-economic measures – micro economics – Demand and supply – Determinants of demand and supply – Elasticity of demand – Demand forecasting techniques (short term & long term) – Problems.

Module:2	Elements of cost	6 hours

Determination of Material cost - Labour cost – Expenses - Types of cost – Cost of production – Over-head expenses–break even analysis - Problems.

Module:3	Productivity	6 hours

Definition – Factors affecting- Increasing productivity of resources - Kinds of productivity measures - Case study.

Module:4	Introduction to work study	6 hours

Method study – Time study – stopwatch time study – Work measurement - performance rating-allowances – Ergonomics.

Module:5	**Plant location and Plant layout**	**7 hours**
Plant location –need - Factors – comparison – quantitative methods for evaluation Plant layout: objectives-principles – factors influencing – tools and techniques including computer based layout design – CRAFT, ALDEP, CORELAP.		
Module:6	**Cellular Manufacturing**	**6 hours**
Group Technology – Cellular layout – Machine-Part Cell Formation (MPCF) – Heuristic approaches – Hierarchical clustering for MPCF.		
Module:7	**Material requirement Planning (MRP)**	**6 hours**
Objectives – functions – MRP system – MRP logic – Management information from MRP – lot sizing consideration – Manufacturing resource planning – capacity requirement planning (CRP) – Bill of material.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	R Dan Reid, and Nada R. Sanders, Operations Management, John wiley& Sons, 5th Edition, 2012.

Reference Books

1.	William J Stevenson, Operations Management, McGrawHill, 12th Edition, India, 2017.
2.	R Panneerselavam, Production and Operations Management, PHI publications 3rd Edition, 2012.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

Mode of assessment:

Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-10-2017

Course code	TOTAL QUALITY MANAGEMENT AND RELIABILITY	L	T	P	J	C
MEE1015		3	0	0	0	3
Pre-requisite	NIL	Syllabus version				
		v. 2.2				

Course Objectives:

1. To impart knowledge about the total quality management principles
2. To demonstrate the importance of statistical process control for process monitoring
3. To familiarize with the concepts of TQM techniques and quality management systems
4. To impart knowledge on system reliability and system maintenance.

Course Outcome:

Upon successful completion of the course the students will be able to

1. Develop action plans for customer centric business on the basis of various quality philosophies.
2. Apply total quality management techniques for design and manufacture of highly reliable products and services.
3. Develop statistical process control charts for monitoring the health of manufacturing systems.
4. Solve various industrial problems using Six Sigma and related techniques.
5. Establish quality management system and environmental management system for product and service industries.
6. Design systems with a focus on enhancing reliability and availability.

Module:1	Quality: Introductory Concepts	6 hours

Definition of Quality, Differing perspectives of quality by Design, Manufacturing, Service, etc. Contributions of Deming, Juran and Crosby. Customer orientation and Customer satisfaction measurement, Quality Control, Quality assurance and Total Quality Management definitions, Employee involvement, Quality Awards.

Module:2	TQM Techniques	6 hours

Principles of TQM, TQM Framework, FMEA, QFD, Bench Marking, 5S, PDCA, Poka Yoke, TPM, 5S, Corrective and Preventive actions with examples.

Module:3	Statistical Process Control	6 hours

7 QC tools, New Management tools, Statistical Process control, Control charts, Process capability, Cp, Cpk analysis.

Module:4	Six Sigma	6 hours

Features of six sigma, Goals of six sigma, DMAIC, Six Sigma implementation. TRIZ, Taguchi Loss function. Case studies and problems.

Module:5	Quality Systems	6 hours

ISO 9000, ISO 9000:2000, ISO 14000, other quality systems.

Module:6	Reliability	6 hours

Introduction to reliability, Failure rate, System reliability- Series, Parallel and mixed configuration, Problems, Weibull distribution and application.

Module:7	**Maintenance**	**7 hours**
Mean time to repair, Mean time between failures, Predictive maintenance, Reliability Centered Maintenance, Reliability improvement – Redundancy – Element – Unit and stand by redundancy – Reliability allocation for a series system – Maintainability and availability – System downtime – Reliability and Maintainability trade off – Simple problems.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours	**45 hours**

Text Book(s)	
1.	Total Quality Management and Operational Excellence: Text with Cases**,** Routledge, 2014.
2.	A Textbook of Reliability and Maintenance Engineering, Charles Ebeling, UBSPD, 2017.
Reference Books	
1.	Dr. Kiran, Total Quality Management, B.S.Publications, 2017.
2.	E. Balagurusamy, Reliability Engineering, UBSPD, 2017.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar			
Mode of assessment:			
Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-10-2017

Course code	LEAN ENTERPRISES AND NEW MANUFACTURING TECHNOLOGY	L	T	P	J	C
MEE1016		3	0	0	0	3
Pre-requisite	NIL	Syllabus version				
		v. 2.2				

Course Objectives:

1. To make the students understand how the philosophy and core methods of lean manufacturing are applied to any business.
2. To make the students understand the value chain and to map the current state of material and information flow through the value chain and to understand where the added value is for the customer.
3. To help the students to identify waste and its root cause in the value stream.
4. To help the students to develop a future state vision of lean systems by using kaizens (improvement events) to eliminate the causes of waste by identifying new ways to achieve continuous flow through manufacturing cells.
5. To make the students to use their leadership skills needed to drive lean initiatives.

Course Outcome:

Upon successful completion of the course the students will be able to

1. Identify key requirements and concepts in lean manufacturing
2. Apply the tools in lean manufacturing to analyze a manufacturing system and plan for its improvements.
3. Find the common pitfalls encountered during lean implementation and initiate a continuous improvement change program in a manufacturing organization.
4. Map the value chain and predict the value addition
5. Apply lean accounting principles towards financial management of all streamlined operations in a lean manufacturing setup.
6. Apply knowledge of facility planning, cellular manufacturing and group technology in a typical lean manufacturing setup.

Module:1	Introduction to Lean manufacturing	6 hours

Definition and concept of lean manufacturing; Principles of lean manufacturing – Just in time – Types of pull systems - Toyota Production systems – Benefits of lean manufacturing – Theory of constraints – Reduction of wastes.

Module:2	Lean Manufacturing Tools-I	6hours

Basic tools of lean manufacturing: 5S, Total Productive Maintenance, Key Performance Indicator, Overall Equipment Effectiveness, Plan Do Check Act, Root Cause Analysis, Poka Yoke, Work Cell, Bottleneck analysis, continuous flow.

Module:3	Lean Manufacturing tools –II	6 hours

Secondary tools of lean manufacturing: Gemba, Heijunka,HoshinKanri, Jidoka, Load leveling, Mind maps, 5 whys, SMDE, Six Big Losses, Standardized work, Visual factory, Zero quality control.		
Module:4	**Strategic Issues and Lean implementation**	**6 hours**
Strategic issues: - Actions - Issues - Focus - Leadership - Management of teams – Training. Focused factory concept – Availability, Variability, Lean implementation strategies, causes for failures, sustaining lean, and constraint management.		
Module:5	**Process Mapping and Value stream mapping**	**6 hours**
Process mapping – Need for process map- Types- Detailed instructions - common mistakes in mapping - limits – facilitation; Value stream mapping: - Overview - Where to use – When to use- Step by step approach – How to use – Present and future states - VSM symbols.		
Module:6	**Lean accounting**	**6 hours**
Lean accounting definition, Need for lean accounting, benefits of lean accounting, Lean accounting Vs traditional cost accounting, Activity based costing - Product costing - Volume adjusted costing, Target costing.		
Module:7	**Cellular manufacturing and Group technology**	**7 hours**
Work cell – Cell design - Facility planning – Plant layout – Balancing the work in work cells – Takt time – Defining - Benefits - Uses – Limitations; Facilities planning tools; Group technology coding classification; Productivity Improvement Aids.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Pascal Dennis, Lean production Simplified, Productivity press, New York, 2013.
Reference Books	
1.	P. James Womack, Lean Thinking: Banish Waste and Create Wealth in Your Corporation, Simon & Schuster, 2003.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar			
Mode of assessment:			
Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-10-2017

Course code	NEW VENTURE PLANNING AND MANGEMENT	L	T	P	J	C
MEE1017		2	0	0	4	3
Pre-requisite	NIL	Syllabus version				
		v. 2.2				

Course Objectives:

1. Understand the basic concepts of entrepreneurship to start an enterprise and prepare a plan for starting a new venture
2. Develop an understanding of the market for a product and economics related to a new venture
3. Know the support offered by the Government and understand the legal aspects related to a business

Course Outcome:

Upon successful completion of the course the students will be able to

1. Apply the basic concepts of entrepreneurship
2. Perform feasibility analysis for a new venture
3. Prepare financial reports related to a new business
4. Adhere to rules and regulations and obtain support from government
5. Prepare a business plan for a new venture or expansion of an existing enterprise
6. Prepare Comprehensive Exam for starting a new venture

Module:1	Concepts of Entrepreneurship and Business	4 hours

Entrepreneurship; Definition and Types - Entrepreneurship as a career - Competencies and qualities of an entrepreneur - Opportunity Identification and Trend Identification - Factors affecting entrepreneurship; Forms of business organization- Advantages and disadvantages - Steps involved in business establishment - Factors to be considered in plant location.

Module:2	Feasibility analysis and Sales & Marketing	4 hours

Product/service feasibility, Market feasibility, Organizational feasibility, Financial feasibility, Technical feasibility- Market Survey and Market research - Channels of distribution. Pricing methods - full cost, target pricing, marginal cost, go rate, customary, sealed bid etc.

Module:3	Financial estimation and Sourcing	4 hours

Estimation of capital requirements – Pre-operative expenses, Fixed expenses, Working capital; Project financing - Sources of funding- Equity financing - Venture Capital, Angel investors, Debentures and shares- types of shares - Crowd funding.

Module:4	Financial Accounting	4 hours

Financial analysis - Balance sheet - Income statement – Cash flow statement – Break even analysis; Pricing policy and Profit planning; Classification of costs; Break-even analysis - Book keeping and accounting terminology.

Module:5	**Legal aspects Related to business**	**4 hours**
Procedure and formalities - Legal aspects relating to registration, labour, licenses and clearances. Leasing and Franchising; Intellectual property rights – Patents, Trademarks, Copyrights, Royalty; Employee welfare measures: –Inside and outside organization - PF - ESI - Medical compensation - Risk coverage; Taxation –Income Tax, Service tax, VAT, TDS, and Excise.		
Module:6	**Governmental assistance and support to Entrepreneurs**	**4 hours**
Incentives, subsidies and grants available from State Government - Incentives, subsidies and grants available from Central Government - Role of DIC and MSME, Role of TBIs, EDIs and other Agencies- Role and support of private agencies.		
Module:7	**Business Plan:**	**4 hours**
Definition, Need and purpose of a Business plan - Contents of Business plan:- Introduction, Executive summary, Project projections, Project details; Competition analysis, competitive advantage - Characteristics of project- General and Technical- Project cost, Production cost, Financial details - Break-even point; Profitability - Pricing for profitability.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)	
1.	Bruce R, Barringer, R Duane Ireland, Entrepreneurship- Successfully launching new ventures, 2013.
Reference Books	
1.	David. F. Summen, Forming Entrepreneurial Institution, 2014.
2.	Sramana Mitra, Entrepreneur Journeys, 2013.

Challenging Projects (Indicative)

Guidelines • Generally a team project [Maximum of 3 members only]. • Concepts studied should have been used. • Down to earth application and innovative idea should have been attempted. • Assessment on a continuous basis with a minimum of 3 reviews. **Sample projects:** 1. Project Cost Estimation. 2. Market survey and Market research. 3. Business plan	**60** [Non-contact hours]

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

Mode of assessment:			
Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-10-2017

Course code	FACILITIES AND PROCESS PLANNING	L	T	P	J	C
MEE1018		3	0	0	0	3
Pre-requisite	NIL	Syllabus version				
		v. 2.2				

Course Objectives:

1. To introduce various processes involved in facility planning
2. To expose factors involved in creation of new facilities
3. To impart knowledge required on plant layout tools for better solute

Course Outcome:

Upon successful completion of the course the students will be able to

1. Plan and develop facilities in manufacturing plants
2. Design different product processes involved in various planning activities
3. Identify plant location and select suitable resources
4. Apply tools for developing and analysing plant layout
5. Apply numerical methods in layout planning
6. Analyse material handling systems in manufacturing firms
7. Evaluate cost and corresponding implementation activities in layout

Module:1	Facilities Planning	6 hours

Introduction to facilities Planning, Significance of Facilities Planning, Objectives of Facilities Planning, Facilities Planning Process, Strategic Facilities Planning, Developing Facilities Planning Strategies.

Module:2	Product process and schedule design, Flow systems, activity relationships and space requirements.	6 hours

Introduction, Product Design, Process Design, Schedule Design, Facilities Design, Flow Systems, Material Flow System, Departmental Planning, Activity Relationships, Space Requirements.

Module:3	Plant Location	6 hours

Basic Factors to be considered – Plant location and site selection – Consideration in facilities planning and Layout capacity – Serviceability and flexibility – Analysis in selection of Equipment – Space requirement – Machine selections, Labour Requirement and selection.

Module:4	Layout Planning	6 hours

Types of Layout – Factors influencing product - Process - Tools and Techniques for developing Layout. Developing and Analysis of plant Layout – Presenting the Layout – Office Layout plot planning. Evaluation and Improvement of Layout.

Module:5	Computer Aided Plant Layout	7 hours

Data requirements – Mathematical programming procedures - Heuristics – CORE LAP -

PLANET - MAT - CRAFT- Probabilistic Approach - Random selection (ALDEP) - Based sampling - Simulation – Graph Theory – Facility design – Layout states – Scale effect. Criticism concerning Computer Aided Plant Layout.		
Module:6	**Material Handling**	**6 hours**
Objectives – Principles – Types – Degree of mechanization – Unit load concept – Material Handling cost – Relationship between Material Handling and Plant Layout – Material Handling system Design - Specification of the Design – Analyzing an existing material Handling system. Basics of material handling selection – AGVS in material Handling – Packing.		
Module:7	**Evaluation and Implementation of layout**	**6 hours**
Evaluating the Layout – Qualitative Evaluation Techniques - Efficiency indices – Cost Evaluation of Layout – Quantitative evaluation Techniques – Evaluation procedures – Making the alteration – Presenting the Layout to management – Displaying the Layout – Follow up – Approval – Reproducing the Layout - Installing the Layout.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	James A Tompkins, John A white ,Yavuz A Bozer,JMA Tanchoco, Facilities Planning, Fourth Edition, Wiley, 2010.
Reference Books	
1.	Francis, Facility Layout and Location: An analytical Approach, Pearson, 2015.
2.	Alberto Garcia-Diaz, J Macgregor smith, Pearson New International, Pearson, 2016.
3.	Sunderesh S. Heragu, Facilities Design, Fourth Edition, CRC Press, 2016.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar			
Mode of assessment:			
Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-10-2017

Course code	OPERATIONS RESEARCH	L	T	P	J	C
MEE1024		2	2	0	0	3
Pre-requisite	MAT2001	Syllabus version				
		v. 2.2				

Course Objectives:

1. To provide students the knowledge of optimization techniques and approaches.
2. To enable the students apply mathematical, computational and communication skills needed for the practical utility of Operations Research.
3. To teach students about networking, inventory, queuing, decision and replacement models.

Course Outcome:

Upon successful completion of the course the students will be able to

1. Apply operations research techniques like L.P.P, scheduling and sequencing in industrial optimization problems.
2. Evaluate transportation problems using various OR techniques.
3. Explain various OR models like Inventory, Queuing, Replacement, Simulation, Decision etc. and apply them for optimization.
4. Use OR tools in a wide range of applications in industries.
5. Identify current topics and advanced techniques of Operations Research for industrial solutions.
6. Identify best techniques to solve a specific problem.
7. Analyse, consolidate and synthesise knowledge to identify and provide solutions to complex problems with intellectual independence.

Module:1	Linear Programming Problem	4 hours

Introduction to Operations Research – Linear Programming - Mathematical Formulation – Graphical method – Simplex method – Penalty methods: M-method, Two Phase method- Duality.

Module:2	Transportation Problem	4 hours

Introduction - Formulation - Solution of the transportation problem (Min and Max): Northwest Corner rule, row minima method, column minima method, Least cost method, Vogel's approximation method – Optimality test: MODI method.

Module:3	Assignment and Sequencing Models:	3 hours

Assignment problems – Applications - Minimization and Maximization; Sequencing - Problem with N jobs and 2 machines – n jobs and 3 machines problem - n jobs and m machines problem.

Module:4	Project Management	4 hours

Introduction - Phases of project management-Construction of Network diagrams- Critical path method (CPM) and Project evaluation and review technique (PERT) - Crashing of project network.

Module:5	**Inventory Control**	**4 hours**
Necessity for maintaining inventory - Inventory costs -Inventory models with deterministic demand - inventory models with probabilistic demand - Inventory models with price breaks - Buffer stock.		
Module:6	**Queuing Models**	**4 hours**
Poisson arrivals and Exponential service times – Single channel models and Multi-channel models - Simulation: Basic concepts, Advantages and disadvantages - Random number generation - Monte Carlo Simulation applied to queuing problems.		
Module:7	**Game theory and Replacement Models**	**5 hours**
Game theory: Competitive games - Useful terminology - Rules for game theory - Two person zero sum game – Property of dominance - Graphic solution – Algebraic method. **Replacement models:** Replacement of items that deteriorate with time: No changes in the value of money, changes in the value of money - Items that fail completely: Individual replacement and group replacement policies.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)	
1.	Hamdy A Taha, Operations Research: An Introduction, 9th edition, Pearson Education, Inc., 2014.
Reference Books	
1.	Hira D S and Gupta P K, Operations Research, S. Chand & Sons, 2014.
2.	Kanti Swarup, Gupta P.K., and Man Mohan, Operations Research, 18th edition, S. Chand &Sons, 2015.
3.	Manohar Mahajan, Operations Research, Dhanpat Rai & Co, 2013.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar			
Mode of assessment:			
Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-10-2017

Course code	INSTRUMENTATION AND CONTROL ENGINEERING	L	T	P	J	C
MEE1027		3	0	2	0	4
Pre-requisite	NIL	Syllabus version				
		v. 2.2				

Course Objectives:

1. To learn the type of the system, dynamics of physical systems, classification of control system, analysis and design objective
2. To provide good knowledge of Instrumentation systems and their applications
3. To provide knowledge of advanced control theory and its applications to engineering problems

Course Outcome:

Upon successful completion of the course the students will be able to

1. Describe the basic principle of typical measurement systems and error characteristics
2. Understand transduction, working principles of typical sensors used in industrial applications.
3. Demonstrate the applications and role of signal conditioning circuits, data acquisition in measurement systems.
4. Formulate mathematical model for physical systems and simplify representation of complex systems using reduction techniques.
5. Describe the basic concepts in control system design and the role of feedback.
6. Analyse the stability performance of the control system design.
7. Design and realize simple circuits for instrumentation control.

Module:1	Introduction to Measurement systems	6 hours

Sensors, Transducers, classification, static and dynamics characteristics, errors, transduction principles.

Module:2	Measurement of Motion, Force and Torque	6 hours

Displacement and speed measurement for translational and rotation systems using potentiometers, LVDT and RVDT, Encoders, accelerometers and gyroscopes. Force and Torque measurements using strain gauges and piezoelectric pickups.

Module:3	Measurement of temperature, pressure and flow	6 hours

Temperature measurement using Thermistors, RTD, Thermocouple and semiconductor sensors. Pressure measurement using gage, manometers, bellows, diaphragm, differential pressure transmitter. Flow measurement using Venturi-tubes, Rotameters and anemometers.

Module:4	Signal conditioning and data acquisition	6 hours

Basic signal conditioning – bridges, amplifiers, filters, monitoring and indicating systems and data acquisition systems.

Module:5	**Modelling and representation of systems -**	**6 hours**
Model of a system, Concept of transfer function, block diagram and state space, Modelling of basic physical systems.		
Module:6	**Control concepts**	**6 hours**
Open loop and closed loop systems with examples, controller design, and performance measurements-Design of P, PI, PD and PID controllers.		
Module:7	**Stability analysis**	**7 hours**
Concept of poles and zeros, Stability analysis of system using root locus, Routh Hurwitz criterion and Phase and gain margins.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	W. Bolton, Instrumentation and Control Systems, Newnes-Elsevier publication, 2nd edition**,** 2015.
Reference Books	
1.	Ernest O. Doeblin, Measurement Systems: Application and Design, 5th Edition, Tata McGraw- Hill, 2012.
2.	Katsuhiko Ogata, Modern Control Engineering, 5th Edition, Prentice Hall of India Pvt. Ltd, 2010.
3.	Patranabis D, Instrumentation and Control, PHI Learning Pvt. Ltd, 2011.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

List of Challenging Experiments (Indicative)		
1.	Study, development and calibration of measuring instruments for displacement, speed, torque, force, temperature, pressure, flow, fluid level etc.	3 hours
2.	Control of DC motor, stepper motor and servomotor.	3 hours
3.	Demonstration of PID control system.	3 hours
4.	Use of MATLAB for control system simulation (Control Systems Toolbox) - Modeling of physical systems using Simulink.	3 hours
5.	Signal Conditioning Circuit for specific application.	3 hours
6.	Determination of Dynamic Performance Characteristics of First Order System.	3 hours
7.	Determination of Dynamic Performance Characteristics of Second Order System.	3 hours
8.	Determination of Dynamic Performance Characteristics of Higher Order Systems.	3 hours

9.	Analog to Digital and Digital to Analog Conversion.			3 hours
10.	Grounding Practices.			3 hours
			Total Laboratory Hours	**30 hours**
Mode of assessment:				
Recommended by Board of Studies	17-08-2017			
Approved by Academic Council	47	Date	05-10-2017	

Course code	ROBOTICS	L	T	P	J	C
MEE1030		2	0	2	0	3
Pre-requisite	NIL	Syllabus version				
		v. 2.2				

Course Objectives:

1. To outline the basic concepts of Industrial Robots and drive system.
2. To plan and to analyze the design concepts and applications of end effectors.
3. To solve kinematics and trajectory related problems.
4. To identify the appropriate sensors for various robotics applications.

Course Outcome:

Upon successful completion of the course the students will be able to

1. Specify various types of Robots for industrial applications
2. Design appropriate end effectors for various applications.
3. Analyze kinematics of various manipulator configurations
4. Compute required trajectory planning for the given task.
5. Select the suitable sensors for real time working of robotic arm.
6. Prepare Robot program for various industrial applications.

Module:1	Introduction to Industrial robot	4 hours

History of Robotics –Basics components of Robotics system – DOF and types of joints – Work space – Robot precession - Types of robotics configurations – Types of robotics drives – Basic motion of robot manipulator – Harmonics drives – Economics aspects of robotics system in industrial automations.

Module:2	Effectors and Grippers	4 hours

Types of end effector - Mechanical gripper – types of mechanical grippers – magnetic gripper – Vacuum gripper – Adhesive gripper – other special grippers – RCC –Tools – painting gun – welding torch –design of mechanical gripper.

Module:3	Robot control system and Robot kinematics	4 hours

Basic control system concepts – Control system analysis – Robot actuation and feedback - Manipulators - Position analysis and finite rotation and translation – Homogeneous matrices – forward and inverse kinematics – DH representation.

Module:4	Manipulator Trajectory planning	4 hours

Point-to-point and continuous path planning – trajectory planning – Cartesian space – joint space – bending path – problems in trajectory planning.

Module:5	Sensor in robotics	4 hours

Range sensing, Triangulation, structured light approach, Light-of-flight range finder – Proximity

sensing: Inductive, Hall-effect, capacitive and ultrasonic sensor –Touch sensing – Force and Torque sensing		
Module:6	**Machine vision system**	**4 hours**
Introduction to Machine vision – functional block diagram of machine vision system - Sensing and Digitizing – Image processing and analysis		
Module:7	**Robot programming**	**4 hours**
Classification of robotics language – instruction set in Vel language - simple robot in palletizing and de- palletizing – simple robot program in robot arc welding.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)

1.	Mikell P. Groover, Mitchell Weiss, Industrial Robotics Technology – Programming and Applications, 2nd edition, McGraw Hill, 2013.

Reference Books

1.	S. R. Deb, Sankha Deb, Robotics Technology And Flexible Automation, 2nd edition, McGraw Hill Education, 2017.
2.	Niku, Saeed. B, Introduction to Robotics: Analysis, Systems, Applications, Prentice Hall of India Pvt. Ltd , New Delhi, 2011.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

List of Challenging Experiments (Indicative)

1.	Experiment on Tool Centre Point (TCP).	3 hours
2.	Developing a robot program with point to point control method.	3 hours
3.	Developing a robot program with Continuous path control method.	3 hours
4.	Developing a robot program on given straight line profile.	3 hours
5.	Developing a robot program on given Curved profile.	3 hours
6.	Pick and place with digital signal interpret.	3 hours
7.	Forward kinematics for two link planner using Sim-Mechanics.	3 hours
8.	Inverse kinematics for two link planner using Sim-Mechanics.	3 hours
9.	Trajectory Planning using third order polynomial.	3 hours
10.	Programming two link planner with given profile.	3 hours
	Total Laboratory Hours	**30 hours**

Mode of assessment:

Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-10-2017

Course code	Mechatronics Systems Design	L	T	P	J	C
MEE1045		3	0	0	4	4
Pre-requisite	NIL	Syllabus version				
		v. 1.0				

Course Objectives:

4. To impart knowledge of the elements and techniques involved in mechatronics systems for industrial automation.

Course Outcome:

1. Students will acquire the knowledge of basic concepts, applications and elements of mechatronic systems.
2. Students will experience design concepts, modeling and simulation of mechatronics system.
3. Students will familiar with sensor interfacing and data acquisition systems.
4. Students will understand the concepts of intelligent systems and its application in control of mechatronics systems.

Module:1	Basics of Mechatronics	5 hours

Basic concepts in mechatronics, need for mechatronics systems, mechatronics systems design approach, classification of mechatronics systems and emerging application areas of mechatronics.

Module:2	Mechatronics systems components	7 hours

Key elements of mechatronics system, control system concepts, basics of sensors, actuators, signal converters, driver circuits and control electronics.

Module:3	Controllers	7 hours

Basics of micro-processors, micro-controllers, logic devices and programmable logic controllers – architecture. Basic programming and input-output devices interfacing with micro-controllers and programmable logic controllers.

Module:4	Mechatronics system modeling	7 hours

Mechatronics design process, modelling and simulation of mechatronics systems - Different systems analogy: mechanical, electrical and hydraulic elements. Hardware-in-loop simulations, model based system design and simulation using MATLAB-Simulink.

Module:5	Interfacing and Graphical Programming	7 hours

Data acquisition- Interface and communication standards, User interfaces in automation - Human/ManMachine Interfaces, Fundamentals of graphical programming and LabVIEW, DAQ Interfacing and Control Systems Design. Ergonomics.

Module:6	Intelligent Systems	5 hours

Introduction to intelligent systems. Application of fuzzy logic and artificial neural network in

mechatronics. Fundamentals of artificial intelligence, expert systems, condition monitoring and machine learning.		
Module:7	**Case Studies**	**5 hours**
Robotics and automation in manufacturing and process industries. Mechatronics control in automotive, prosthetics and artificial limbs, virtual reality and haptics. Mechatronics in agriculture and energy systems.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45**

Text Book (s)	
1.	W. Bolton, Mechatronics - Electronic Control systems in Mechanical and Electrical Engineering (2010), Pearson Education.
Reference Books	
1.	Devdas Shetty, Richard A. Kolk, Mechatronics System Design (2012), 2nd edition, Cengage learning India Pvt. Ltd.
2.	Nitaigour Premchand Mahalik, “Mechatronics Principles, Concepts and Applications”, 2015, McGraw Hill Education, New Delhi.
3.	Davis G. Alciatore and Michael B. Histand, “Introduction to Mechatronics and Measurement systems”, 2011, McGraw Hill Education, New Delhi.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar			
Mode of assessment:			
Recommended by Board of Studies	22/02/2018		
Approved by Academic Council	49	Date	15-03-2018

Course code	CAD/CAM	L	T	P	J	C
MEE2007		2	0	4	0	4
Pre-requisite	MEE1007	Syllabus version				
		v. 2.2				

Course Objectives:

1. Demonstrate basics of CAD/CAM concepts.
2. Explain computer graphics and solid modelling techniques.
3. Demonstrate part programs and group technology techniques.
4. Discuss latest advances in the manufacturing perspectives.

Course Outcome:

Upon successful completion of the course the students will be able to

1. Apply design concepts.
2. Utilise CAD standards for geometrical modelling.
3. Demonstrate Solid modelling techniques.
4. Develop part programs for solid models.
5. Apply group technology concept in manufacturing product.
6. Make use of FEA concept for analysis.
7. Explain FMS and CIM wheel for manufacturing industry
8. Develop the model for analysing and manufacturing structural member.

Module:1	Introduction	4 hours

Definition and scope of CAD/CAM- Computers in industrial manufacturing, design process- Computer Aided Design (CAD)-Computer Aided Manufacturing (CAM)-Computer Integrated Manufacturing (CIM) - Introduction to Computer graphics -Raster scan graphics-Co-ordinate systems.

Module:2	Graphics and computing standards	4 hours

Data base for graphic modeling-transformation geometry-3D transformations –Clipping-hidden line removal-Colour-shading-Standardization in graphics- Open GL Data Exchange standards – IGES, STEP - Graphic Kernal system (GKS).

Module:3	Geometric modelling	4 hours

Geometric construction methods-Constraint based modeling- Wireframe, Surface and Solid – Parametric representation of curves, solids & surfaces.

Module:4	CNC Machine Tools	4 hours

Introduction to NC, CNC, DNC - Manual part Programming – Computer Assisted Part Programming – Examples using NC codes- Adaptive Control – Canned cycles and subroutines – CAD/ CAM approach to NC part programming – APT language, machining from 3D models.

Module:5	**Role of information systems in manufacturing**	**4 hours**
Discrete part manufacture-information requirements of a production organization-manufacturing strategies-Integration requirement - Group technology-coding-Production flow analysis-computer part programming-CAPP implementation techniques.		
Module:6	**Introduction to FEA concepts**	**4 hours**
Nodes -Meshing – Pre and Post processing – Modal analysis – Stress analysis – Steady state and Transient analysis.		
Module:7	**Automated manufacturing systems**	**4 hours**
Flexible Manufacturing systems (FMS) – the FMS concepts – transfer systems – head changing FMS – Introduction to Rapid prototyping, Knowledge Based Engineering, Virtual Reality, Augmented Reality –automated guided vehicle-Robots-automated storage and retrieval systems - computer aided quality control-CMM-Non contact inspection methods.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)	
1.	P.N.Rao, CAD/CAM: Principles and Applications-3rd Edition, Tata McGraw Hill, India, 2010.
Reference Books	
1.	Mikell P. Groover, Automation, Production Systems and Computer Integrated Manufacturing, Pearson Education, 2005.
2	James A. Rehg, Henry W. Kraebber, Computer Integrated Manufacturing, Pearson Education, 2002.
3	Ibrahim Zeid, Mastering CAD/CAM, Tata McGraw Hill International Edition,2005.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

List of Challenging Experiments (Indicative)		
1.	2D Geometry –Splines.	4 hours
2.	Surface Modelling –NURBS.	4 hours
3.	Solid Modelling-CSG, Brep.	4 hours
4.	Preparing solid models for analysis-Neutral files.	4 hours
5.	Real time component analysis-STRESS, STRAIN Analysis.	4 hours
6	Model analysis of different structures.	4 hours
7	Tolerance analysis of any mechanical component.	4 hours
8	CNC Milling program involving linear motion and circular interpolation.	4 hours
9	CNC Milling program involving contour motion and canned cycles.	4 hours
10	CNC Milling program involving Pocket milling.	4 hours

11	Diagnosis and trouble shooting in CNC machine.	4 hours
12	Route sheet generation using CAM software.	4 hours
13	Generation of CNC programming using DXF file format using Wire EDM.	4 hours
14	Generation of CNC programming and machining using Master Cam.	4 hours
15	Generation of STL file format for the given component.	4 hours
	Total Laboratory Hours	**60 hours**

Mode of assessment:			
Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-10-2017

Course code	PRODUCT DESIGN FOR MANUFACTURING	L	T	P	J	C
MEE2008		2	0	0	4	3
Pre-requisite	MEE1007/MEE2031	Syllabus version				
		v. 2.2				

Course Objectives:

1. To apply the role of DFM in product specification and standardization
2. To analyze methods of material, shape and process selections
3. To assess the design rules for manufacturing and assembly processes
4. To use approach towards robust design

Course Outcome:

Upon successful completion of the course the students will be able to

1. Evaluate constraints of manufacturing processes that limit design possibilities with respect to cycle time, material handling and other factory costs
2. Apply various design rules in manufacturing processes
3. Evaluate the process by design guidelines for optimum design and analyze the design alternatives in the manufacture of components
4. Apply quantitative methods to assess DFA between different designs Contents
5. Utilize CAD, CAM, CIM concepts to assess DFMA.
6. Analyze the new product development.
7. Perform DFMA on an existing design and improve its manufacturing.

Module:1	Product Design	4 hours

Introduction to Product design: Asimow's Model - Product design practice in Industry - Industrial design - Aesthetics in product design. Need Identification and Problem Definition, Concept Generation and Evaluation, Embodiment Design.

Module:2	Material Selection	4 hours

Physical and Mechanical Properties of Engineering Materials, Selection of Materials, Selection of Shapes, Strength consideration in product design, Design for stiffness and rigidity: Material savings in design - Ribs, corrugations, Laminates and Members. Case Studies- I.

Module:3	Manufacturing Process Selection	4 hours

Review of Manufacturing Processes, Design for Casting, Design for Bulk Deformation Processes, Design for Sheet Metal Forming Processes, Design for Machining, Design for Powder Metallurgy, Co-selection of Materials and Processes, Case Studies – II.

Module:4	Assembly Process Selection	4 hours

Review of Assembly Processes, Design for Welding, Design for Brazing and Soldering, Design for Adhesive Bonding, Design for Joining of Plastics, Design for Heat Treatment. Case Studies- IV.

Module:5	Use of Computer Aided Tools	4 hours

Role of computers in Product design and manufacturing: CAD/CAM softwares - product life cycle - design process – CIM - Collaborative manufacturing. Computer aided process planning.

Module:6	Design for Manufacture and Assembly	4 hours

Design for manufacturing and Assembly - principles of DFMA and applications. (Boothroyd/ Dewhurst Method – case studies using DFMA software.)		
Module:7	**New Product Development**	**4 hours**
Supporting techniques for new product development processes such as quality function deployment and quality engineering and Taguchi Method.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)	
1.	A.K. Chitale, R.C. Gupta, Product Design and Manufacturing, Sixth Edition, Prentice –Hall of India, 2013.
Reference Books	
1.	Boothroyd, G.,Peter Dewhurst, Winston A. Knight, Product Design for Manufacture and Assembly, Third Edition, CRC Press, Taylor & Francis, 2010.
2	Michael Ashby., Materials Selection in Mechanical Design, 5th edition, Butterworth-Heinemann, U.K, 2016.
3	Karl T. Ulrich, Ateven D. Eppinger, Product Design and Development, 6th edition, Tata McGraw-Hill,
4	O. Molloy, S. Tilley and E. A. Warman., Design for Manufacturing and Assembly: Concepts, Architectures and Implementation. Springer. USA, 2012.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

List of Challenging Experiments (Indicative)	
Guidelines for Project: • The project will be a group project with a maximum of 3 members in a group. The size will reflect the complexity of the project. Students should make sure that the concepts to be studied are reflected in the project. • There will be a minimum of three reviews conducted in a semester and the marks will be awarded and taken for final assessment. The marks distribution for 3 reviews will be 20:30:50. • Minimum pass marks for project is 50%. If the student fails to get 50%, he/she has to re-register and redo in a subsequent semester. • If the student has got >= 50% in project, and fails in Theory, then the same marks can be taken up for grading purposes after he/she completes the Theory FAT. • Evaluation is through continuous assessment with 3 reviews. No separate FAT. Sample Projects: 1. Design of Products by implementing Design for manufacturing and assembly principles. 2. Design of home appliances using DFMA principle. 3. Design of engineering components for concurrent costing. 4. Design of automobile components using DFMA software. 5. DFMA of any new products.	**60** hours

Mode of assessment:			
Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-10-2017

Course code	TRIBOLOGY	L	T	P	J	C
MEE2009		2	2	0	0	3
Pre-requisite	MEE1002, MEE1004	Syllabus version				
		v. 2.2				

Course Objectives:

5. To introduce tribology as an important design consideration that affects the performance of various machine components in relative motion and in contact
6. To understand the importance of friction and wear while designing components for functional applications
7. To recognize the importance of lubrication in machine components and in the design of various types of bearings
8. To understand the pressure development mechanism in a full film bearing and analyze a journal bearing
9. To introduce latest developments in fields such as micro and nanoscale tribology

Course Outcome:

Upon successful completion of the course the students will be able to

1. Design machine components related to industrial tribology
2. Estimate the friction and wear in interacting surfaces
3. Apply the principles of lubrication in designing various types of bearings
4. Analyse the pressure and estimate the load carrying capacity of a journal bearing
5. Estimate the friction and power loss in a journal bearing
6. Test components and Characterize tribological failures
7. Apply tribological principles in designing components for use in MEMS, tribotronics and automotive applications
8. Determine experimentally the tribological properties.

Module:1	Introduction to Tribology	4 hours

Tribology in Design - Mechanical design of oil seals and gasket - Tribological design of oil seals and gasket, Tribology in Industry (Maintenance).

Module:2	Friction	4 hours

Laws of friction - Stick-slip phenomenon - Friction characteristics of metals and non-metals - Ploughing theory of friction - Measurement of friction.

Wear - Wear mechanisms – Interfacial wear and Chemical wear-Wear measurements - Ferrography and oil analysis.

Module:3	Lubrication and Bearings	4 hours

Lubrication types, Regimes, Basic Modes of Lubrication, Properties of Lubricants, Lubricant Additives, Bearing Terminology – Sliding contact bearings – Rolling contact bearings, Comparison between Sliding and Rolling Contact Bearings.

Module:4	**Hydrodynamic Lubrication**	**5 hours**
Fluid film in simple shear – Mechanism of pressure development in a convergent film – pressure induced and velocity induced flows - Reynolds equation for fluid film lubrication – Slider bearing- Load carrying capacity – Journal bearing – Pressure development. Squeeze film lubrication.		
Module:5	**Lubrication of bearings**	**4 hours**
Long bearing and short bearing approximations - Load carrying capacity – Sommerfeld Number – Friction – Petroff's equation – Oil flow and Thermal equilibrium.		
Module:6	**Nanoscale Tribology**	**4 hours**
Interatomic Interactions, Atomic Force Microscope (AFM), Challenges of Tribological Testing at Small Scales.		
Module:7	**Tribological testing and applications**	**3 hours**
Common Geometries, Instrumentation and Methods used for Testing, Influences of Test Parameters – Tribology in metal cutting – Automotive Tribology.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)

1.	GwidonStachowiak, Andrew W Bachelor, Engineering Tribology, Butterworth-Heinemann, 2013.

Reference Books

1.	Majumdar.B.C, Introduction to Tribology of Bearings, Universal Books, 2010.
2.	Bharat Bhushan, Introduction to Tribology, John Wiley & Sons, 2013.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

List of Challenging Experiments (Indicative)

1.	Evaluation of bearing friction using Petroff's equation and Sommerfield Number.	6 hours
2.	Apply wear equations and find out the wear rate.	6 hours
3.	Lubricant selection for a particular application.	9 hours
4.	Problems on fluid film thickness and pressure.	9 hours
	Total Laboratory Hours	**30 hours**

Mode of assessment:

Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-10-2017

Course code	DESIGN OF COMPOSITE MATERIALS	L	T	P	J	C
MEE2010		2	2	0	0	3
Pre-requisite	MEE1005	Syllabus version				
		v. 2.2				

Course Objectives:

1. Provide students with a basic understanding of the composition and uses of composite materials, their structural and mechanical properties.
2. Develop the student's skills in understanding the different manufacturing methods available for composite material
3. Illuminate the knowledge and analysis skills in applying mechanics to the composite materials.

Course Outcome:

Upon successful completion of the course the students will be able to

1. Classify composite materials and their applications.
2. Make use of the knowledge in manufacturing processes of composite materials
3. Apply failure criteria on composite structures subjected to various types of loading.
4. Analyze composite laminates using the fundamentals of Classical Lamination Theory
5. Design composite laminates subjected to mechanical, thermal stresses for different environmental conditions.

Module:1	Introduction & Applications	2 hours

Definitions -Composites, Multiscale Compositesand Nanocomposites, Reinforcements and Matrices, Properties ofthesecomposites in comparison with standardmaterials.

Applications: Applications of metal, ceramic and polymermatrix composites, Multiscale and nano composites, Hybrid compositesand Sandwich composites, self-reinforced composites andcarbon/carbon composites.

Module:2	Manufacturing of Composites:	3 hours

Raw Materials: Introduction, Reinforcements manufacturing, Matrix materials manufacturing, Fabric constructions, 3D Braided performs, Pepregs, Moulding compounds-Materials selections, guidelines.

Module:3	Manufacturing composite laminates	3 hours

Manufacture of PMC's, VARTEM and SCRIMP, Manufacture of MMC's C/C and CMC's - processing- Forming structural shapes- Different casting methods, Sol-gel method, Non-autoclave curing- Manufacturing defects.

Module:4	Micro and Macro mechanical analysis of composite materials:	5 hours

Introduction to composite materials- Classification-Micromechanical Analysis of a Lamina- Volume and Mass Fractions, Density, and Void Content- Prediction of engineering properties

using micromechanics-Material properties of the fiber and matrix.
Macro mechanical analysis of a lamina -linear elastic stress-strain characteristics of Fiber-Reinforced material: Stress and deformations in Fiber-Reinforced materials-Maxwell-Betti reciprocal theorem- Stress-strain relations- Effects of free thermal strains and moisture strains.

Module:5	**Stress and Strain**	**5 hours**

Stress-strain relations for plane stress- Effects of free thermal and free moisture strains- Plane stress & strain relations in a global coordinate system- Transformation relations-Transformed reduced compliances & stiffness- Effects of free thermal and free moisture strains.

Module:6	**Classical Lamination Theory & Theories of Failures**	**6 hours**

Kirchhoff Hypothesis- Laminate Nomenclature and Classification-Laminate strains and displacements - Laminate stresses & strains -Stress distributions through the thickness- Force and moment resultants-Laminate stiffness matrix: ABD Matrix-Classification of laminates and their effect on the ABD Matrix-Elastic couplings.
Theories of Failures of Laminates: Maximum stress and strain criterion- Tsai-Hill, Tsai-Wu criterion- Environmental effects- Inter-laminar stresses- Impact resistance- Fracture resistance- Fatigue resistance.

Module:7	**Assembly and Composite Products**	**4 hours**

Smart composites, Joints and assembly of composites, Design for assembly and environment,Materialsselection-principlesincomposites,Casestudiesindesignanddevelopment of composite parts, boats, pressure vessels, automotive parts, aerospace parts, electronics parts and composites for spacevehicles.

Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)

1.	M.Balasubramanian, Composite materials processing, 1st edition, CRC press, 2013.

Reference Books

1.	Ever J. Barbero, Introduction to Composite Materials Design, 2nd edition, CRC Press, 2010.
2.	K.K. Chawla, Composite Materials, 3rd edition, Springer-Verlag, New York, 2012.
3.	Roy Cox, Engineered Tribological Composites: The Art of Friction Material Development, 1st edition, SAE International, 2011.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

Mode of assessment:

Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-07-2017

Course code	WELDING ENGINEERING	L	T	P	J	C
MEE2011		2	0	0	4	3
Pre-requisite	MEE1007	Syllabus version				
		v. 2.2				

Course Objectives:

1. To impart the basic principles of welding
2. To expose various types of advanced joining processes
3. To introduce about welding defects and remedial measures for it

Course Outcome:

Upon successful completion of the course the students will be able to

1. Demonstrate the application of different heat sources used for welding
2. Determine the application of various welding processes
3. Develop a heat transfer model for different welding processes and weld-geometries
4. Analyze weld solidification and slag/metal interactions
5. Apply appropriate distortion control and correction techniques to reduce weld residual stress
6. Analyze welding parameters and weld defects of components joined using various welding techniques

Module:1	Introduction to welding	4 hours

Classification of welding processes- heat sources, power sources, arc characteristics, V-I relationship, differently pesofel ectrodes, ingredients and function of electrode coverings, types of weld joints.

Module:2	Fusion welding processes	4 hours

Shielded metal arc welding, TIG welding, MIG welding, Submerged arc welding, Electron beam, laser beam welding, plasma arc processes, under water welding processes.

Module:3	Solid state welding processes	4 hours

Resistance, friction, friction stir, ultrasonic, induction pressure, diffusion welding processes, explosive welding.

Module:4	Temperature distribution	4 hours

Heat flow - temperature distribution - cooling rates - influence of heat input, joint geometry, plate thickness, preheat, significance of thermal severity number.

Module:5	Solidification	4 hours

Solidification - Epitaxial growth - weld metal solidification - columnar structures and growth morphology- effect of welding parameters - absorption of gases - gas/metal and slag/metal reactions.

Module:6	**Weldability**	**4 hours**
Weldability of low alloy steels, welding of stainless steels use of Schaffler and Delong diagrams, welding of cast irons - Welding of Cu, Al, Ti and Ni alloys – processes.		
Module:7	**Welding defects**	**4 hours**
Difficulties, microstructure changes, defects and remedial measures in the welding processes.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)	
1.	Lancaster L.F, The Physics of Welding: International Institute of Welding, Pergamon Press, 2013.
Reference Books	
1.	Investigate the microstructure at the weld zone of AISI 304 obtained by SMAW.
2.	Determine the microstructure and hardness across the weldment of dissimilar weld joints.
3.	Estimate the tensile strength of stainless steel welds produced by gas tungsten arc welding process. Compare the same with the base metal.
4.	Study the effect of welding current on the heat input during GTA welding of Ni based super-alloy.
5.	Study the effect of welding speed on the depth of penetration during the GTA welding of Ferritic stainless steel.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar			
Mode of assessment:			
Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-07-2017

Course code	MANUFACTURING AUTOMATION	L	T	P	J	C
MEE2012		3	0	2	0	4
Pre-requisite	MEE2031/MEE1007	Syllabus version				
		v. 2.2				

Course Objectives:

1. To help students gain essential and basic knowledge of automated systems.
2. To familiarize the students with the design of hydraulic and pneumatic circuits for various automated applications.
3. To make students understand the Programmable Logic Controller to control the systems at industrial premises
4. To enable the students to apply the knowledge of information technology in the field of automation for better enhancement.

Course Outcome:

Upon successful completion of the course the students will be able to

1. Apply automation principles and strategies and model manufacturing systems
2. Design automated storage and retrieval systems and employ robots in material handling
3. Implement concepts of automation in inspection and testing
4. Apply PLC timers and counters for the control of industrial processes
5. Design of Hydraulic Circuit and pneumatic circuit for manufacturing application
6. Monitor production using smart sensors based on Industry 4.0 techniques
7. Implement artificial intelligence based systems and IOT in manufacturing

Module:1	Automation	5 hours

Introduction, automation principles and strategies, basic elements of advanced functions, levels modeling of manufacturing systems, Introduction to CNC programming.

Module:2	Automated Handling And Storage system	6 hours

Automated material handling systems , AGV, Transfer mechanism , Buffer storage , Analysis of transfer lines, Robots in material handling, Automated storage and Retrieval Systems (AS/RS) - carousel storage, Automatic data capture, bar code technology, Automated assembly systems

Module:3	Automated Manufacturing system	6 hours

Group Technology, Part family, Sensor technologies, Automated inspection and testing, Coordinate measuring machines, Machine vision, Rapid prototyping.

Module:4	Programmable controllers in Automation	7 hours

PLC Architecture, Modes of operation, Programming methods, Instructions, Instruction addressing, latches, timers and counters.

Module:5	Advanced Control Strategies in Automation	7 hours

SCADA, DCS, Integration of PLC, SCADA and DCS with manufacturing systems, Man-machine interfaces, Introduction to PLM, Case studies.		
Module:6	**Smart Factory and Smart Manufacturing**	**6 hours**
Industry 4.0- Standard, Real-time production monitoring techniques with smart sensors, Configuration of smart shop floor, traceability and call back of defective products		
Module:7	**Intelligent Manufacturing Systems**	**6 hours**
Artificial Intelligence based systems, Virtual Business, e-Commerce Technologies, Global Manufacturing Networks, Digital enterprise technologies, IOT in manufacturing		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	Mikell P. Groover, Automation, Production Systems and Computer-Integrated Manufacturing, 2016, Fourth edision, Pearson Education, New Delhi.

Reference Books

1.	P. Radhakrishnan, S. Subramanyan, V. Raju, CAD/CAM/CIM, New age International, New Delhi.
2.	Yusuf Altintas, Manufacturing Autmation, 2012, Cambridge University Press, USA.
3.	David Bedworth, Computer Integrated Design and Manufacturing, TMH, New Delhi.
4.	Gupta A. K., Arora S. K., Industrial Automation and robotics, 2013, Third Edision, University Science Press, New delhi.
5.	Rajesh Mehra, Vikrant Vij, PLSc & SCADA Thory and Practice, 2011, First Edision, University Science Press, New delhi.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

List of Challenging Experiments (Indicative)

	The lab itself provides students with the opportunity to design and construct an automated manufacturing system and alerts them to the types of problems that arise. Specifically, students will: • Design and build an automated manufacturing system • Learn to programme state of the art industrial robots • Manage a project and learn how to work as a team	
1.	Industrial Robot Programming	4 hours
2.	Automation using PLC such as bottle filling, elevator control	6 hours
3.	Online inspection using machine vision system	5 hours
4.	Process automation simulation using SCADA	5 hours
5.	Interfacing HMI with PLC	5 hours
6.	Factory flow simulation	5 hours

		Total Laboratory Hours	**30 hours**
Mode of assessment:			
Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-10-2017

Course code	MODELING AND SIMULATION OF MANUFACTURING SYSTEMS	L	T	P	J	C
MEE2013		3	0	0	4	4
Pre-requisite	MEE1007/MEE2031	Syllabus version				
		v. 2.2				

Course Objectives:

1. Expose the students to Discrete-Event Simulation as a design and analysis tool, problem solving tool, risk analysis tool, and decision-making tool in manufacturing environment.
2. Know how to conduct a successful project using manufacturing-oriented software such as Arena.

Course Outcome:

Upon successful completion of the course the students will be able to

1. Identify and formulate advance problems and apply knowledge of mathematics and simulation packages to solve manufacturing problems.
2. Use the techniques, skills, and modern packages, necessary for professional practices.
3. Explain the concept of simulation and how to develop and analyze a simulation model.
4. Analyze the fundamental logic, structure, components and management of simulation modelling.
5. Demonstrate knowledge of how to use Arena.
6. Design a simulation model with detailed basic operations and inputs.
7. Demonstrate statistical analysis of output obtained from simulation model.

Module:1	Introduction to System Simulation	6 hours

Introduction to system simulation – Applications – Discrete and Continuous simulation – Simulation models – Simulation procedure – Simulation Examples – General Principles - Simulation software.

Module:2	Mathematical and Statistical Models	6 hours

Review of basic probability and Statistics – Statistical models in simulation – Selecting input probability distributions.

Module:3	Random-Number Generation	6 hours

Properties of random numbers - Generation of Pseudo-Random numbers - Techniques for generating random numbers -Testing of Random numbers.

Module:4	Random-Variate Generation	6 hours

Inverse Transform techniques - Convolution method – Acceptance - Rejection techniques.

Module:5	Input modelling	6 hours

Data collection – Identifying the distribution with data- Parameter estimation - Goodness of fit

tests – Selecting input models without data - Multi Variate and Time Series Input Models.		
Module:6	**Verification and Validation of Simulation Models**	**6 hours**
Model building, verification, and validation - Verification of simulation models - Calibration and validation of models.		
Module:7	**Applications - Simulation modeling using ARENA**	**7 hours**
A packaging line, Modeling machine failures, Assembly operations Batch processing, production/Inventory system.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Jerry banks, John S Carson, Barry L Nelson and David M Nicol, Discrete Event System, Simulation, 5th Edition, Pearson Education Asia, 2013.
Reference Books	
1.	Averill M. Law, Simulation modeling and analysis, 5th edition, McGraw-Hill Education, 2014.
2.	W. David Kelton, Randall P. Sadowski, Nancy B. Zupick, Simulation with Arena, 6th edition, McGraw-Hill Education, 2014.
3.	Sheldon M. Ross, Simulation, 5th Edition, Academic Press, 2012.
4.	Barry L. Nelson, Mathematics, Stochastic Modeling: Analysis and Simulation, Dover Publications, 2014.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

List of Challenging Projects (Indicative)	
Project Guidelines ▪ Generally a team project [Maximum 4 members]. ▪ Report in digital format which includes problem & system description, input data collection and analysis, arena model, experimentation & output analysis and conclusions. ▪ Focus on practical real life applications of simulation in manufacturing environment ▪ Assessment on a continuous basis with a minimum of 3 reviews. ▪ Simulation methodologies and techniques studied in Modeling and Simulation of Manufacturing Systems are to be applied. **Sample projects** ▪ Life-cycle of simulation models: requirements and case studies in the automotive industry. ▪ Simulation metamodel development using neural networks for automated	60 [Non-contact hours]

material handling systems in semiconductor wafer fabrication. ▪ Fast simulations of large-scale highly congested systems. ▪ General modeling and simulation for enterprise operational decision-making problem.	

Mode of assessment:			
Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-10-2017

Course code	METAL CASTING TECHNOLOGY	L	T	P	J	C
MEE2014		2	0	0	4	3
Pre-requisite	MEE1007	Syllabus version				
		v. 2.2				

Course Objectives:

1. To impart knowledge about basic principles and foundry operations in metal casting
2. To develop basic awareness on thermal and metallurgical aspects during solidification of metal and alloys.
3. To give introduction to various types of casting process, principles and application
4. To provide knowledge on design of gating system and risers for manufacturing of defect free sand casting

Course Outcome:

Upon successful completion of the course the students will be able to

1. Design metal casting processes and sequence of foundry operations in casting
2. Analyse suitable melting techniques and practices for ferrous and non-ferrous castings
3. Evaluate various metal casting processes and their applications
4. Analyze the solidification in casting by considering thermal and metallurgical aspects and their role on mechanical properties of casting
5. Design gating and riser system needed for defect free casting
6. Design a casting by considering pattern making, moulding technique, core making, assembly and quality control
7. Improve mechanical properties of cast metal
8. Design, Realise and Test a cast component.

Module:1	Moulding Practices -Production of Moulds and Cores	4 hours

Introduction to casting and foundry industry; basic principles of casting processes; sequence in foundry operations; Moulding sand and its properties. Carbon dioxide moulding, Moulding Equipment, moulding technique, Patterns and Cores.

Module:2	Melting technology	4 hours

Melting furnaces for ferrous and non-ferrous foundries. Electric and fuel fired furnaces. Induction Furnaces; Types of Furnaces, Electromagnetic Stirring, power supplies; Recent developments in energy considerations. Melting practice – ferrous, non-ferrous metals and alloys and composites. Melting practices; Fluxing, inoculation, degassing and grain refinement treatments. Control of pouring temperature Heat treatments of castings, Shop floor melt quality tests.

Module:3	Casting Processes – Detailed study	4 hours

Shell moulding, Plaster Mould casting, Squeeze casting, Investment Casting, Die-casting, Centrifugal casting, Stir casting - Fundamental principles, production techniques, characteristics and its applications.

Module:4	**Solidification of Casting**	**4 hours**
Concept of solidification of metals. Homogenous and heterogeneous nucleation. Growth mechanism. Solidification of pure metals and alloys. Mechanism of columnar and dendritic growth. Solidification time and Chvorinov's rule. Concept of progressive and directional solidifications.		
Module:5	**Principles of Gating and Risering**	**4 hours**
Purpose of the gating system. Components of the gating System and its functions. Design of the gating System. Different types of gates. Gating ratio and its functions. Definition and functions of the riser. Types of risers and their application. Design of the riser - its shape. Size and location. Use of insulating material and exothermic compounds in risers.		
Module:6	**Design of Casting**	**5 hours**
Factors to be considered in casting design. Design consideration in pattern making, moulding techniques and core making and assembly. Cooling stresses and hot spots in casting and modification in casting geometry to overcome them – Modeling and Simulation using Solidcast, Opticast and Flowcast. **Casting Quality Control**: Casting defects and factors responsible for them. Different inspection and testing methods to evaluate the casting. Quality control activities in a foundry.		
Module:7	**Structure and Properties of Cast Metal**	**3 hours**
Detailed study of microstructure, mechanical and other properties of ferrous and non-ferrous metals and alloys and composites. Techniques of strengthening and improving the properties of cast metals and alloys.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)

1.	John K.C, Metal casting and Joining, PHI publications, 2015.

Reference Books

1.	P.N. Rao, Manufacturing Technology: Foundry, Forming and Welding, Volume I, 4th Edition, McGraw Hill, 2013.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

Mode of assessment:

Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-10-2017

Course code	NON-DESTRUCTIVE TESTING	L	T	P	J	C
MEE2015		3	0	2	0	4
Pre-requisite	MEE1005	Syllabus version				
		v. 2.2				

Course Objectives:

1. Teach different surface inspection techniques.
2. Impart knowledge on different Non-destructive testing methods
3. Demonstrate various special Non-destructive testing methods.

Course Outcome:

Upon successful completion of the course the students will be able to

1. Identify appropriate surface inspection techniques for various engineering component.
2. Select suitable radiography testing methods for different applications.
3. Apply eddy current and ultrasonic testing methods suitably for detecting internal defects.
4. Apply acoustic emission techniques for suitable engineering applications
5. Select suitable special non-destructive technique for various applications.
6. Detect the defects using non-destructive testing methods

Module:1	Introduction to NDT	5 hours

Procedure,testing and evaluation, Visual examination.

Module:2	Surface NDT Techniques	7 hours

Liquid penetrant testing - Dye penetrant testing,Basic principle, Types of dye and methods of application, Developer; Magnetic particle testing - Magnetic particle testing,Basic theory of magnetism, Magnetization methods, Field indicators, Particle application, Inspection. Advantages and limitations of techniques.

Module:3	Radiographic Testing	6 hours

Radiography principle, X-ray films, exposure, penetrameter, radiographic imaging, inspection standards and techniques, Radiography applications, limitations and safety.

Module:4	Eddy Current Testing	6 hours

Principle, depth of penetration, eddy current response, eddy current instrumentation, probe configuration, applications and limitations.

Module:5	Ultrasonic Testing	6 hours

Properties of sound beam, ultrasonic transducers, inspection methods, flaw characterization technique, immersion testing.

Module:6	Acoustic emission testing	6 hours

Theory of AE sources and Waves, Equipment, Signal Features, Data display, source location,

Barkhausen noise, Applications.		
Module:7	**Special / Emerging Techniques**	**7 hours**
Leak testing, Holography, Thermography, Magnetic resonance Imaging, Magnetic Barkhausen Effect. In-situ metallography.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	Wong B Stephen, Non-Destructive Testing - Theory, Practice and Industrial Applications, 1st edition, LAP Lambert Academic Publishing, USA, 2014.

Reference Books

1.	Ravi Prakash, Nondestructive Testing Techniques, 1st rev. edition, New Age International Publishers, 2010.
2.	J. Prasad and C. G. K. Nair, Non-Destructive Test and Evaluation of Materials, 2nd edition, Tata McGraw-Hill Education, 2011.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

List of Challenging Experiments (Indicative)

1.	Inspection of welds/samples using solvent removable visible dye. penetrant.	2 hours
2.	Inspection of welds using solvent removable fluorescent dye. penetrant.	2 hours
3.	Familiarization and calibration of eddy current equipment.	2 hours
4.	Inspection on non magnetic/magnetic materials by eddy current. method.	2 hours
5.	Detection of surface flaws in bore holes using eddy current..testing.	2 hours
6.	Conductivity variation measurement using eddy current testing.	3 hours
7.	Dimensional variations measurement using eddy current testing.	3 hours
8.	Inspection of welds/samples by Magnetic Particle Testing - Drymethod	3 hours
9.	Inspection of welds/samples by Magnetic Particle Testing- Wetmethod	3 hours
10.	Inspection of a welded plate by radiographic single wall single image technique- X rays.	3 hours
11.	Corrosion survey using Ultrasonic testing.	3 hours
12.	Detection of surface flaws using eddy current testing in nonferrous material.	2 hours
	Total Laboratory Hours	**30 hours**

Mode of assessment:

Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-10-2017

Course code	**RAPID MANUFACTURING TECHNOLOGIES**	**L**	**T**	**P**	**J**	**C**
MEE2016		**2**	**0**	**0**	**4**	**3**
Pre-requisite	**MEE1031 / MEE1007**	**Syllabus version**				

		v. 2.2

Course Objectives:

1. To introduce students about the basics of rapid prototyping/manufacturing technologies and its applications in various fields, reverse engineering techniques and its significance in rapid manufacturing.
2. To familiarize students about CAD format and process parameter required for commercial rapid prototyping systems
3. To teach students about mechanical properties, geometric issues and post processing relating to specific rapid prototyping techniques.

Course Outcome:

Upon successful completion of the course the students will be able to

1. Demonstrate the knowledge of Rapid Prototyping/Manufacturing technologies.
2. Get exposed to design rules for commercial Rapid Prototyping systems.
3. Possess the knowledge of the Rapid Prototyping software.
4. Create awareness of rapid manufacturing applications in tooling, biomedical, architecture, etc.,
5. Ability to use techniques, skills and modern engineering tools necessary for engineering practice
6. Create critical thinking and innovative skills

Module:1	**Introduction to Rapid Manufacturing**	**4 hours**

Additive Manufacturing evolution, Additive manufacturing processes and their relationship with subtractive manufacturing, Advantages of RM. Generalized rapid manufacturing process chain, Rapid Tooling –Benefits, Applications.

Module:2	**Data Processing for Rapid Manufacturing**	**4 hours**

Conceptualization and CAD model preparation, data formats – Conversion to STL file format, Fixing the STL file, Part orientation, Support structure design, Model Slicing, Direct and adaptive slicing,Tool path generation.

Module:3	**Rapid Manufacturing Processes, Materials and its application**	**4 hours**

Sintering, Powder Bed Fusion, extrusion, jetting, Photo-polymerization, direct-write, sheet lamination, directed-energy deposition and the latest state of the art. Multiple Materials, Hybrids, Composite Materials, current and future directions.

Module:4	**Post-Processing**	**4 hours**

Support material removal, surface texture improvement, accuracy improvement, aesthetic improvement, preparation for use as a pattern, property enhancements using non-thermal and thermal techniques.

Module:5	**Design for Rapid Manufacturing (DFRM)**	**4 hours**

Core DFAM Concepts and Objectives: Complex Geometry, Customized Geometry, Integrated Assemblies and Elimination of Conventional design for manufacture (DFM) Constraints. RM Unique Capabilities, Exploring Design Freedoms and Design Tools for RM.		
Module:6	**Guidelines for process selection**	**4 hours**
Introduction, selection methods for a part, challenges of selection, example system for preliminary selection, production planning and control.		
Module:7	**Rapid Tooling**	**4 hours**
Direct tooling & Indirect Tooling methods, Applications of Rapid Tooling in Reaction Injection Molding, Wax Injection Molding, Vaccum Casting, RTV Silicone Rubber Molds, Spin-Casting, Cast Resin Tooling, Hydroforming and Thermoforming.		
Module:8	**Contemporary issues**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)	
1.	Ian Gibson, David W. Rosen, Brent Stucker, Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, 2nd Ed., Springer Science & Business Media, 2015.
Reference Books	
1.	DongdongGu, Laser Additive Manufacturing of High-Performance Materials, Springer Publications, 2014.
2.	Chua Chee Kai., Leong Kah Fai., Chu Sing Lim, Rapid Prototyping: Principles andApplications in Manufacturing, World Scientific, 2010.
3.	Andreas Gebhardt, Understanding additive manufacturing: rapid prototyping, rapid tooling, rapid manufacturing, Hanser Publishers, 2011.

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List of Challenging Experiments (Indicative)

Guidelines:

Generally a team project of Five.

Concepts studied in different Modules, as relevant, should have been used.

Report in Digital format with all drawings using software package to be submitted.

Sample Projects: • Projects on CAD data generation for 3D printing using various tools including: various scanning and reverse engineering techniques and related software. • Projects on CAD data processing such as STL file corrections, orientation	60 [Non-contact hours]

optimization, support and toolpath generation for economically producing the components with desired properties. • Design and fabrication of working models for the conceptual testing applications. • Build complex engineering assemblies in plastic material with less process planning. • Redesign the existing locomotive key-components for weight reduction without effecting the functionality that can be produced only by additive manufacturing.	

Mode of assessment:			
Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-10-2017

Course code	MATERIALS CHARACTERIZATION TECHNIQUES	L	T	P	J	C
MEE2019		2	0	0	4	3
Pre-requisite	MEE1005	Syllabus version				
		v. 2.2				

Course Objectives:

1. To provide a broad exposure to the aspects of optical characterization methods including Raman and infrared spectroscopy
2. To provide an extensive acquaintance to the theory and practice of x-ray and electron diffraction
3. To expose various other characterization features using electron microscopy and also other characterization techniques involving thermal analysis

Course Outcome:

Upon successful completion of the course the students will be able to

1. Determine crystal structures using diffraction methods
2. Characterize an unknown sample using spectroscopic techniques
3. Elucidate the modes of operation of SEM and TEM
4. Identify and justify the selection of at least three techniques to evaluate a particular sample
5. Evaluate the uncertainty of observations and results from the different methods
6. Evaluate an unknown sample and collect a targeted data set on it using available instrument.
7. Characterise a given specimen using an appropriate technique.

Module:1	Basic Crystallography and Need for Materials Characterization	2 hours

Basic crystallography and Need for Material Characterization - Unit cells, Crystal structure, Primitive and Non- primitive cells, Symmetry elements and point group notations, Streographic projections - Need for Material Characterization - Methodology for Material Characterization and Analysis.

Module:2	Diffraction and Imaging	3 hours

Phenomena of diffraction; Radiation-matter Interactions and response signals; X-ray diffraction: powder diffraction, phase identification, Scherrer formula, strain and grain size determination; Fundamentals of Imaging: magnification, resolution, depth of field and depth of focus, aberration and astigmatism; X-Ray reflectivity.

Module:3	Optical Microscopic techniques	3 hours

Special microscopy techniques and applications: Bright field and dark field imaging; confocal microscopy; interference microscopy; polarized light microscopy; phase contrast microscopy. Scanning near field laser microscopy; Image processing and quantification.

Module:4	Optical Spectroscopic techniques	5 hours

Principle, Working and Result Analysis of Fourier Transformation Infra-Red Spectroscopy;

Raman Spectroscopy; UV-Vis Absorption Spectroscopy; Photoluminescence Spectroscopy - Ellipsometer Spectroscopy.		
Module:5	**Electron Microscopic Techniques**	**6 hours**
Basics of Electron Microscopy - Introduction - Principle of SEM, Instrumentation, Contrast formation, Operational variables, Specimen preparation, imaging modes, Applications, Limitations – FE-SEM , FIB, EDAX. TEM - Introduction, Instrumentation, Specimen preparation: Mechanical thinning, electrochemical thinning, ion milling, sputter coating and carbon coating, replica methods. Image modes - mass density contrast, diffraction contrast, phase contrast, Applications, Limitations.		
Module:6	**Thermal analysis**	**4 hours**
Instrumentation, experimental parameters, Differential thermal analysis, Differential Scanning Calorimetry, Thermogravimetry, Dilatometry, Dynamic mechanical analysis- Basic principles, Instrumentation, working principles, Applications, Limitations.		
Module:7	**Advanced Characterization Techniques**	**5 hours**
Rutherford back scattering (RBS), Scanning Tunneling Microscopy (STM), Atom Force Microscopy (AFM) and different operational modes, X-ray Photoelectron Spectroscopy (XPS): Auger Electron Spectroscopy (AES), Dynamic SIMS and static SIMS. Characterization of Fluids - Viscosity, Relative density, thermal conductivity.		
Module:8	**Contemporary issues**	**2 hours**
	Total lecture hours	**30 hours**

Text Book(s)	
1.	P.R. Khangaonkar, An introduction to Materials Characterization, Reprint 2013, Penram International Publishing (India) PVT Ltd., 2010.
2.	Yang Leng, Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, 2nd edition, ISBN: 978-3-527-33463-6, Wiley Publications, 2013.
Reference Books	
1.	E.J. Mittemeijer, Fundamentals of Materials Science - the microstructure-property relationship using metals as model systems, Springer, 2010.
2.	Cullity, Elements of X-Ray Diffraction, by.. Pearson Education India; 3rd edition, 2014.
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar	
List of Challenging Experiments (Indicative)	

Guidelines

- Generally a team project of Five
- Concepts studied in Modules 2, 4, 6 should have been used.
- Down to earth application and innovative idea should have been attempted.

Report in Digital format with all drawings using software package to be submitted.		
Sample Projects		
1.	Analysis and data interpretation of SEM Images.	60 [Non - contact hours]
2.	Analysis and data interpretation of TEM Images.	
3.	Interpreting and analyzing chemical composition from XPS.	
4.	Investigation of optical properties through UV-Vis spectrophotometer.	
5.	Chemical composition determination using FTIR.	
6.	Structural investigations using XRD.	
7.	Investigation of optical properties through photoluminescence.	
8.	Ellipsometer investigation of materials.	
9.	Microfluids characterization.	

Mode of assessment:			
Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-10-2017

Course code	METAL FORMING THEORY AND PRACTICE	L	T	P	J	C
MEE2020		3	0	0	0	3
Pre-requisite	MEE1007	Syllabus version				
		v. 2.2				

Course Objectives:

1. Explain the basic principles of metal forming theory
2. Demonstrate various types of forming processes
3. Impart knowledge various unconventional forming processes over the conventional ones

Course Outcome:

Upon successful completion of the course the students will be able to

1. Evaluate the state of stress during yielding of ductile and brittle materials when forming a component
2. Estimate problems and defects during forming on the basis of materials, their workability and frictional analysis
3. Recommend appropriate metal forming processes when provided a set of functional requirements and product development constraints
4. Recommend cost effective material options based upon near net shape, predicting load, torque and power requirements
5. Integrate product and process quality levels through the use of precision forming techniques
6. Substitute unconventional forming techniques instead of conventional ones for forming complex shapes and profiles.

Module:1	Theory of Plasticity	6 hours

Theory of Plasticity - stress tensor – hydrostatic & deviator components of stress – flow curve – true stress strain – yielding criteria – yield locus – octahedral shear stress and shear strains – invariants of stress strain – slip line field theory - plastic deformations of crystals.

Module:2	Fundamentals of Metal working	6 hours

Classification of forming processes, mechanics of metal working, temperature in metal working, strain rate effects, metallurgical structure, friction and lubrication, deformation zone geometry, hydrostatic pressure, workability, residual stresses.

Module:3	Forging process	6 hours

Classification, Forging in plane strain, forging equipment, open die forging, closed die forging, calculation of forging loads in closed die forging, Forging defects, powder metallurgy forging, residual stresses in forgings.

Module:4	Rolling	6 hours

Classification - rolling mills - rolling of bars & shapes – rolling forces, analysis of rolling – defects in rolling- theories of hot & cold rolling – torque power estimation.

Module:5	**Extrusion**	**6 hours**
Classification - equipment – deformation lubrication and defects – analysis – hydrostatic extrusion – tube extrusion - Drawing, rod & wire drawing, analysis of wire drawing, tube drawing processes, analysis of tube drawing, residual stresses in rod, wire and tubes.		
Module:6	**Sheet metal forming**	**6 hours**
Methods – shearing and blanking, bending, stretch forming – deep drawing – forming limit criteria – defects in formed parts.		
Module:7	**Unconventional Forming Methods**	**7 hours**
Explosive forming, Electro hydraulic forming – magnetic pulse forming – super plastic forming – electro forming – fine blanking – P/M forging-Isothermal forging – HERF.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	George E Dieter, Mechanical Metallurgy,Third Edition Tata McGraw HillEducation PVT Ltd, 2014.

Reference Books

1.	Juneja.B.L,Fundamentals of Metal forming processes,2 nd Edition,New Age International,India, 2010.
2	Henry S. Valberg, Applied Metal Forming: Including FEM Analysis, Cambridge University Press, 2010.
3	William F. Hosford and Robert M. Caddell, Metal Forming: Mechanics and Metallurgy, 4th edition, Cambridge University Press, 2011.
4	Uday S. Dixit, Metal Forming, 1st edition, McGraw Hill Education, 2013.
5	Hingole, Rahulkumar Shivajirao,Advances in Metal Forming Expert System for Metal Forming, Springer Publications, 2015.
6	Micro Metal Forming, Editors: Vollertsen, Frank (Ed.), Springer publication, https://doi.org/10.1007/978-3-642-30916-8, 2013.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar			
Mode of assessment:			
Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-10-2017

Course code	POWER PLANT ENGINEERING	L	T	P	J	C
MEE2022		3	0	0	0	3
Pre-requisite	MEE1003/ MEE1033/ CHE1003	Syllabus version				
		v. 2.2				

Course Objectives:

1. To equip students about the working of various power generation units and steam cycles.
2. To educate the students to understand the steam generators, combustion and firing methods in order to make the fullest use of thermal power potentialities.
3. Enable the students to understand in detail about nuclear, gas turbine, hydro and diesel power plants which play an important role in power generation.

Course Outcome:

Upon successful completion of the course the students will be able to

1. Analyse different kinds of steam generators and their subsystems
2. Explain different combustion mechanisms, coal, ash and flue gas handling systems
3. Explain the functioning of various types of Nuclear power plants
4. Select the suitable conventional power plant by taking into account all the technical constraints.
5. Evaluate the economic aspects of power plant installation and operation

Module:1	Steam Power Plant	9 hours

Site selection, Components and Layout of steam power plant, vapor power cycles. Steam Generators – Classification and Types of Boilers - Fire tube and Water tube boilers - High pressure and Supercritical boilers - Positive circulation boilers - Fluidized bed boiler - Waste heat recovery boiler, Heat Exchangers - Feed water heaters - Super heaters - Reheaters -Economiser - Condenser-Cooling tower.

Module:2	Combustion and Firing Methods	6 hours

Coal handling and preparation -Combustion equipment and firing methods - Mechanical stokers - Pulverized coal firing systems - Cyclone furnace - Ash handling systems - Electrostatic precipator - Fabric filter and Bag house -Forced draft and Induced draft fans.

Module:3	Nuclear Power Plants	7 hours

Site selection, Components and Layout Principles of nuclear energy - Energy from nuclear reactions - Energy from fission and fuel Burnup - Decay rates and Half - Lives.

Boiling water reactor - Pressurized water reactor Pressurized Heavy Water Reactor - Gas cooled reactor - High temperature gas cooled reactor - Fast breeder reactor - Liquid metal fast breeder reactor-reactor materials - Radiation shielding.

Module:4	Gas Turbine Power Plants	6 hours

Site selection, Components and Layout, Open and closed cycles - Intercooling - Reheating and Regenerating - Combined cycle power plant types.

Module:5	**Hydro Electric Power Plants**	**5 hours**
Site selection, Components and Layout, Classification of Hydro - electric power plants and their applications - Selection of prime movers - Governing of turbine.		
Module:6	**Diesel Engine Power Plant**	**5 hours**
Site selection, Components and Layout, Subsystems - Starting and stopping - Heat balance - Lubricating and Cooling startegies - Constraints in operating range.		
Module:7	**Economics of Power Plants**	**5 hours**
Cost of electric Energy - Fixed and operating costs - Energy rates - Types tariffs Economics of load sharing - Load Curves.		
Module:8	**Contemporary issues**	**2 hours**
Total lecture hours		**45 hours**

Text Book(s)

1.	P. K. Nag, Power Plant Engineering: Steam and Nuclear, Tata McGraw-Hill Publishing Company Ltd., Fourth Edition. New Delhi, 2014.

Reference Books

1.	R.K.Hegde, Power Plant Engineering Pearson India Education services Pvt. Limited Noida, India, 2015.
2.	R. K. Rajput, A Text Book of Power Plant Engineering, Laxmi Publications (P) Ltd. New Delhi, 2015.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar			
Mode of assessment:			
Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-10-2017

Vellore Institute of Technology
(Deemed to be University under section 3 of UGC Act, 1956)

Course code	GAS DYNAMICS AND JET PROPULSION	L	T	P	J	C
MEE2023		2	2	0	0	3
Pre-requisite	MEE1003, MEE1004 / CHE1003 / MEE1032	Syllabus version				
		v. 2.2				

Course Objectives:

1. To understand the basic difference between the compressible and incompressible flow
2. To understand the effect of isentropic compressible flow through the variable duct such as nozzle and diffusers.
3. To acquaint the students with the compressible flow with features such as normal and oblique shock application in real life situation.
4. To make the students understand the effect of compressible flow through a constant area duct with friction.
5. To make the students understand the effect of compressible flow through a constant area duct with heat transfer.
6. To acquaint the students with aircraft propulsion and different types of jet engines and understand the performance of these engines.
7. To acquaint the basic concept of rocket propulsion and the performance of rocket engines.

Course Outcome:

Upon successful completion of the course the students will be able to

1. Explain the features of compressible flows.
2. Design C-D nozzles by applying the concepts of isentropic compressible flow through variable area duct.
3. Analyze normal shock, oblique shock and expansion waves in high speed flows.
4. Apply the concepts of Fanno flow and Rayleigh flow towards the design of combustion sections and jet pipes.
5. Apply the knowledge of shock-shock interaction, shock reflection and Prandtl-Meyer expansion fan-shock interaction.
6. Explain various types of propulsion engines used in aircraft and rocket vehicles and understand the engine performance.
7. Describe real time applications of compressible flow such as supersonic missiles, jet and rocket engines on the light of theories of gas dynamics

Module:1	Introduction to compressible fluid flow and control volume analysis	3 hours

Coefficient of Compressibility - Stagnation state – Critical state - Various regions of flow- Physical significance of Mach number - Mach cone - Differences between Incompressible and Compressible flows. Properties of atmosphere - Effect of Mach number on compressibility, Conservation laws for mass - Momentum and energy in steady flow.

Module:2	Isentropic Variable area flows	5 hours

Isentropic flow through a variable area duct – Mach number variation - Area ratio as a function of Mach number - Impulse function - Mass flow rate through nozzles and diffusers. Phenomenon of choking – subsonic and supersonic designs - Pressure values for nozzles and diffusers. T-S and H-S diagrams showing Nozzle and Diffuser process.		
Module:3	**Shocks and Expansion waves in compressible flows**	**6 hours**
Flow with normal shock waves - Governing equations - Prandtl–Meyer equation - Impossibility of rarefaction shock - Mach number downstream of shock – Property variation across shock - Strength of shock wave - entropy change, Oblique shock-Property relations, Relation between M_x and M_y, θ-β-M relation, Maximum Value of Oblique shock, Detached shock, Prandtl-Meyer Expansion fans.		
Module:4	**Flow through constant area ducts with Friction**	**3 hours**
Fanno flow - Fanno curves - Equation and its solution - Variation of flow properties with duct length - Applications. Normal shocks in Fanno flow.		
Module:5	**Flow through constant area ducts with heat transfer**	**5 hours**
Rayleigh flow - Rayleigh flow equation - Rayleigh line - Variation of flow properties - Maximum heat transfer – Applications. Normal shocks in Rayleigh flow.		
Module:6	**Aircraft Propulsion**	**3 hours**
Air craft propulsion – Types of jet engines - Energy flow through jet engines - Thrust - Thrust power and Propulsive efficiency - Turbojet components - Diffuser compressor - Combustion chamber - Turbines - Exhaust system - Performance of jet engines.		
Module:7	**Rocket Propulsion**	**3 hours**
Rocket propulsion – Rocket engines - Basic theory of equation - Thrust effective jet velocity - Specific impulse - Rocket engine performance - Solid and Liquid propellant rockets - Comparison of various propulsion systems.		
Module:8	**Contemporary issues:**	**2 hours**
	Total lecture hours	**30 hours**
Text Book(s)		
1.	S.M.Yahya, Fundamentals of compressible flow with Aircraft and Rocket propulsion, 4th edition, New Age International Publisher, 2012.	
Reference Books		
1.	Babu, V., Fundamentals of Gas dynamics. John Wiley & Sons, 2014.	
2.	Hodge, Koenig (2015), Compressible Fluid Dynamics with personal computer applications. 1st edition, Pearson Education India, 2015.	

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar			
Mode of assessment:			
Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-10-2017

Course code	FLUID POWER SYSTEMS	L	T	P	J	C
MEE2025		3	0	2	0	4
Pre-requisite	MEE1004 / MEE1032	Syllabus version				
		v. 2.2				

Course Objectives:

1. To enable the students understand the basics of hydraulics and pneumatics.
2. Improve students' knowledge on hydraulic pumps and compressor power packs.
3. To teach students about the utilization of cylinders, accumulators, valves and various electrical and electronic control components.
4. Introduce students to fluid power condition monitoring, maintenance and troubleshooting.

Course Outcome:

Upon successful completion of the course the students will be able to

1. Select and identify fluid power components
2. Describe the function and operation of fluid power systems
3. Apply multiactuator fluid power system for various purposes in industry.
4. Design and Develop fluid power multiactuation circuits
5. Understand the various control components and accessories used in fluid power systems
6. Troubleshoot and find out faults in fluid power circuits

Module:1	Introduction to fluid power	6 hours

Hydraulics Vs Pneumatics, Pascal's Law, Bernoulli's equation, Torricelli's theorem, Basic properties of and nomenclature of standard hydraulic fluids, Basic principles of Pneumatics, Properties of air, Gas laws, ANSI symbols for circuit components.

Module:2	Fluid Power drives	6 hours

Hydraulic power supply-Types, construction and selection of Hydraulic pumps and motors, Pneumatic power supply source – Types, construction and selection of Compressors and air motors, conditioning of air and its distribution, Selection of prime mover.

Module:3	Fluid Power Control Components	7 hours

Valves – Pressure, direction and flow control valves, proportional and servo valves, Accumulators, Filter Regulator Lubricator (FRL), Actuators-Linear and rotary.

Module:4	Basic Fluid Power Circuits	7 hours

Fail safe circuits, Regenerative circuits, Meter in and Meter out circuits, Accumulator circuits, Pressure intensifier circuit, Counter balance circuit, Multi cylinder sequencing circuits and Synchronizing circuit

Module:5	Fluid Power Circuit Design and applications	7 hours

Travel step diagram, cascade and Karnaugh – Veitch map method, Low cost Automation, Bottling

and Packaging Industry, Material handling and assembly applications.		
Module:6	**Electronic and Electrical controls for Fluid Power Systems**	**5 hours**
Electro pneumatic & Electro hydraulic components- solenoids, relays, proximity sensors, Programmable Logic Controllers, Ladder diagram, Timers and Counters.		
Module:7	**Maintenance and troubleshooting of Fluid Power System**	**5 hours**
Condition monitoring, maintenance and troubleshooting of fluid power systems, Reservoir System-Pressurized and non-pressurized, sealing devices, Fire-resistant fluids, Types of filters-Selection of filters and strainers, beta ratio of filters		
Module:8	**Contemporary issues**	**2 hours**
Total lecture hours		**45 hours**

Text Book(s)

1.	Anthony Esposito, Fluid Power Systems,: Pearson New International edition, 2013.

Reference Books

1.	James R.Daines, Hydraulics and Pneumatics, 2nd Edition, The Goodheart-Willcox Company, Inc., 2013.
2.	W.Bolton, Mechatronics, Electronic control systems in Mechanical and Electrical Engineering, Perason Education, 2013.
3.	Andrew Parr, Hydraulics and Pneumatics, Butterworth and Heinmann, 2011.
4.	Festo, Basic Pneumatic, Electro pneumatic, Hydraulic text and work books, 2015.
5.	John Pippenger, Fluid Power Controls, Literary Licensing LLC, 2012.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

List of Challenging Experiments (Indicative)

1.	Hydraulic circuit design using Hydrosim / Automation studio/PLC.	6 hours
2.	Pneumatic circuit design using Pneumosim / Automation studio/PLC.	6 hours
3.	Hydraulic circuit design using hydraulic trainer kit.	6 hours
4.	Pneumatic circuit design using Pneumatic trainer kit.	6 hours
5.	Electro pneumatic and electro hydraulic circuit design using trainer kits.	6 hours
	Total Laboratory Hours	**30 hours**

Mode of assessment:

Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-10-2017

Course code	TURBOMACHINES	L	T	P	J	C
MEE2026		2	2	2	0	4
Pre-requisite	MEE1003, MEE1004/ MEE1032	Syllabus version				
		v. 2.2				

Course Objectives:

1. To familiarize the student with the various Thermal and Hydro Turbomachines.
2. To impart the design related knowledge related to various Turbomachines.
3. To develop problem solving abilities in Turbomachines.
4. To develop the skills of experiment design.

Course Outcome:

Upon successful completion of the course the students will be able to

1. Define Euler's equation for turbomachines from second law of motion
2. Apply Euler's equation of motion to various types turbomachines
3. Demonstrate the knowledge of working and stages of turbomachines
4. Analyze stage parameters and performance characteristics of various turbomachines
5. Suggest suitable compounding technique for muti-stage operation of Turbines
6. Identify governing and selection of turbo-machinery
7. Solve analytical problems in turbomachines for both compressible and incompressible fluid flows
8. Experimentally determine the performance characteristics of both power absorbing and power generating turbomachines

Module:1	Energy Transfer	3 hours

Definition and classification of Turbomachines, Specific work - T-s and H-s diagram - Equation of energy transfer - Losses - Various efficiencies - Effect of reheat - Preheat.

Module:2	Cascading	3 hours

Aero–Foil section - Cascading of compressor and Turbine blades - Energy Transfer in terms of lift and drag co-efficient for compressor and turbine blades - Variation of lift - Deflection and stagnation pressure loss with incidence.

Module:3	Centrifugal Compressors	4 hours

Centrifugal fans - Blowers and Compressors - construction details - Inducers - Backward and Radial blades - Diffuser - volute casing stage work - Stage pressure rise - Stage pressure co-efficient - Stage efficiency - Degree of reaction - Various slip factors H-S diagram for centrifugal compressor.

Module:4	Axial Compressors	4 hours

Axial flow Fans and Compressors - Stage velocity triangles - Blade loading and flow co-efficient - Static pressure rise - H-S diagram - Degree of reaction - Work done factors - Free and Forced

Vortex flow performance - Stalling and Surging.		
Module:5	**Radial Turbines**	**4 hours**
Inward flow radial turbine stages - IFR Turbine - T-s diagram - and degree of reaction - Steam turbine governing – Features of Steam turbine and Gas turbine.		
Module:6	**Axial Turbines**	**4 hours**
Axial turbine stages - Stage velocity triangle - Work - Single stage Impulse Turbine - Speed ratio maximum utilization factor - Multistage velocity compounded impulse - Multi stage pressure compounded impulse - reaction stages - Degree of reaction - Zero reaction stages - Fifty percent reaction stages - Hundred percent reaction - Negative reaction - Free and Forced vortex flow.		
Module:7	**Hydraulic Machines**	**6 hours**
Centrifugal pumps – Work done - Head developed - Pump output and Efficiencies - priming - minimum starting speed - performance of multistage pumps - Cavitation - methods of prevention - Pump characteristics – Classification of hydraulic turbines - Pelton wheel - Francis turbine - Kaplan and Propeller turbines - Velocity triangles - Specific speed - Theory of draft tube - Governing - Performance characteristics - Selection of turbines.		
Module:8	**Contemporary issues**	**2 hours**
	Total lecture hours	**30 hours**

Text Book(s)	
1.	S.M. Yahya, Turbine, Fans and Compressors, 4th Edition, Tata McGraw-Hill, 2017.
2.	R. K. Bansal, A Textbook of Fluid Mechanics and Hydraulic Machines, 9th Edition, Laxmi Publications, 2017.
Reference Books	
1.	S. Larry Dixon and Cesare Hall, Fluid Mechanics and Thermodynamics of Turbomachinery, 7th Edition, Butterworth-Heinemann, 2013.
2.	Kadambi and Prasad, Energy conversion Vol. III – Turbomachines, New Age International, 2011.
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar	

List of Challenging Experiments (Indicative)		
1.	To study the performance of Gear Pump at different discharge pressures.	
2.	To study the performance of Reciprocating Pump at different discharge pressures.	
3.	To study the performance of Constant Speed Centrifugal Pump at different discharge pressures.	
4.	To study the performance characteristics of Variable Speed Centrifugal	

	Pump at different speeds and different discharge pressures.	
5.	To study the performance of Jet Pump at different discharge pressures.	
6.	To study the performance of Submersible Pump at different discharge pressures.	
7.	To study the performance of Kaplan Turbine at constant speed, constant load and different vane and blade positions.	
8.	To study the performance of Francis Turbine at constant speed, constant load and different vane positions.	
9.	To study the performance of Pelton Turbine at constant speed and constant load conditions.	
10	To study the impact of jet on vanes.	
	Total Laboratory Hours	**30 hours**

Mode of assessment:			
Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-10-2017

MEE2067	COMPUTATIONAL MULTIBODY DYNAMICS	L	T	P	J	C
		3	0	0	4	4
Pre-requisite	**MEE 1002**	**Syllabus version**				
Anti-requisite	**NIL**	v. 0				

The advent of high-speed digital computers has enabled the possibility of solving complex problems in mechanics. In the design of most physical and engineering systems, the simulation and analysis of interconnected bodies is of primary importance.

Course Objectives:

- To familiarize students with the basic concepts of computational dynamics.
- To introduce techniques for formulating the equations of motion of a multi-body system.
- To enable the students to solve the equations of motion using tools such as MATLAB or SciLab.

Course Outcome:

By the end of this course the student will be able to –

- Model a multi-body system with rigid links and connections.
- Distinguish between the types of joints and formulate the constraint equations.
- Compute the kinematics of any point in a given multi-body system.
- Write the equilibrium equations and determine the forces acting at the joints.
- Formulate the equations of motion of the multi-body system using different methods.
- Code and solve the equations of motion using tools such as MATLAB or SciLab.

Module:1	**Vectors and Kinematics**	**6 hours**

Vector algebra - unit vectors, free vectors and non-free vectors, derivative of a vector, total and partial derivatives, matrix operations - linear dependence and independence of rows/columns of a matrix, differentiation of a matrix.

Angular velocity, matrix representation of angular velocity, simple angular velocity, Differentiation in two reference frames, angular acceleration, velocity and acceleration equations, two points fixed on a rigid body, point moving on a rigid body – MATLAB implementation.

Module:2	**Joints and Kinematics**	**6 hours**

Types of joints – revolute and translational joints – vector formulation of constraint equations, Jacobian, Computation of kinematics – MATLAB implementation. Transformations – body - fixed and space – fixed rotations. Velocity transformations.

Module:3	**Basic Principles of Dynamics**	**7 hours**

D'Alembert's Principle, Equilibrium and Virtual work, Virtual displacements, generalized forces, workless constraints, Lagrange's equation, Non-holonomic constraints, Lagrange's form of D'Alembert's principle – Jourdain - Kane Method, Generalized Inertia, Mass matrix.

Module:4	**Newton-Euler Equations**	**6 hours**

Constraint equations, augmented formulation, Lagrange multipliers, embedding technique and amalgamated formulation – MATLAB implementation – Problems.

Module:5	**Principle of virtual work and Lagrange's equation**	**6 hours**

Kinetic energy, potential energy function, generalized forces on a rigid body, derivation of equations of motion using Lagrange's method – practice problems.

Module:6	**Principle of virtual powers and Kane's equation**	**6 hours**
Principle of virtual power for a rigid body, virtual velocities, Kane's equation – Handling of non-holonomic constraints – MATLAB implementation – practice problems.		
Module:7	**Solution to the equations of motion using MATLAB**	**5 hours**
State – space representation of second order differential equation and solution of the equations of motion using numerical methods in MATLAB – practice problems.		
Module:8	**Contemporary issues**	**3 hours**
	Total lecture hours	**45 hours**
# Mode: Flipped Class Room [Lecture to be videotaped], Use of physical models to lecture, Problem Solving: The course will aim at improving problem solving capability `		
Sample projects (J component): Kinematic analysis and solving the equations of motion in MATLAB for various multi-body systems. 1. Four bar mechanism 2. Slider crank mechanism 3. Pendulum on a freely moving base 4. Double pendulum 5. Inverted double pendulum 6. Gyroscope 7. Inverted double pendulum with a circular base 8. Shopping cart # Assessment on a continuous basis with a min of 3 reviews.		**60 Non-Contact Hrs**.

Text Book(s)	
1.	Ahmed A. Shabana, Computational Dynamics. Wiley, 2010.
2.	Francis C. Moon, Applied Dynamics with Applications to Multibody and Mechatronic Systems, John Wiley & Sons, Inc. 1998.
Reference Books	
1.	Parviz E. Nikravesh, Computer-Aided Analysis of Mechanical Systems, Prentice Hall, 1988
2.	Thomas R. Kane and David A. Levinson, Dynamics Theory and Application, McGraw-Hill Book Company, 1985.
3.	Reza N. Jazar, Advanced Dynamics, John Wiley & Sons, Inc. 2011.

Course code	FINITE ELEMENT ANALYSIS	L	T	P	J	C
MEE3002		2	2	2	0	4
Pre-requisite	MAT3005, MEE1032 / MEE2002	Syllabus version				
		v. 2.2				

Course Objectives:

1. To enable the students understand the mathematical and physical principles underlying the Finite Element Method (FEM) as applied to solid mechanics, heat transfer and fluid flow problems.
2. To teach the students the characteristics of various elements and selection of suitable elements for the problems being solved.
3. To make the students derive finite element equations for simple and complex elements.

Course Outcome:

Upon successful completion of the course the students will be able to

1. Distinguish different numerical methods involved in Finite Element Analysis
2. Apply equations in finite element methods for 1D, 2D and 3D problems.
3. Apply shape functions in finite element formulations and use linear, quadratic, and cubic shape functions for interpolation
4. Formulate and solve basic problems in heat transfer, solid mechanics and fluid mechanics.
5. Analyse beams and shafts using finite element analysis.
6. Apply commercial FEA packages like ANSYS and modern CAD/CAE tools for solving real life problems.

Module:1	Introduction to Finite Element Method	3 hours

General description of Finite Element Method – Historical development – Comparison with classical methods – Other numerical methods such as FDM, BEM, etc. - General procedure of FEM – Application software's in FEM.

Module:2	Approximate Solutions to Engineering Problems	4 hours

General field problems - GDE formulation - discrete and continuous models – approximate solution as a polynomial - minimization of residue – Weighted residual methods – collocation method, sub domain method, method of least squares and Galerkin method - Variational formulation Ritz method - numerical problems.

Module:3	Finite Element Formulations to 1-D problems	4 hours

II order problems - Bar Problem – Formulation for the whole domain – Formulation for the sub-domain (finite element) using interpolation polynomial - Nodal approximation using shape function – computing element matrices - Assembly of element matrices – Application of B.Cs – solution – post processing.

Module:4	Beam problems	4 hours

(IV order problems) – B.Cs & loading conditions on to nodes – element matrices - solution and

post processing of results – I Dimension problems such as Heat transfer problems, Vibration problems in bar and beams etc.		
Module:5	**Two Dimensional problems**	**5 hours**
Discretization: Geometrical approximations – Simplification through symmetry – Element shapes and behaviour – Choice of element types – Simplex - Complex and Multiplex elements – Selection of interpolation polynomials (shape functions) - Convergence requirements – Element shape and distortion – Location of nodes – Node and Element numbering.		
Module:6	**Field problems – scalar and vector variables**	**4 hours**
Scalar variable problems such as heat transfer, torsion of non-circular shafts etc – Vector variable problems such as plane stress, plane strain and axi-symmetric problems.		
Module:7	**Natural coordinate systems**	**4 hours**
Derivation of shape functions for various elements – Isoparametric elements – 1D, 2D and 3 D elements - Numerical Integration and its advantages.		
Module:8	**Contemporary issues**	**2 hours**
	Total lecture hours	**30 hours**

Text Book(s)	
1.	Tirupathi R. Chandrupatla and Ashok D. Belugundu, Introduction to Finite Elements in Engineering, 4th Edition, Prentice Hall, 2011.
Reference Books	
1.	Daryl L. Logan, A First Course in the Finite Element Method, Cengage Learning, 2011.

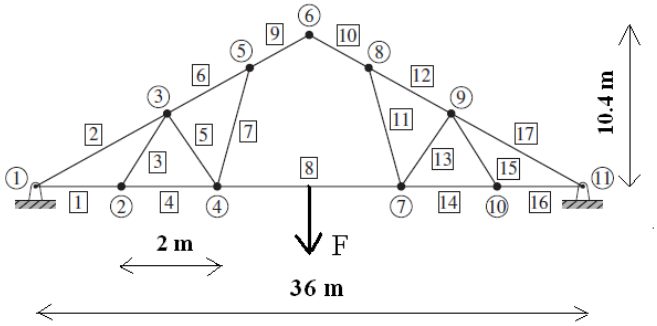
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

List of Challenging Experiments (Indicative)			
Sample Tutorials		Module	Hours
1.	Problems in Weighted residual methods , collocation method, sub domain method, method of least squares and Galerkin method - Variational formulation Ritz method.	2	2
2.	Problems in stress analysis in a bar due to point load and uniformly distributed load; with uniform and non-uniform cross section.	3	4
3.	Problems in 1 D bar element - Heat Transfer Problem; Uniform and non-Uniform bars.	4	4
4.	Problems in 1 D bar element - Vibration Problem.	4	3
5.	Problems in 1 D beam element- Stress analysis of beam with uniform and varying cross section and varying BCs.	4	3
6.	Problems in Beam element- With mass and springs	4	2

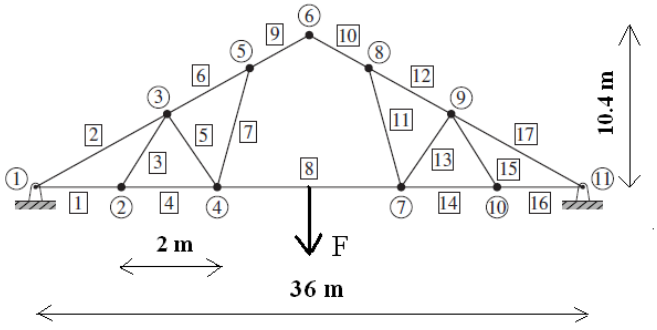
	attached to ends.		
7.	Stress analysis in a plate: Triangular element applicable to axial and bending applications.	5	6
8.	Problems on stress analysis of axisymmetric solids.	6	2
9.	Problems on Plain stress and plain strain examples.	6	2
10.	Problems on Numerical integration and Gauss Quadrature.	7	2
		Total Laboratory Hours	**30 hours**

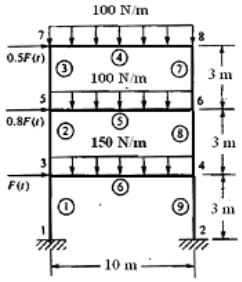
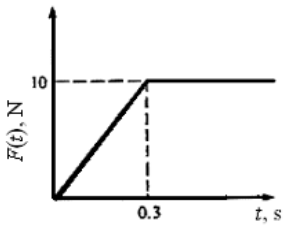
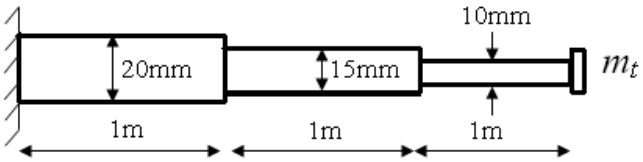
List of Challenging Experiments

1. Evaluate the stress developed at each bar and natural frequencies of the plane truss structure shown in figure which is composed of members having a square 15 mm x 15 mm cross section, modulus of elasticity *E*= 69 GPa and density 1000 kg/m^3. b) Plot the graph between the maximum displacement of the structure and the various excitation frequencies (ω rad/s) when a load of F= 10e$^{i\omega t}$ is applied at the mid-point of the truss #8 as shown in the figure. Write MATLAB codes to solve the problem and compare the results evaluated using ANSYS or any commercial FE software.



2. Evaluate the stress developed at each bar and natural frequencies of the plane truss structure shown in figure which is composed of members having a square 15 mm x 15 mm cross section, modulus of elasticity *E*= 69 GPa and density 1000 kg/m^3. b) Plot the graph between the maximum displacement of the structure and the various excitation frequencies (ω rad/s) when a load of F= 10e$^{i\omega t}$ is applied at the mid-point of the truss #8 as shown in the figure. Write MATLAB codes to solve the problem and compare the results evaluated using ANSYS or any commercial FE software.



3.	Determine the maximum stress and displacement of the aluminium frame structure shown in Figure. Consider the following properties: For the elements 1 and 9: A= 8000 mm^2; I =1.6x10^5 mm^4; For the elements 2, 3, 7 and 8: A= 4000 mm^2; I =0.6x10^5 mm^4; For the elements 4, 5 and 6: A= 8500 mm^2; I =4 x10^5 mm^4; Write MATLAB codes to solve the problem and compare the results evaluated using ANSYS or any commercial FE software.  Frame structure  Loading condition
4.	Determine the first ten natural frequencies for transverse vibration and draw the first five mode shapes of the rectangular beam with varying cross section and tip mass 10N as shown in Figure. The width of the beam is 10mm. The other properties of the beam are as: ρ = 7810 kg/m^3; E = 2.1x10^{11}; v = 0.3; Also perform the modal analysis of the beam and prove the orthogonality of normal modes. A harmonic force of 100$e^{i\omega t}$ is applied at one third of the length from the left support. Determine the maximum displacement of the structure. Write MATLAB codes to solve the problem and compare the results evaluated using ANSYS or any commercial FE software. 
5.	Consider an isotropic beam with a variable cross section and tip mass as shown in figure . The thickness of the beam is kept constant and the characteristics width of the cross-section is assumed to vary exponentially along the length of the beam according to the following relations: $A(x) = A_0 e^{(-x/l)}$, where A_0 is the area at the root. Investigate the free transverse vibration response of the beams (*ie*., determination of natural frequencies and mode shapes). The various parameters to be considered for the analysis are specified in Table 1. Write MATLAB codes to solve the problem and compare the results evaluated using ANSYS or any commercial FE software.

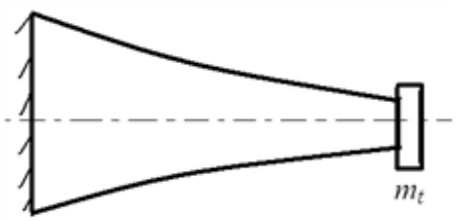
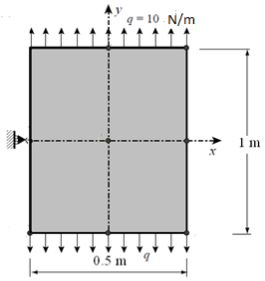


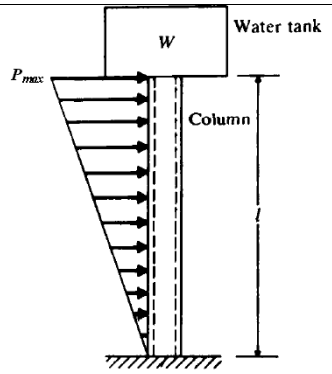
Table 1. Parameters for the free transverse vibration response

Parameter	
Length of the beam	5 m
Young's Modulus of the material of the beam	100 Gpa
Density	1000Kg/m^3
Area of cross section of the beam at the left end	0.2 m^2
Thickness of the beam at the left end	0.02
Tip mass	10 N
Poisson's ratio	0.3

6. Evaluate the maximum stress and displacement of the following structure by assuming the density of each part as 1000 kg/m^3, Young's modulus as 20000 MPa, Poisson's ratio as 0.3. Write MATLAB codes to solve the problem and compare the results evaluated using ANSYS or any commercial FE software and thickness as 2 mm.



7. A water tank of weight 4500 kg is supported by a hollow circular steel column of inner diameter 0.5m, wall thickness 25 cm, and height 10m. The wind pressure acting on the column can be assumed to vary linearly from 0 to 700 kPa, as shown in figure. Find the first ten natural frequencies of the water tank using beam elements. Plot the graph between the maximum displacement of the structure and the various excitation frequencies (ω) when a load of $q= P_{max}e^{i\omega t}$ is applied. Solve the problem using any commercial FE software and compare the answers.

	
Total laboratory hours	**60 hours**
Mode of assessment:	
Recommended by Board of Studies	17-08-2017
Approved by Academic Council	47 Date 05-10-2017

Course code	ENGINEERING FAILURE ANALYSIS	L	T	P	J	C
MEE3003		3	0	0	4	4
Pre-requisite	MEE2002 /MEE1032	Syllabus version				
		v. 2.2				

Course Objectives:

1. Explain the importance of failure study of mechanical components.
2. Discuss about various material characterization tools and analyse the failure.
3. Equip students with knowledge on (i) how to design against failures and (ii) skills required in carrying out failure analysis.

Course Outcome:

Upon successful completion of the course the students will be able to

1. Identify and explain different types of failure of engineering materials and their characteristic features.
2. Differentiate the significance, usage and limitations of various material characterization tools used for failure studies.
3. Apply various theories of failure to the components subjected to multidirectional loading.
4. Determine the life of a mechanical component subjected to variable loading.
5. Apply the principles of fracture mechanics and design for failure against fracture.
6. Design for failure against wear failure and creep loading
7. Develop expertise on the experimental techniques and simulations utilized for failure analysis of various components and interpret the probable reasons for failure.

Module:1	Introduction	7 hours

Material failure modes and their identification; Tools for failure analysis: Optical microscopy, Transmission electron microscopy, Scanning electron microscopy. Systematic approach to failure analysis.

Module:2	Mechanical aspects of Failure	6 hours

Tensile test, Static loading, Combined stress, Principal stresses, Theories of failure, Triaxial stresses and constraint, Plane stress, Plane strain, Stress concentration factors and notch sensitivity. Shock and impact loading.

Module:3	Fatigue	7 hours

Loading under high cycle fatigue conditions, Test methods, S-N-P curves, endurance diagrams, influence factors - Low cycle fatigue, fretting fatigue; Fatigue design for combined stress; cumulative damage and life prediction, statistical interpretation of fatigue test data.

Module:4	Analysis of Fatigue	6 hours

Failures related to corrosion, hot corrosion and stress corrosion cracking; Damages due to hydrogen; Creep of metallic materials, service failures during high temperature service; Failures

related to wear.		
Module:5	**Failure Mechanisms**	**6 hours**
Fracture processes, Meaning of ductile and brittle fracture, Effect of strain rate and temperature.		
Module:6	**Fracture Mechanics**	**6 hours**
Fracture mechanics and Failures, Linear elastic fracture mechanics, fracture mechanics principles in design practice, Elastic Plastic fracture mechanics, Examples of crack-growth Analysis for cyclic loading.		
Module:7	**Failures in joints and fasteners**	**5 hours**
Welded constructions and screw fastenings, Environmental degradation, Embrittlement of metals and alloys.		
Module:8	**Contemporary issues:**	**5 hours**
	Total Lecture hours:	**45 hours**

Challenging Projects

Project — 60 [Non contact hours]

Guidelines for Project:

- The project will be a group project with a maximum of 3 members in a group. The size will reflect the complexity of the project. Students should make sure that the concepts to be studied are reflected in the project.
- Concepts studied should have been used.
- Down to earth application and innovative idea should have been attempted.
- There will be a minimum of three reviews conducted in a semester and the marks will be awarded and taken for final assessment. The marks distribution for 3 reviews will be 20:30:50.
- Minimum pass marks for project is 50%. If the student fails to get 50%, he/she has to re-register and redo in a subsequent semester.
- If the student has got >= 50% in project, and fails in Theory, then the same marks can be taken up for grading purposes after he/she completes the Theory FAT. Evaluation is through continuous assessment with 3 reviews. No separate FAT.

Sample Projects:

Failure Analysis Project – Team or Individual. Topic of the project work may be chosen based on Failure analysis and investigation of engineering component like

1. Failure of a large air conditioner fan blade.
2. Cracked automobile suspension lower arm.

3. A cracked vacuum bellows. 4. Failed welded railroads rails. 5. Broken stainless steel hinge for a check valve., etc It is essential to apply the knowledge gained in this course and incorporate them in the project. The project report should consist of Introduction, experimental and/or numerical investigation, results and discussion and conclusion. Final project report has to be submitted at the end of the course.	
Text Book(s)	

1	Arthur J. McEvily, Metal Failures: Mechanisms, Analysis, Prevention, 2nd edition, John Wiley & Sons Inc. USA, 2013.
Reference Books	
1.	Hock-Chye Qua, Applied Engineering Failure Analysis: Theory and Practice, CRC press, Taylor & Francis, U.K, 2017.
2	F.C. Campbell, Fatigue and Fracture: Understanding the basic, 1st edition, ASM International, 2012.
3	Abdel Salam Hamdy Makhlouf, Mahmood Aliofkhazraei, Handbook of Materials Failure Analysis with Case Studies from the Aerospace, BH, Elsevier,U.K, 2016.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar			
Mode of assessment:			
Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-10-2017

Course code	INTERNAL COMBUSTION ENGINES	L	T	P	J	C
MEE3004		3	0	0	0	3
Pre-requisite	MEE2003	Syllabus version				
		v. 2.2				

Course Objectives:

1. To introduce students to the working of spark ignition and compression ignition engines and their systems.
2. To teach students about the usage of alternate fuels for IC engines.
3. To enhance the understanding of students in engine emissions, pollution and their control.
4. To introduce students to the recent trends in IC Engines like stratification, multi point injection, plasma ignition etc.

Course Outcome:

Upon successful completion of the course the students will be able to

1. Compare the merits and demerits of different types of fuel injection systems used in IC engines
2. Determine performance and combustion characteristics of SI and CI engines.
3. Propose design modifications for the existing turbochargers and superchargers
4. Analyze the emissions from IC engines and its effects on human beings and environment
5. Identify and critically evaluate different types of alternate fuels for automobiles.
6. Demonstrate the developments to enhance the efficiency and performance of IC engines.

Module:1	Mixture preparation	11 hours

Mixture preparation in Spark Ignition Engines: Spark ignition Engine mixture requirements - Feedback Control Carburetors –Properties of Fuel - Injection systems -Monopoint and Multipoint injection – Gasoline Direct Injection – Airmotion.

Mixture preparation in Compression Ignition Engines: Direct and indirect injection systems – Combustion chambers - Properties of Fuel -Fuel spray behavior - spray structure - spray penetration and evaporation – Air motion- Injectors and nozzles.

Module:2	Combustion in CI and SI Engines	5 hours

Stages of combustion in SI and CI engines – Combustion phasing - heat release rate based on cylinder pressure measurement-Knock in CI and SI engines- Measurement and control of Knock.

Module:3	Power Boosting Systems	5 hours

Supercharging – Turbocharging - Variable area turbochargers, twin entry turbochargers - waste gate in turbocharger - different arrangements of turbochargers and super chargers - Effect on power and emission - basics of intake manifold tuning.

Module:4	Engine Emission and Control	6 hours

Pollutant - Sources and types – Effect on environment and human health - formation of NOx - Hydrocarbon Emission Mechanism - Carbon Monoxide Formation - Particulate emissions -

Methods of controlling Emissions - Catalytic converters and Particulate Traps - Selective Catalytic Reduction(SCR) - Diesel Oxidation Catalyst (DOC).		
Module:5	**Emission Measurement and Emission Norms**	**6 hours**
Methods of measurements – Chemiluminescence - Non-Dispersive Infrared - Flame Ionisation Technique - Emission Norms and Driving cycles - Indian and Euro norms.		
Module:6	**Alternative Fuels**	**6 hours**
Alcohol - Hydrogen - Natural Gas and Liquefied Petroleum Gas – Biodiesel- Biogas - Properties - Suitability - Engine Modifications - Merits and Demerits as fuels.		
Module:7	**Recent Trends in IC Engines**	**4 hours**
LHR Engines - Learn Burn Engines - Stratified charge spark ignition engine – Homogeneous charge compression Ignition –Reactivity Controlled Compression Ignition-Rotary engine-Six stroke engine concept.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	V Ganesan, Internal Combustion Engine, 4th edition, Tata Mc-Graw Hill, 2012.
2.	Mathur.M.L & Sharma R.P, Internal Combustion Engine, Dhanpat Rai Publications, 2010.
Reference Books	
1.	Richard Stone, Introduction to Internal Combustion Engines, 4thedition, Palgrave Macmillan, 2012.
2.	John B.Heywood, Internal Combustion Engine Fundamentals, 2nd Edition, Tata McGraw Hill, 2011.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar			
Mode of assessment:			
Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-10-2017

Course code	REFRIGERATION AND AIR CONDITIONING	L	T	P	J	C
MEE3005		3	2	0	0	4
Pre-requisite	MEE2003	Syllabus version				
		v. 2.2				

Course Objectives:

1. To equip the students to understand vapour compression refrigeration cycle in it's various configuration and applications.
2. To enable the students to design summer and winter air conditioning systems.
3. To enable the students think innovatively to modify the vapour compression refrigeration process including control systems to meet the new challenges in the industry.

Course Outcome:

Upon successful completion of the course the students will be able to

1. Analyse and perform calculations for vapour compression refrigeration system.
2. Analyse different components of vapour compression refrigeration system.
3. Compare different refrigerants and suggest environmental friendly refrigerant.
4. Estimate different psychrometric properties using psychrometric chart and equations.
5. Calculate the load on the cooling coil and fix the supply conditions for various air-conditioning systems.

Module:1	Refrigeration Cycle Analysis	6 hours

Development of Vapour Compression Refrigeration Cycle from Reverse Carnot Cycle – conditions for high COP – deviations from ideal vapour compression cycle – Multi-pressure Systems - Cascade Systems – Analysis.

Module:2	System Components	6 hours

Compressor - Types – performance – Characteristics of Reciprocating Compressors – Capacity Control – Types of Evaporators & Condensers and their functional aspects – Expansion Devices and their behaviour with fluctuating load.

Module:3	Refrigerants	6 hours

Classification of Refrigerants – Refrigerant properties – Oil Compatibility – Environmental Impact- Montreal / Kyoto protocols – Eco Friendly Refrigerants. Different Types of Refrigeration Tools – Evacuation and Charging Unit – Recovery and Recycling Unit – Vacuum Pumps.

Module:4	System Balancing and Control	6 hours

Estimation of Cooling Load – System Equilibrium and Cycling Controls – Electric Circuits in Refrigerators – Window A/C – Types of motors – Relays.

Module:5	Psychrometry	6 hours

Moist Air properties – use of Psychrometric Chart – Various Psychrometric processes – Air

Washer – Adiabatic Saturation		
Module:6	**Summer and Winter Air Conditioning**	**6 hours**
Air conditioning processes – RSHF – summer Air conditioning – Winter Air conditioning – Bypass Factor. Applications with specified ventilation air quantity – Use of ERSHF – Application with low latent heat loads and high latent heat loads.		
Module:7	**Automotive air-conditioning and refrigeration applications**	**7 hours**
Food processing and preservation – Freezing and drying – Cold storage – Refrigerated Containers and Trucks.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	Eugene Silberstein , Refrigeration and Air Conditioning Technology, 7th Edition (International), Delmar publications, 2012.

Reference Books

1.	Manohar Prasad, Refrigeration and Air conditioning, Wiley Eastern Ltd., 2011.
2.	Arora, C. P. (2012), Refrigeration and Air Conditioning, 3rd edition, McGraw-Hill Education, 2012.
3.	G F Hundy, A R Trott, T C Welch, Refrigeration, Air Conditioning and Heat Pumps, 5th edition, (International), Butterworth-Heinemann Publications, 2016.
4.	Andrew D. Althouse, Carl H. Turnquist, A.F. Bracciano, D.C. Bracciano, G.M. Bracciano, Modern Refrigeration and Air Conditioning, 20th Edition, Goodheart-Willcox Publications, 2017.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar			
Mode of assessment:			
Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-10-2017

Course code	AUTOMOBILE ENGINEERING	L	T	P	J	C
MEE3006		2	0	2	0	3
Pre-requisite	NIL	Syllabus version				
		v. 2.2				

Course Objectives:

1. To broaden the understanding of students in the structure of vehicle chassis and engines.
2. To introduce students to steering, suspension, braking and transmission systems.
3. To introduce students to engine auxiliary systems like heating, ventilation and air-conditioning.
4. To teach students about the importance of alternate fuels and modifying the engine suitably.

Course Outcome:

Upon successful completion of the course the students will be able to

1. Choose and suggest a suitable engine chassis layout for different applications
2. Analyse various types of steering systems
3. Discuss various types of braking and suspension system
4. Select a suitable conventional and automatic transmission system
5. Troubleshoot the electrical and instrumentation system in the automobiles
6. Propose advance technologies to improve vehicle performance characteristics.

Module:1	Vehicle Structure and Performance:	4 hours

Automotive components, subsystems and their positions- Chassis, frame and body, front, rear and four wheel drives, Operation and performance, Traction force and traction resistance, Power required for automobile - Rolling, air and gradient resistance.

Module:2	Transmission Systems	4 hours

Clutch - Types- diaphragm type clutch, single and multi-plate clutches - Gear box: Types-constant mesh, sliding mesh and synchromesh gear box, layout of gear box, gear selector and shifting mechanism, overdrive, automatic transmission, Propeller shaft, universal joint, slip joint, differential and real axle arrangement, hydraulic coupling.

Module:3	Steering System	4 hours

Types of steering systems, Ackermann principle, Davis steering gear, steering gear boxes, steering linkages, power steering, wheel geometry-caster, camber toe-in, toe out etc., wheel Alignment and balancing.

Module:4	Suspension System	4 hours

Types - front and rear suspension, conventional and independent type suspension, leaf springs, coil springs, dampers, torsion bars, stabilizer bars, arms, air suspension systems.

Module:5	Braking System	4 hours

Forces on vehicles, tyre grip, load transfer, braking distribution between axles, stopping distance,

Types of brakes, Mechanical, Hydraulic, Air brakes, Disc & Drum brakes, Engine brakes anti-lock braking system.		
Module:6	**Automobile Electrical System and Instrumentation**	**4 hours**
General electrical circuits. Battery, Starting motor, DC generator, Alternator, Ignition circuit, Dash board instrumentation, Lighting system.		
Module:7	**Advances in Automobile Engineering**	**4 hours**
Passenger comfort - Safety and security - HVAC - Seat belts - Air bags - Automotive Electronics - Electronic Control Unit (ECU) - Variable Valve Timing (VVT) - Active Suspension System (ASS) - Electronic Brake Distribution (EBD) – Electronic Stability Program (ESP) Traction Control System (TCS) - Global Positioning System (GPS) - Electric - Hybrid vehicle.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)	
1.	William. H. Crouse, Donald L Anglin, Automotive Mechanics, 10th Edition, McGraw-Hill, 2017.
Reference Books	
1.	Bosch Automotive Hand Book, 8th Edition, Bentley Publishers, 2011.
2	Kirpal Singh, Automobile Engineering, Vol.1, Standard Publishers, 2012.
3	Kirpal Singh, Automobile Engineering, Vol.2, Standard Publishers, 2011.
4	N. K. Giri, Automobile Mechanics, 5th Edition, Khanna Publishers, 2014.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

List of Challenging Experiments (Indicative)

1.	Study of chassis and body (different types).	3 hours
2.	Assembling and disassembling of gear box (different types).	3 hours
3.	Study of transfer case, propeller shaft, slip joint and universal joint.	3 hours
4.	Assembling and disassembling of steering box (different types).	3 hours
5	Assembling and disassembling of differential and rear axle	3 hours
6	Assembling and disassembling of clutch.	3 hours
7	Determination of camber, caster, toe-in/toe-out.	3 hours
8	Assembling and disassembling of components of hydraulic brake system.	3 hours
9	Assembling and disassembling of components of air brake system.	3 hours
10.	Study on advanced technologies (ABS, EBD, VVT, Hybrid).	3 hours
	Total Laboratory Hours	**30 hours**

Mode of assessment:	
Recommended by Board of Studies	17-08-2017

Approved by Academic Council	47	Date	05-10-2017

Course code	MECHANICAL VIBRATIONS	L	T	P	J	C
MEE3008		2	2	2	0	4
Pre-requisite	MEE2004	Syllabus version				
		v. 2.2				

Course Objectives:

1. Formulate mathematical models of problems in vibrations using Newton's second law or energy principles,
2. Determine a complete solution to the modeled mechanical vibration problems
3. Obtain linear vibratory models of dynamic systems with changing complexities (SDOF, MDOF)

Course Outcome:

Upon successful completion of the course the students will be able to

1. Construct the equations of motion for free-body diagrams
2. Compute the natural frequency for free and forced vibration of a single degree of freedom under damped or un-damped system
3. Apply vibration absorbers and isolators for minimizing vibration in systems with two degree of freedom
4. Compute natural frequencies of free and forced vibrations in systems with multi-degree of freedom
5. Analyze properties of vibrating system using mathematical tools.
6. Examine the vibration response for continuous systems.
7. Perform free and forced vibrations tests and analyze the results.

Module:1	Fundamentals of Vibration	3 hours

Harmonic motion- periodic motion- coordinates system- types of vibration- vibration terminology- Duhamel's integral - Impulse response function - Virtual work - Euler and Lagrange's equations.

Module:2	Single degree of freedom System	3 hours

Free and forced vibration with and without elastically coupled viscous dampers – System identification from frequency response - Transient vibration - Laplace transformation formulation.

Module:3	Two Degree of Freedom System	3 hours

Free vibration of spring- coupled system - Mass coupled system - Forced vibration – Vibration absorber - Vibration isolation.

Module:4	Multi Degree of Freedom System	4 hours

Normal mode of vibration for free and forced vibration systems - Derivation of equation, calculation of natural frequencies by Rayleigh, Stodala, matrix, matrix iteration and Holzer methods.

Module:5	**Properties of vibrating system**	**5 hours**
Flexiblity matrix and stiffness matrix - Eigen value and Eigen vector – Orthogonal properties - Modal matrix - Modal analysis - Forced vibration by matrix inversion - Modal damping in forced vibration.		
Module:6	**Vibration of Continuous Systems**	**5 hours**
Systems governed by wave equations - Vibration of strings - Vibration of rods - Euler's equation for beams - Effect of Rotary inertia and shear deformation.		
Module:7	**Experimental Methods in Vibration Analysis**	**5 hours**
Vibration instruments - Vibration exciters Measuring Devices - Analysis - Vibration Tests -Free and Forced Vibration tests. Examples of vibration tests - Industrial case studies.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)

1.	S.S. Rao, Mechanical Vibrations, 6th Edition, Pearson Education, 2016.

Reference Books

1.	Dukkipati RV, Advanced Mechanical Vibrations, Narosa Publications, 2012.
2.	Kelly SG, Mechanical Vibrations, Mcgraw Hill(India) Ltd., 2013.
3.	W.T. Thomson, Theory of Vibration with Applications, 5th Edition, Prentice – Hall, 2013.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

List of Challenging Experiments (Indicative)

1.	Free vibration analysis of a compound pendulum.	3 hours
2.	Experimental study of Influence of damping on Free and forced vibration studies.	3 hours
3.	Estimation of natural frequencies and damping ratio on a beam.	3 hours
4.	Forced vibration analysis of a beam subjected to harmonic excitation.	3 hours
5.	Determination of transmissibility ratio of a vibrating table.	3 hours
6.	Free Vibration analysis of a beam using (I) Rayleigh's Method, (ii) Dunkerley's Method.	3 hours
7.	Free Vibration tests of different components using impact hammer and shaker.	3 hours
8.	Modal analysis of simply supported structure using FE software and comparison with experimental modal analysis.	3 hours
9.	Determination of critical speed of shaft.	3 hours

10.	Determination of torsional vibration characteristics on single rotor and two rotor system.	3 hours
	Total Laboratory Hours	**30 hours**
Mode of assessment:		
Recommended by Board of Studies	17-08-2017	
Approved by Academic Council	47	Date 05-10-2017

MEE3010	Robot Dynamics and application	L	T	P	J	C
		3	0	0	4	4
Version No.	-					
Prerequisite	Nil					
Objectives:	• To introduce basic components of robotics system. • To solve basic problem in robot forward and inverse kinematics • To solve basic problem in robot forward and inverse dynamics • To understand the application of Jacobin in robot arm design • To lean the trajectory planning for industrial robot					
Expected Outcome:	• Ability to design a simple robot arm • Simulation robotic arm using software packages • Learn to plane the trajectory • Understanding the implementation of advance control system in robotics					

Module I	**Introduction to Robot manipulator**	**4 hours**
Components of Industrial robot – Basic classifications – DOF of serial and parallel manipulator – Specifications of industrial robots – Singularity in robot work envelop – Dexterity – Introduction to redundant manipulator.		
Module II	**Robot Kinamatics**	**8 hours**
Representing Position and orientation – Homogeneous matrices - Forward kinematics – Inverse Kinematics – Denavit hartenberg representation – case study: Puma 500, standford arm and SCARA robot		
Module III	**Velocity kinematics**	**7 hours**
Velocity propagation – Velocity transformation – angular and linear velocity - Static force analysis – Derivation of Jacobian – inverse velocities and acceleration – wrist and arm singularity		
Module IV	**Robot Dynamics**	**7 hours**
Euler-Lagrange Equations – equation of motion – forward and inverse dynamics – properties of robot dynamics equations – Newton-Euler formulation		
Module V	**Trajectory planning**	**6 hours**
Trajectory Vs path planning – Cartesian space and joint space interpolation – third and fifth polynomial equation for trajectory planning		
Module VI	**Advance robot control**	**5 hours**
Disturbance rejection – PD and PID control – Computer torque control – Adaptive control – Feedback linearization for under actuated systems.		
Module VII	**Industrial application**	**4 hours**
Welding – Assembly – Material handling –Loading and Unloading – Pressing – fettling – paining		
Module VIII	**Social robots**	**4 hours**
Mobile robot – types of wheeled mobile robot – Underwater robot – space robot - service robot – surgical robot		
	Total Lecture hours:	**45 hours**
Challenging experiment		

1. Using sim-Mechanics develop and control robotics arm
2. Simulation of PUMA 500
3. Simulation of Stand-ford arm
4. Simulation of SCADA robot
5. Developing program for controlling stewart platform using Matlab
6. Develop coding for trajectory planning
7. Simulating the robotic control using ROS
8. Designing work-cell of industrial robot application
9. Simulate a robotic arm in V-REB-Pro
10. Experiment using fanuc robot

Text Books	
Mark W. Spong, Seth Hutchinson, and M. Vidyasagar 'Robot Dynamics and Control' John Wiley & Sons, 04-Aug-2008	
References	

- S. R. Deb, Sankha Deb , (2009)Robotics Technology And Flexible Automation, McGraw Hill Edition.
- Fu, K.S., Gonzalez, R.C. and Lee, C.S.G., "Robotics: Sensing, Vision and Intelligence", Tata McGraw-Hill, New Delhi, 2008.
- Craig, John. J., "Introduction to Robotics: Mechanics and Control", Second Edition, Pearson Education, New Delhi, 2002.
- Niku, Saeed.B "Introduction to Robotics: Analysis, Systems, Applications", New Delhi: Prentice Hall of India Pvt Ltd , 2005

Mode of Evaluation	
Recommended by the Board of Studies on:	
Date of Approval by the Academic Council:	
Benchmarked with	IIT Kharagpur Carnegie Mellon University

Course code	PRODUCT DEVELOPMENT AND MANAGEMENT	L	T	P	J	C
MEE3501		2	0	2	4	4
Pre-requisite	Nil	Syllabus version				
Anti-requisite	Nil	v. 1.0				

Course Objectives:

The main objectives of the course are to:

1. Impart skills to students for applying Design innovation, Design for quality and Design optimization for designing new products
2. Train students to select materials, manufacturing processes, correct formats for documentation and to work in ways to show respect to stake holders.

Course Outcome:

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

1. Develop concepts, design modular systems and carry out documentation.
2. Evaluate the safety of new designs using the principles of mechanics of machines
3. Apply Quality function deployment (QFD), Theory of Problem solving (TRIZ), DFX, FMEA, and six sigma to design new products.
4. Use resources efficiently and Treat confidential information correctly.
5. Create documents using documentation tools from the organization's knowledge base.
6. Organize and work with stake holders to integrate their work effectively with them

Module:1	Fundamentals of drafting and presentation	7 hours

Freehand sketches, Layout and Presentation, Graphical Standards, Dimensioning and tolerances, Symbols, Product configurations and Component relationships, Design of Modular System - abstract design, Process of conception and its documentation. Product Attributes, Product configurations and Component relationships (component Matrix).

Module:2	Review of fundamentals of kinematics and dynamics	5 hours

Classifications of mechanisms-components of mechanisms – mobility analysis –D.O.F, kinematic chains, Position Analysis – Vector loop equations for four bar, slider crank and inverted slider crank mechanisms. Introduction to Vibrations-SHM, SDOF, Damping, whirling speed of shaft.

Module:3	Design and Development:	5 hours

Design Conceptualization and Philosophy, Concept generation, selection and testing, Product life cycle, Concurrent Engineering and design optimization. Design Bench Marking, Design Process development (QFD), Theory of Problem solving (TRIZ) – Value Analysis - Design Innovation, DFX, FMEA, Design for quality and six sigma.

Module:4	Material and manufacturing process selection	3 hours

Introduction to metals, nonmetals, composites and ceramics, Bio materials, Nano materials. Fundamentals of material behavior and selection. Selection of manufacturing process- casting, Forging, Metal Forming, Machining, Welding and 3D printing.

Module:5	**Document Creation and Knowledge Sharing**	**2 hours**
Access existing documents, language standards, templates and documentation tools from respective organization's knowledge base. Confirm the content and structure of the documents with appropriate people.		
Module:6	**Self and work Management**	**3 hours**
Establish and agree the work requirements with appropriate people - Keep immediate work area clean and tidy - utilize time effectively - Use resources correctly and efficiently - Treat confidential information correctly.		
Module:7	**Team Work and Communication**	**3 hours**
Leadership and management, Communicate with stake holders clearly, concisely and accurately - Work with stake holders to integrate their work effectively with them - Pass on essential information to stake holders in line with organizational requirements - Work in ways that show respect for stake holders.		
Module:8	**Contemporary issues:**	**2 hours**
Industrial Expert Guest Lecture and Seminars		
	Total Lecture hours:	**30 hours**

Text Book(s)	
1	Karl T. Ulrich and Steven D. Eppinger, Product Design and Development, , McGraw-Hill International Edns. 2011.
2	Radhakrishnan P, Subramanyan S and Raju V., "CAD/CAM/CIM", 2nd Edition, New Age International (P) Ltd, New Delhi,2008.
3	Norton L. R., "Machine Design – An Integrated Approach" Pearson Education, 2005.
Reference Book(s)	
1.	Amitabha Ghosh and Asok Kumar Mallik, "Theory of Mechanism and Machines", EWLP, Delhi, 2000.
2	Kevin Otto and Kristin Wood, Product Design Techniques in Reverse Engineering and New Product Development, Pearson Education (LPE). 2001
3	Dieter, George E., "Engineering Design - A Materials and Processing Approach", McGraw Hill, International Editions, Singapore, 2000.

Challenging Lab Exercises (Indicative)		**30 [Non-contact hours]**

1. Brief Introduction of design modelling packages
2. Industrial component drafting – 2 Exercises
3. Industrial component modelling using form features - 2 Exercises
4. Industrial Product Assembly, BOM – 2 Exercises
5. Deploy problem solving methods TRIZ, DFX, FMEA tools – 3 Exercises
6. Industry standards & Documentation – 1 Exercise

Challenging Projects (Indicative)		**60 [Non-contact hours]**

An independent/team project focusing on:

1. Identify a consumer product as needed by the market, develop concept, develop CAD model, simulate in CAE environment, optimize, and develop tooling.
2. Prototyping and testing – cost evaluation –categories of cost – BOM.
3. Make a physical prototype.
4. Prepare a detailed report.

Areas of Focus(not restricted to):

Automation, Robotics, Cyber Physical System, Advanced Mechanisms Design, Automobiles Engineering, Aerospace, energy, Biomechanical and material development etc.

Recommended by Board of Studies	04-02-2020		
Approved by Academic Council	No.	Date	

Course code	DESIGN PROCESS PLANNING & MANAGEMENT	L	T	P	J	C
MEE3502		2	0	2	4	4
Pre-requisite		Syllabus version				
Anti-requisite		v. 1.0				

Course Objectives:

The main objectives of the course are to:

3. Impart students skills to apply CAD/CAM/CAE tools to develop products, manage product data and information
4. Train students to excel in document creation, team work, health, safety, self and work management

Course Outcome:

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

1. Apply CAD/CAM/CAE tools efficiently to design and develop new products
2. Analyze accuracy of assemblies and execute data exchange as per standards
3. Excel in document creation and work in line with the organization's policies and procedures
4. Evaluate knowledge, skills and competence regularly and take appropriate action
5. Implement organization's health, safety and security policies and procedures
6. Develop e-governance and manage digital data and information.

Module:1	CAD/CAM/CAE	5 hours

Review of : Product cycle- Design process- sequential and concurrent engineering- Computer aided design – CAD system architecture- Computer graphics –Introduction to CAM- NC/CNC Machines, Manufacturing Planning, Manufacturing control, Manufacturing methods, Introduction to CAE.

Module:2	Assembly Of Parts And Product Data Exchange	4 hours

Assembly modeling - interferences of positions and orientation - tolerances analysis – mass property calculations - mechanism simulation. Graphics and computing standards– Open GL Data Exchange standards – IGES, STEP etc– Communication standards.

Module:3	Document preparation with policies, procedures and guidelines	4 hours

Create documents using standard templates and agreed language standards. Review documents with appropriate people and incorporate their inputs. Treat confidential information correctly - Work in line with organization's policies and procedures Work within the limits of their job role, Publish Documents in agreed format, importance of policies, procedures and guidelines of organization while creating documents.

Module:4	Organization work place procedures and policies	3 hours

Work place show respect for colleagues, commitments to execute the work in time, identify problems in working with colleagues and solve the problems. Adopt organization policy and procedures

Module:5	**Managing Health and Safety**	**4 hours**
Safety and security policies, policies and standards. Industry pollution and hazards. Comply with organization's current health, safety and security policies and procedures, Report any identified breaches in health, safety, and Security policies and procedures, Identify, report and correct any hazards, Organization's emergency procedures, Identify and recommend opportunities for improving health, safety, and security. Physical and mental health practices. Psychological counseling process.		
Module:6	**Data and Information Management**	**4 hours**
Fetching the data/information from reliable sources, Checking that the data/information is accurate, complete and up-to-date, Rule-based analysis of the data/information, Insert the data/information into the agreed formats, Reporting unresolved anomalies in the data/information, e-governance, Digital Transformation, Digital data and information management.		
Module:7	**Learning and Self Development**	**4 hours**
Identify accurately the knowledge and skills needed, Current level of knowledge, skills and competence and any learning and development needs, Plan of learning and development activities to address learning needs, Feedback from appropriate people, Review of knowledge, skills and competence regularly and appropriate action taken.		
Module:8	**Contemporary issues:**	**2 hours**
Industrial Expert Guest Lecture and Seminars		
	Total Lecture hours:	**30 hours**

Text Book(s)	
1	Karl T. Ulrich and Steven D. Eppinger, Product Design and Development, McGraw-Hill International Edns. 2011.
2	Radhakrishnan P, Subramanyan S. and Raju V., "CAD/CAM/CIM", 2nd Edition, New Age International (P) Ltd, New Delhi, 2008.
Reference Book(s)	
1.	Amitabha Ghosh and Asok Kumar Mallik, "Theory of Mechanism and Machines", EWLP, Delhi, 2008
2	Dieter, George E., "Engineering Design - A Materials and Processing Approach", McGraw Hill, International Editions, Singapore, 2000.
3.	Kevin Otto and Kristin Wood, Product Design Techniques in Reverse Engineering and New Product Development, Pearson Education (LPE). 2001
4	Norton L. R., "Machine Design – An Integrated Approach" Pearson Education, 2011

Challenging Lab. Exercise's (Indicative)		**30 [Non-contact hours]**
1. Brief Introduction of CAE/CAM tools packages 2. Preparing CAD models for manufacturing– 2 Exercises		

3. Use CAE tools for design validation - 2 Exercises 4. Industrial mechanism simulation – Different types of applications - 3 Exercises 5. NC/CNC based Industrial component modelling - 2 Exercises 6. Preparation manufacturing drawing with tolerances – 1 Exercise		
Challenging Projects (Indicative)		**60 [Non-contact hours]**
An independent/team project focusing on: 5. Identify a consumer product as needed by the market, develop concept, CAD model, simulate in CAE environment, optimize, and develop tooling. 6. Prototyping and testing – cost evaluation –categories of cost – BOM. 7. Make a physical prototype. 8. Prepare detailed documentation with standards. **Areas of Focus(not restricted to):** Automation, Robotics, Cyber Physical System, Advanced Mechanisms Design, CAM, Rapid Prototyping, Automobiles Engineering, Metal Casting, Forging, Tool Design.		

Recommended by Board of Studies	04-02-2020		
Approved by Academic Council	No.	Date	

Course code	TOOL DESIGN	L	T	P	J	C
MEE4001		3	0	0	4	4
Pre-requisite	MEE2031/MEE2006	Syllabus version				
		v. 2.2				

Course Objectives:

1. To teach how to select materials for cutting tools and tool material improvement methods and design of cutting tools
2. To enable the students design of locating devices and clamps
3. To analyze the design of jigs and fixtures
4. Analyze the tools for Bending, Forming and Drawing operations, and design of press tools for automotive and other industrial components

Course Outcome:

Upon successful completion of the course the students will be able to

1. Select suitable tool material and cutting tool design
2. Analyze the performance of jigs and fixtures
3. Design locators and clamps for jigs and fixtures
4. Design Jigs and Fixtures for Manufacturing, Testing and Assembly applications
5. Design Press Tools and forming dies using various design rules
6. Analyze the design constraints in the given problem
7. Design of cutting tools, Work holding tools and Forming tools for various industrial and automotive applications.

Module:1	Introduction to Tool Design	6 hours

Tool Engineering – Tool Classifications– Tool Design Objectives – Tool Design in manufacturing- Challenges and requirements- Standards in tool design-Tool drawings -Surface finish – Fits and Tolerances - Tooling Materials - Ferrous and Nonferrous Tooling Materials-Carbides, Ceramics and Diamond -Nonmetallic tool materials-Designing with relation to heat treatment.

Module:2	Design of Cutting Tools	6 hours

Metal cutting process - Selection of tool materials - Design of single point and multipoint cutting tool - Form tools, Drills, Milling cutters, broaches and chip breakers – Problems on design of single point cutting tools only.

Module:3	Locating and Clamping Methods	6 hours

Basic Principles of location - Locating methods and devices - Principles of clamping - Mechanical, Pneumatic and Hydraulic actuations - Clamping force analysis – Design problems.

Module:4	Design of Jigs	6 hours

Types of drill jigs - General considerations in the design of drill jigs - Drill bushings - Types,

methods of construction - Simple designs of Plate, Channel, Boxes, Post, Angle plate, Turnovers and Pot Jigs.		
Module:5	**Design of Fixtures**	**6 hours**
Principles - Types of fixtures - Fixtures for machine tools: Lathe, Milling, Boring, Broaching and grinding - Assembly fixtures - Inspection and Welding fixtures.		
Module:6	**Design of Press Tool Die**	**6 hours**
Types of Dies –Method of Die operation–Clearance and cutting force calculations- Blanking and Piercing die design – Pilots – Strippers and pressure pads- Presswork materials – Strip layout – Short-run tooling for Piercing.		
Module:7	**Design of Forming Dies**	**6 hours**
Bending dies– Forging dies – Extrusion dies - Drawing dies-Design and drafting		
Module:8	**Contemporary issues:**	**3 hours**
	Total Lecture hours:	**45 hours**

Projects

• Generally a team project [Maximum of 3 members only]. • Concepts studied should have been used. • Down to earth application and innovative idea should have been attempted. • Assessment on a continuous basis with a minimum of 3 reviews. **Sample projects:** 1. Design a blanking punch and die for a given component. 2. Design a stripper and Die plate. 3. Design a forming die for sheet metal bending. 4. Design an angular milling fixture for machining a component. 5. Design a drill jig for a given component. 6. Design a cold drawing die for the given dimension of pipe. 7. Design the turning fixture. 8. Design the milling fixture. 9. Design a Broaching fixture. **10.** Design a friction welding fixture.	**60**[Non contact hours

Text Book(s)

1.	Donaldson C., Lecain G.H., Goold V.C., Tool Design, 4th edition, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2012.

Reference Books

1.	E.G.Hoffman, Jig and Fixture Design, Thomson Asia Pvt Ltd, Singapore, 2010.
2.	John Nee,Fundamentals of Tool Design, Sixth Edition, SME, 2010.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar			
Mode of assessment:			
Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-10-2017

Course code	ADVANCED MACHINING PROCESSES	L	T	P	J	C
MEE4002		2	0	0	4	3
Pre-requisite	MEE2031/ MEE2006	Syllabus version				
		v. 2.2				

Course Objectives:

1. To acquaint the basic concepts and applications of micro and nano machining processes
2. To encourage the students for developing the models (experimental/theoretical) of micro and nano machining processes.
3. To impart knowledge about the significance of controlling process parameters for the optimal performance for newly developed engineering materials used in industries and research organizations.

Course Outcome:

Upon successful completion of the course the students will be able to

1. Select the appropriate machining process based on tool-workpiece interaction and source of energy for the end product.
2. Apply the water jet cutting process with relevant process parameters for a product.
3. Recognize the material removal mechanism and process parameters of Ultrasonic machining process
4. Demonstrate the material removal mechanism of various thermal energy based processes.
5. Extend the mechanism of Electrical energy based processes and their process parameters for different applications
6. Make use of Chemical energy based processes.
7. Identify various Hybrid machining processes.
8. Utilize appropriate machining process to produce a product of required geometry and quality.

Module:1	Introduction	3 hours

Need and classification of non-traditional machining processes – Material removal in traditional and non-traditional machining process - considerations in process selection.

Module:2	Advanced cold cutting processes	4 hours

Abrasive Jet Machining (AJM), Water Jet Machining (WJM) and Abrasive Water Jet Machining (AWJM) - Basic principles, process variables, process Mechanism of metal removal, applications and limitations.

Module:3	Ultrasonic machining (UM)	3 hours

Working principle, Mechanism of metal removal, Theory of Shaw and modelling of USM, Estimation of material removal, Effect of process parameters – Application, Limitation and case studies.

Module:4	High Energy Beam Machining	4 hours

Laser Beam Machining (LBM) – Electron Beam Machining (EBM) – Plasma Beam Machining (PBM) - Ion Beam Machining (IBM) – Mechanism of metal removal, Process characteristics, Accuracy and surface quality, Application.		
Module:5	**Electric Discharge Machining (EDM)**	**5 hours**
Theory of EDM, Working principle, Pulse generator circuit – RC and Controlled pulse generator – Analysis of RC circuit - Selection of process parameters, tool electrode, dielectric fluid, Machining characteristics of spark eroded surface – Recent development in EDM process - Wire Electrical discharge machining (WEDM) – working principle, process variables, characteristics, applications.		
Module:6	**Chemical and Electro Chemical Machining Process**	**5 hours**
Chemical machining - Fundamental principle, types of chemical machining, maskants, etchants - Electro Chemical Machining (ECM) – Theory of ECM – Working principle, Mechanism of metal removal, Modelling of ECM, Process characteristics – Advantages, limitations and applications.		
Module:7	**Hybrid Machining Process & Advanced Finishing Process**	**4 hours**
Hybrid Machining Process: Electro Chemical Drilling – Shaped Tube Electrolytic Machining – Electrostream Drilling – Electro Chemical Jet Drilling – Electro Chemical Deburring - Electro Chemical Grinding (ECG) – Electro Chemical Honing (ECH) – Electrochemical super finishing – Electrical Discharge Grinding (EDG) – Electrical Discharge Diamond Grinding (EDDG) - Electro Chemical Discharge Grinding (ECDG) – Process capabilities and applications. **Advanced Finishing Process:** Abrasive Flow Machining (AFM) – Magnetic Abrasive Finishing (MAF) – Magneto-rheological Finishing (MRH) - Chemo Mechanical Polishing (CMP) – Working principle – Mechanism of material removal – Surface quality – Applications.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**
Text Book(s)		
1.	P Pandey and H Shan, Modern Machining Processes, McGraw Hill Education, 2017.	
2.	Kapil Gupta, N.K.Jain and R.F.Laubscher, Hybrid Machining Process: Perspectives on machining and finishing, Springer International Publishing, 2016.	
Reference Books		
1.	H. El-Hofy, Fundamentals of Machining Processes: conventional and non-conventional, 2nd edition, CRC press, Taylor & Francis group, 2014.	
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar		
Challenging Projects (Indicative)		
	Guidelines:	

	# Generally a team project of Five. # Concepts studied in Modules 2, 4, 6 should have been used. # Down to earth application and innovative idea should have been attempted. # Report in Digital format with all drawings using software package to be submitted. # Assessment on a continuous basis with a min of 3 reviews.	
	Sample Projects: 1. Evaluate the machinability of difficult to machine materials and super alloys using any of the advanced machining processes. 2. Study the surface integrity of the electric discharge machined parts by analyzing the surface finish, surface and subsurface cracks, heat affected zone, etc. 3. Analyse the geometry of small holes drilled by spark erosion machining using coordinate measuring machine and video measurement system. 4. Development of new attachments for enhancing the utility of EDM and Wire EDM machines beyond their intended purpose. (e.g. orbital EDM, wire EDM turning, Electric discharge grinding, etc.) 5. Sustainable manufacturing practices in advanced machining (e.g. near dry/dry EDM). 6. Analyze the surface characteristics of Electro Chemical Machined component. 7. Evaluate the performance of new wire material in wire-EDM. 8. Analyze the surface characteristics of components machined using advanced finishing process.	**60**[Non-contact hours]

Mode of assessment:			
Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-10-2017

Course code	MICRO AND NANO MACHINING	L	T	P	J	C
MEE4003		3	0	0	0	3
Pre-requisite	MEE2006 / MEE2031	Syllabus version				
		v. 2.2				

Course Objectives:

1. To acquaint the basic concepts and applications of micro and nano machining processes
2. To encourage the students for developing the models (experimental/theoretical) of micro and nano machining processes.
3. To impart knowledge about the significance of controlling process parameters for the optimal performance for newly developed engineering materials used in industries and research organizations.

Course Outcome:

Upon successful completion of the course the students will be able to

1. Classify the appropriate micro and nano machining process based on material removal mechanism.
2. Recognize the traditional micro and nano machining process and their process parameters.
3. Identify various advanced mechanical energy based Micro-Nano Machining processes, and their process parameters on the desired product.
4. Demonstrate the material removal mechanism of various Advanced Thermo-electric Micro-Nano machining Processes
5. Extend the mechanism of High Energy Advanced Thermo-electric Micro-Nano machining Processes and their process parameters for required output.
6. Select suitable Advanced Electro-chemical, Micro-Nano Machining Processes relevant to the desired product.
7. Utilize various micro and nano finishing processes.

Module:1	Introduction to Micro and Nano machining	4 hours

Classification and types of machining processes, Fundamentals of Micro and Nano machining processes, Nano materials and their applications in various industrial applications.

Module:2	Traditional Micro and Nano machining Processes	6 hours

Theory of micromachining, Operating principles and process parameters of Micro turning, Micro-milling, Micro-grinding, Applications and Limitations of micro machining.

Module:3	Advanced Mechanical Micro-Nano Machining processes	6 hours

Introduction -Classification of advanced Mechanical Micro - Nano Machining processes, Operating principles and process parameters of Abrasive Jet Micromachining (AJM), Water jet micro machining (WJM), Abrasive Water Jet Machining (AWJM),Ultrasonic Micromachining (USM), Abrasive Flow Nano finishing, Magnetic Abrasive Nano finishing.

Module:4	**Advanced Thermo-electric Micro-Nano machining Processes**	**6 hours**
Operating principles and process parameters of Electric Discharge Micromachining, Electric Discharge Grinding and Electric Discharge Diamond Grinding, Wire Electric Discharge Micromachining.		
Module:5	**High Energy Advanced Thermo-electric Micro-Nano machining Processes**	**5 hours**
Operating principles and process parameters of Laser Beam Micromachining (LBM), Electron Beam Micromachining (EBM), Focused Ion Beam Machining (IBM)		
Module:6	**Advanced Electro-chemical Micro-Nano Machining Processes**	**6 hours**
Operating principles and process parameters of Electrochemical Micromachining, Electrochemical Micro Grinding, Electro stream Micro drilling, Electro-chemical Micro deburring.		
Module:7	**Modern Finishing Processes**	**10 hours**
Advanced finishing processes (AFPs), abrasive flow machining (AFM), magnetic abrasive finishing (MAF), magnetorheological finishing (MRF), magnetorheological abrasive flow finishing (MRAFF), magnetic float polishing (MFP), elastic emission machining (EEM), ion beam machining (IBM), and chemical mechanical polishing (CMP). MEMS and Actuators - Sensors and Actuators, MEMs, Wet and Dry Etching-Surface Micromachining, Metrology For Micro manufactured Products.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Golam Kibria, B. Bhattacharyya, J. Paulo Davim, Non-traditional micro machining processes: Fundamentals and applications, Springer International publishing, 2017.
2.	V.K.Jain, Micro manufacturing processes, CRC press Taylor & Francis group, 2013. (e-book)
Reference Books	
1.	H. El-Hofy, Fundamentals of Machining Processes: conventional and non-conventional, 2ndedition, CRC press, Taylor & Francis group, 2014.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar			
Mode of assessment:			
Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	15-10-2017

Course code	SURFACE ENGINEERING	L	T	P	J	C
MEE4005		3	0	0	0	3
Pre-requisite	MEE2006	Syllabus version				
		v. 2.2				

Course Objectives:

1. Select an appropriate surface modification technique depending on the need.
2. Characterize the coatings developed using these techniques.
3. Apply the knowledge to find solution for surface degradation.

Course Outcome:

Upon successful completion of the course the students will be able to

1. Select a conventional surface engineering treatment for a specific application
2. Design a suitable thermal spray technique for surface modification of various materials
3. Deploy laser modification of surfaces to enhance properties
4. Select and use an appropriate deposition technique for various materials
5. Use various characterisation tools
6. Design a suitable Nano coating system for various applications

Module:1	Introduction	7 hours

Fundamental of surface engineering – Surface dependent properties and failures of engineering components. Surface engineering – Scope, Classification, definition and general principles.

Module:2	Conventional Surface Engineering	6 hours

Cleaning, pickling, etching, grinding, polishing and diffusion process - carburizing, nitriding - Electroless and Electroplating - Anodization and Electrophoretic deposition.

Module:3	Advanced Surface Engineering Practices	6 hours

Thermal spray technologies –introduction - APS and HVOF - Effect of process parameters on coating properties - Cold spraying , warm spraying and Solution plasma spraying.

Module:4	Laser surface modification	6 hours

Laser hardening - Laser cladding - Laser texturing.

Module:5	Thin film technologies	6 hours

PVD and CVD Technologies - Evaporation –thermal and Electron beam - PVD, RF- DC, EBM, CVD-HFCVD, PECVD and ion implantation.

Module:6	Coating characterization	6 hours

Thickness and Roughness - Porosity and Adhesion - SEM and AFM - Raman and XPS - XRD – phases and stresses - Scratch and wear testing.

Module:7	**Nano-coatings**	**6 hours**
Importance and applications – Preparation of nano-coatings.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Peter Martin, Introduction to Surface Engineering and Functionally Engineered Materials, Interscience Wiley, 2011.
Reference Books	
1.	Steven Abbott, Nigel MacDermid , Nanocoatings: Principles and Practice: FromResearch to Production, DEStech Publications, 2013.
2.	Atul Tiwari, Lloyd Hihara, James Rawlins, Engineered Tribological Composites: The Art of Friction Material Development, 1st edition, Butterworth, 2014.
3.	Angela Piegari, François Flory, Optical Thin Films and Coatings, 1st edition, Woodhead Publishing, 2013.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar			
Mode of assessment:			
Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-10-2017

Course code	COMPUTATIONAL FLUID DYNAMICS	L	T	P	J	C
MEE4006		2	2	2	0	4
Pre-requisite	MEE1004, MEE2005, MAT3005 (or) MEE1032, MEE1033	Syllabus version				
		v. 2.2				

Course Objectives:

1. To provide the students with sufficient background to understand the mathematical representation of the governing equations for fluid flow and heat transfer problems.
2. To equip the students to address complex fluid flow and heat transfer problems by approximating the governing differential equations with boundary conditions through Finite difference and finite volume discretization methods.
3. To enable students to understand different types of grid and its attributes and their suitability for different engineering applications
4. Develop the students to use appropriate turbulence model for solving engineering problems.

Course Outcome:

Upon successful completion of the course the students will be able to

1. Apply mathematics and engineering fundamentals to recognize the type of fluid flow and heat transfer that occur in a particular physical system and to use the appropriate model equations to investigate the problem.
2. Solve governing equations using finite difference discretization technique
3. Solve governing equations using finite volume method
4. Generate appropriate type of grids required for solving engineering problems accurately.
5. Apply suitable turbulence model for the chosen real world engineering problems.
6. Solve fluid flow and heat transfer problems using commercial CFD tools

Module:1	Introduction	1 hour

CFD overview - Applications of CFD.

Module:2	Governing Equations of Fluid Dynamics and Heat Transfer:	6 hours

Models of Flow – Conservation and Non-conservation form - Continuity, Momentum and Energy Equation in conservation and non-conservation form (differential equations only) - Characteristics of PDE's - elliptic, parabolic and hyperbolic.

Module:3	Discretization and Finite Difference method	7 hours

Discretization: Basic aspects of Discretization – Comparison of finite difference, finite volume and finite element techniques.

Finite Difference method: Forward, Backward and Central difference schemes, Transient one and two dimensional conduction - Explicit, implicit, semi-implicit and ADI methods - Stability analysis and error estimation.

Module:4	**Grid Generation**	**3 hours**
Grid Generation: Choice of grid, grid oriented velocity components, Cartesian velocity components, staggered and collocated arrangements.		
Module:5	**Convection and Diffusion**	**7 hours**
Convection and Diffusion: Steady one-dimensional convection and diffusion - Central difference, upwind, quick, exponential, hybrid and power law schemes- False diffusion, SIMPLE – Algorithm.		
Module:6	**Turbulence Modeling**	**4 hours**
Turbulence Modeling : Introduction – Types of Turbulence modeling – Reynolds Time Averaging – Reynolds Time Averaged conservation equations – Boussinesq approach – One equation k - ε model.		
Module:7	**Contemporary issues**	**2 hours**
	Total Lecture hours:	**30hours**

Text Book(s)	
1.	John D Anderson, Computational Fluid Dynamics – The Basics with Applications, 1st Edition, McGraw Hill, 2012.
Reference Books	
1.	Chung T.J, Computational Fluid Dynamics, Cambridge University Press, 2014.
2.	Muralidhar K and Sundararajan T, Computational Fluid Flow and Heat Transfer, Narosa Publications, New Delhi, 2014.
3.	Versteeg H.K and Malalasekara W, An Introduction to Computational Fluid Dynamics - The Finite Volume Method, 2nd Edition, Pearson, 2010.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

List of Challenging Experiments (Indicative)		
1.	Modeling of simple and complex geometries.	3 hours
2.	Hexahedral meshing for simple geometries like square duct, circular pipe.	3 hours
3.	O-grid hexa meshing for circular pipe.	3 hours
4.	Tetrahedral meshing for simple geometries including fluid and solid domains.	3 hours
5.	Preprocessing in FLUENT – Case setup and analyzing for already mesh generated model.	3 hours
6.	Steady state temperature distribution in a rectangular plate (ANSYS Fluent and FDM).	3 hours
7.	Diffuser for a hydropower turbine.	3 hours
8.	Flow over an airfoil - Laminar and turbulent flow.	3 hours

9.	Supersonic flow past a wedge in a channel.			3 hours
10.	Exercise (for each student – different exercise) from FLUENT tutorial (case setup, analyzing, and post-processing).			3 hours
			Total Laboratory Hours	**30 hours**
Mode of assessment:				
Recommended by Board of Studies	17-08-2017			
Approved by Academic Council	47	Date	05-10-2017	

Course code	DESIGN OF TRANSMISSION SYSTEMS	L	T	P	J	C
MEE4007		2	2	0	4	4
Pre-requisite	MEE2004/ MEE3001/MEE2032	Syllabus version				
		v. 2.2				

Course Objectives:

10. To understand the various elements involved in a transmission system.
11. To analyse the various forces acting on the elements of a transmission system.
12. To design the system based on the input and the output parameters.
13. To produce working drawings of the system involving various machine elements like pulleys, gears, clutches and brakes.

Course Outcome:

Upon successful completion of the course the students will be able to

6. Design of pulleys, chain drives, rope drives and belt drives.
7. Design journal bearings and select rolling contact bearings
8. Analyze forces acting on elements of transmission systems
9. Determine performance requirements in the selection of commercially available transmission drives.
10. Design of various types of gears and gear boxes.
11. Apply various systems, materials and methods and design transmission systems

Module:1	Flexible transmission elements	7 hours

Introduction to transmission systems –factors -materials selection –stresses – belt &chain drives, Design of flat and V- belts, Design of chain drives, Design of rope drives.

Module:2	Design of bearings	4 hours

Lubrication, Design of journal bearings – using Sommerfeld number – using McKee's equations, Selection of rolling contact bearings – problems.

Module:3	Design of spur gears	4 hours

Introduction - gear kinematics – forces & stresses – factors –materials selection – design of spur gears.

Module:4	Design of helical gears	4 hours

Introduction – types - gear kinematics – virtual number of teeth - forces & stresses – factors – design of helical gears.

Module:5	Design of bevel gears	3 hours

Introduction – classifications - gear kinematics – factors – design of bevel gears – force analysis.

Module:6	Design of worm gears	3 hours

Introduction – classifications – applications – efficiency – design of worm gears.		
Module:7	**Design of gear boxes**	**3 hours**
Introduction – Types – Components – gear box housing – progression ratio – kinematic arrangement – ray diagram – design of multi speed gear boxes.		
Module:8	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s)	
1.	Richard G. Budynas, J.Keith Nisbett, Shigley's Mechanical Engineering Design, 10th edition, McGraw–Hill Education, 2014.
2.	Robert L.Norton, Machine Design – An Integrated Approach, 5th edition, Pearson Higher Education, 2014.
Reference Books	
1.	Juvinal, R.C and Kurt M.Marshek, Machine component design, John Wiley, 2012.
2.	V.B. Bhandari, Design of Machine elements, 3rd Edition, Tata Mc Graw Hill, 2010.
3.	Design Data, PSG College of Technology, DPV Printers, Coimbatore, 2010.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar			
Mode of assessment:			
Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	47	Date	05-10-2017