Academic Program: UG

Academic Year 2019-20

Syllabus

VII & VIII Semester B.E.

Mechanical Engineering

SHRI DHARMASTHALA MANJUNATHESHWARA COLLEGE OF ENGINEERING & TECHNOLOGY,
DHARWAD – 580 002
(An Autonomous Institution recognized by AICTE & Affiliated to VTU, Belagavi)

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SDM College of Engineering & Technology, Dharwad

It is certified that the scheme and syllabus for VII& VIII semester of UG program in Mechanical Engineering is recommended by Board of Studies of Mechanical Engineering Department and approved by the Academic Council, SDM College of Engineering &Technology, Dharwad. This scheme and syllabus will be in force from the academic year 2019-20 till further revision.

Principal Chairman BoS & HoD

SDM College of Engineering & Technology, Dharwad
Department of Mechanical Engineering

College

Vision:
To develop competent professionals with human values.

Mission:
1. To have contextually relevant Curricula.
2. To promote effective Teaching Learning Practices supported by Modern Educational Tools and Techniques.
3. To enhance Research Culture.
4. To involve Industrial Expertise for connecting classroom content to real life situations.
5. To inculcate Ethics and impart soft-skills leading to overall Personality Development.

SDMCET- Quality Policy
- In its quest to be a role model institution, committed to meet or exceed the utmost interest of all the stake holders.

SDMCET- Core Values
- Competency
- Commitment
- Equity
- Team work and
- Trust

Department

Vision:

To establish a synergetic Mechanical Engineering program anchored in fundamentals and relevant state of the art technologies, thereby enabling the students to achieve all round development for careers in industry and for higher learning, being responsible to society and environment.

Mission:

1. To establish a curricula & syllabi consisting of robust core courses with emphasis on imparting fundamental principles of mechanical engineering coupled with adaptive and relevant electives catering to the cutting edge technologies.
2. To promote interactive teaching practices using modern educational tools & techniques to attain synergy in teaching, research and industrial practices.
3. To imbibe industrial expertise for connecting class room learning to real life situation.
4. To impart soft skills and professional ethics enabling students to achieve an all-round personality development, making them responsive to societal needs and environmental concerns.

Programme Educational Objectives (PEOs):

1. Graduates will be successful in industry, research and higher learning.
2. Graduates will formulate, analyze and solve engineering problems.
3. Graduates will work in teams to address industrial and socially relevant problems / projects.
4. Graduates exhibit awareness and commitment to lifelong learning & practice professional ethics.

Program Outcomes (POs)

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

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

Program Specific Outcomes (PSOs)

13. **Industrial interactions:** Enhance knowledge of mechanical engineering with industrial practices and standards by exposure to industries.

14. **Role of economics and costing:** Learn the concepts of economics and costing to provide effective solutions to mechanical engineering problems.

VII Semester

Course code	Course title	Teaching		Examination				
		L-T-P (Hrs/week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
				Max. Marks	*Max Marks	Duration in hours	Max. Marks	Duration in hours
15UMEC700	Mechanical Vibrations	3-2-0	4	50	100	3	-	-
15UMEC701	Hydraulics & Pneumatics	4-0-0	4	50	100	3	-	-
15UMEC702	Operation Research & Optimization Techniques	3-2-0	4	50	100	3	-	-
15UMEL703	Dynamics Lab	0-0-2	1	50	-	-	50	3
15UMEL704	Project – Phase 1	0-0-8	4	50	-	-	50	3
15UMEEXXX	Elective – 5	4-0-0	4	50	100	3	-	-
15UMEEXXX	Elective – 6	4-0-0	4	50	100	3	-	-
	Total	18-4-10	25	350	500	-	100	-

CIE: Continuous Internal Evaluation SEE: Semester End Examination L: Lecture T: Tutorials P: Practical *SEE for theory courses is conducted for 100 marks and reduced to 50 marks

Electives

Course code	Course title
15UMEE725	Non-conventional Energy Sources
15UMEE726	Total Quality Management
15UMEE727	Computer Integrated Manufacturing
15UMEE728	Computational Fluid Dynamics
15UMEE729	Experimental Stress Analysis
15UMEE730	Synthesis of Mechanisms
15UMEE731	Power Plant Engineering
15UMEE732	Value Engineering
15UMEE733	Introduction to Aircraft Industry & Aircraft Systems*****
15UMEE734	Project Management

*** Interdisciplinary elective open for all Engineering Departments**

CIE: Continuous Internal Evaluation **SEE**: Semester End Examination
L: Lecture **T**: Tutorials **P**: Practical
*SEE for theory courses is conducted for 100 marks and reduced to 50 marks.

VIII Semester

Course Code	Course Title	Teaching		Examination				
		L-T-P(Hrs/Week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
				Max. Marks	*Max. Marks	Duration in hours	Max. Marks	Duration In hours
15UMEC800	Control Engineering	3-2-0	4	50	100	3	-	-
15UMEC801	Mechatronics	4-0-0	4	50	100	3	-	-
15UMEL802	Seminar	0-0-4	2	50	-	-	-	-
15UMEL803	Project – Phase 2	0-0-16	8	50	-	-	50	3
15UMEEXXX	Elective – 7	4-0-0	4	50	100	3	-	-
15UMEEXXX	Elective – 8	4-0-0	4	50	100	3	-	-
	Total	15-2-20	26	300	400	-	50	-

CIE: Continuous Internal Evaluation SEE: Semester End Examination L: Lecture T: Tutorials P: Practical

*SEE for theory courses is conducted for 100 marks and reduced to 50 marks

Electives

Course Code	Course Title
15UMEE825	Design of Heat Exchangers
15UMEE826	Machine Tool Design
15UMEE827	Energy Management
15UMEE828	Cryogenics
15UMEE829	Fracture Mechanics
15UMEE830	Industrial Robotics
15UMEE831	Automotive Engineering
15UMEE832	Design of Aircraft Structures*
15UMEE833	Advanced Finite Elements Method

* Inter disciplinary elective open for all Engineering Departments

CIE: Continuous Internal Evaluation **SEE**: Semester End Examination
L: Lecture **T**: Tutorials **P**: Practical
*SEE for theory courses is conducted for 100 marks and reduced to 50 marks.

Note:
Interdisciplinary Elective open for all Engineering Branches:
Applied Numerical Methods (VIII Sem)
For detailed syllabus contact HOD of Mathematics department
Nano Technology (VIII Sem)
For detailed syllabus contact HOD of Physics department

VII Semester

15UMEC700	Mechanical Vibrations	(3-2-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Concepts and types of vibrations.
2. Natural frequencies of physical problems.
3. Vibration transmission and methods to reduce vibrations.
4. Numerical methods to solve multi degree systems.

Course outcomes (COs):

ID	Description of the course outcome: At the end of the course the student will be able to:	Mapping to POs (1-12)/PSO (13-14)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Explain basic concepts and terms in mechanical vibration.	-	-	1
CO-2	Derive mathematical model using Newton's and energy methods for one and two degree of freedom mechanical systems.	1	2	3
CO-3	Determine natural frequency of multi-degree freedom systems using numerical methods.	1,2,5	4	-
CO-4	Formulate mathematical relations for over damped, critical damped and under damped systems.	1,2	3	-
CO-5	Evaluate the performance parameters of single degree of freedom systems under forced vibrations.	4	-	-
CO-6	Describe the working of instruments used in vibration measurement.	1	-	-

POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
Mapping Level	2.2	2.7	1.7	2.5	3	-	-	-	-	-	-	-	-	-

Pre requisites: Engineering Mathematics, Engineering Mechanics.

Course Contents:

1. **Fundamental of Vibrations:** Types, Causes, Effects, Terms in Vibration, Simple Harmonic Motion, Representation of SHM, Combination of SHM, Beats, Fourier series. **6 Hrs**

2. **Single Degree Freedom System: (**Undamped) Natural Frequency, Equivalent System, Parallel Springs, Series Springs, Inclined Springs, Geared System. Energy Method-Energy Principle, Principle of Conservation of Energy, Maximum Energy Principle. **6 Hrs**

3. **Single Degree Freedom System: (**Damped) Damping Models- Viscous Damping, Structural Damping, Coulomb Damping Single Degree Freedom System with Damping- Over Damped, Under Damped, Critically Damped, Logarithmic Decrement. **5L+2T Hrs**

4. **Single Degree Freedom System – Forced Vibrations:** Forced Vibrations with constant Excitation – Steady State Vibrations, Forced Vibrations with Rotating and Reciprocating unbalance, Forced Vibration due to base excitation, Critical Speed of shaft. **4L+2T Hrs**

5. **Two Degree Freedom System:** Free Vibration of spring Coupled system, Principle mode of vibrations, combined rectilinear and angular modes, Vibration Absorbers, Forced Damped Vibrations. **4L+2T Hrs**

6. **Continuous System:** Vibration of String, Longitudinal Vibration of Bars Lateral Vibration of beams. **5 Hrs**

7. **Numerical Methods:** Holzer Method, matrix method & matrix iteration method. **7L+4T Hrs**

8. **Experimental Methods in Mechanical Vibrations:** Vibrometers, Accelerometers, Frequency Measuring Instruments, FFT Analyzer. **5 Hrs**

Reference Books:

1. S.S.Rao, Mechanical Vibrations, 4th Edition, Pearson Publications, 2009
2. Graham Kelly, Fundamentals of Mechanical Vibrations, 2nd Edition, Mac-Graw Hill Publications, 2000.
3. G K Grover, Mechanical Vibrations, TATA Mac-Graw Hill Publications
4. Seto, Mechanical Vibration, Schaum series publication TATA Mac-Graw Hill Publications
5. Kelly S.G, Mechanical Vibrations, Mac-Graw Hill, 2014

15UMEC701	Hydraulics & Pneumatics	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

Types of Hydraulic power actuators, motors and concepts of circuit design.

1. Maintenance of hydraulics systems.
2. Actuators, valves, control signal processing elements and multi cylinder applications.

Course outcomes (COs):

ID	Description of the course outcome: At the end of the course the student will be able to:	Mapping to POs (1-12)/PSO (13-14)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	List various hydraulic components and explain the need of them in automation systems.	1	--	--
CO-2	Explain the construction and working of Positive displacement pumps and motors in hydraulic systems.	1	4	-
CO-3	Discuss different control components used in Hydraulic and Pneumatic systems.	1	4	--
CO-4	Design hydraulic circuits with various hydraulic components for mechanical applications.	1,2	3	--
CO-5	Design pneumatic circuits with various pneumatic components for pneumatic and electro-pneumatic applications	1,2	3	--
CO-6	Explain the various trouble shooting methods for hydraulic and pneumatic systems	1	4	--

POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
Mapping Level	3	3	2	2	-	-	-	-	-	-	-	-	-	-

Pre requisites: Fluid mechanics, Engineering mathematics, Basic Electrical and Electronics.

Course Contents:

1. **Introduction to Fluid Power:** Hydraulic system Components, Pneumatics system components, advantages, applications in the field of M/c tools, material handling, hydraulic presses, mobile & stationary machines, Pascal's Law and its application, Problems on Pascal's Law, Types of Hydraulic fluid petroleum based, synthetic & water based. Properties of fluids. Selection of fluids ISO Symbols for hydraulic & pneumatic circuits. **6Hrs**

2. **The Source of Hydraulic power:** Pumping theory, Classification, Principle of working and constructional details of Gear Pump, Vane Pump, Axial and Radial Piston Pumps, Variable displacement Pumps, Power and Efficiency calculations, Pump Selection for hydraulic power transmission. **6 Hrs**

3. **Hydraulic Actuators and Motors:**Classification cylinder and hydraulic motors, Linear Hydraulic Actuators [cylinders], single and double acting cylinder, Mechanics of Hydraulic Cylinder Loading, mounting arrangements, cushioning, special types of cylinders, problems on cylinders, construction and working of rotary actuators such as gear, vane, piston motors, Hydraulic Motor Theoretical Torque, Power and Flow Rate, Hydraulic Motor Performance, problems, symbolic representation of hydraulic actuators (cylinders and motors) **8 Hrs**

4. **Control Components in fluid power:**

   PRESSURE CONTROL VALVES: Necessity of pressure control directional control, flow control valves, Principle of pressure control valves, direct operated, pilot operated, relief valves pressure reducing valve, sequence valve & methods of actuation of valves.

   FLOW CONTROL VALVES: Principle of operation, pressure compensated, temp. Compensated flow control valves,

   DIRECTION CONTROL VALVES: Check valves, types of D.C. Valves : Two way two position, four way three position, four way two position valves, open center, close center tandem center valves, method of actuation of valves, manually operated solenoid operated, pilot operated etc. **8 Hrs**

5. **Hydraulic Circuit Design and Analysis:**

   Control of Single and Double -Acting Hydraulic Cylinder, Regenerative circuit, Pump Unloading Circuit, Double Pump Hydraulic System, Counter balance Valve Application, Hydraulic Cylinder Sequencing Circuits, Automatic cylinder reciprocating system, Locked Cylinder using Pilot check Valve, Cylinder synchronizing circuit using different methods, factors affecting synchronization, Hydraulic circuit for force multiplication, Speed Control of Hydraulic Cylinder, Speed Control of Hydraulic Motors, Safety circuit, Accumulators, types, construction and applications with circuits. **8 Hrs**

6. **Basic Pneumatic control and Electropneumatics:** Physical properties in pneumatics, DC valves, linear and rotary actuators, flow control valves, pneumatic symbols and control element description, Symbols, Impulse operation, Speed control, sequencing of motion, vacuum

handling.Introduction, actuating magnets, construction of electromagnet, contactors and switches, relays, limit switch, electropneumatic circuits, single acting and double acting cylinder control examples. **10 Hrs**

7. **Maintenance and Troubleshooting:** Maintenance need of pneumatic systems, common problems in pneumatic systems, maintenance schedule of pneumatic system, trouble shooting and maintenance tips. **6 Hrs**

Reference Books:

1. Anthony Esposito, “Fluid Power with applications” 6th edition, PHI, 2009
2. S R Majumdar, “Pneumatic systems, Tata McGraw Hill New Delhi, 2010
3. F Don Norvelle “Fluid Power Technology” West Publishing Company, Minneapolis 1995
4. S R Majumdar, “Oil hydraulic systems” PHI, 2010

15UMEC702 Operations Research and Optimization Techniques (3-2-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

Modeling, solving and analyzing the problems using linear programming with emphasis on theory and applications.

1. Mathematical tools that are needed to solve optimization problems.

Course outcomes (COs):

ID	Description of the course outcome: At the end of the course the student will be able to:	Mapping to POs(1-12) & PSO (13-14)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Formulate real-world problems as mathematical linear programming model.	1, 2	4	-
CO-2	Compute optimal solutions to various linear programming problems by graphical and iterative methods.	1, 2	3, 4	-
CO-3	Construct appropriate models for queuing systems and competitive situations &solve problems.	1, 2	3	4
CO-4	Estimate minimum elapsed time using Jonson's algorithm and graphical methods for sequencing of jobs.	1, 3	2	-
CO-5	Predict the presence of uncertainty in real life projects & determine critical parameters.	2	-	1
CO-6	Identify the significance of integer programming and obtain the optimum solutions.	1, 2	3	-

POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
Mapping Level	2.7	2.4	2.5	1.6	-	-	-	-	-	-	-	-	-	-

Pre requisites: Basic Algebra, Statistics, Portability distributions

Course contents:

1. **Introduction:** Linear programming, Definition, scope of Operations Research (O.R) approach and limitations of OR Models, Characteristics and phases of OR Mathematical formulation of L.P. Problems. Graphical solution methods.

4 Hrs

2. **Linear Programming Problems:** The simplex method - slack, surplus and artificial variables, degeneracy and procedure for resolving degenerate

cases,artificial variables techniques, special cases, concept of duality, dual simplex method. **6L+2T Hrs**

3. **Transportation Problem:** Formulation of transportation model, Basic feasible solution using different methods, Optimality Methods, Unbalanced transportation problem, Degeneracy in transportation problems, Applications of Transportation problems. Assignment Problem: Formulation, unbalanced assignment problem, Traveling salesman problem. **6L+2T Hrs**
4. **Sequencing:** Johnson's algorithm, n - jobs to 2 machines, n jobs 3 machines, n jobs m machines without passing sequence. 2 jobs n machines with passing. Graphical solution. **6L+2T Hrs**
5. **Queuing Theory:** Queuing system and their characteristics. The M/M/1 Queuing system, Steady state performance analysing of M/M/ 1 and M/M/C queuing model. **4 Hrs**
6. **PERT-CPM Techniques:** Network construction, determining critical path, floats, scheduling by network, project duration, variance under probabilistic models, prediction of date of completion, crashing of simple networks. **6L+2T Hrs**
7. **Game Theory:** Formulation of games, two person-Zero sum game, games with and without saddle point, Graphical solution (2x n, m x 2 game), dominance property, method of sub-groups. **6 Hrs**
8. **Integer programming:** Gommory's technique, branch and bound logarithm for integer programming problems, zero one algorithm. **6 Hrs**

Reference Books:

1. Taha H. A, Operation Operations Research and Introduction, 9th edition, Pearson Education, 2014
2. S. D. Sharma, Operations Research, Kedarnath Ramnath & Co 2002.
3. Prem Kumar Gupta, D S Hira, Operations Research, S Chand Pub, New Delhi, 2007
4. Hiller and Lieberman, Introduction to operation research, 5th edition, McGraw Hill, 2001

15UMEL703	Dynamics Lab	(0-0-2) 1

Contact Hours: 26

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Balancing of rotating masses whirling of shafts, SDOF systems Concept of governors and their characteristics.
2. Principles of strain gauges and photo elasticity.
3. Importance of Pressure distribution around journal bearing.
4. Effect of unbalance in machinery & method of balancing of rotary and reciprocating forces.
5. Concept of gyroscope and gyroscopic effect in automobiles. Aero planes & ships.

Course outcomes (COs):

ID	Description of the course outcome: At the end of the course the student will be able to:	Mapping to POs (1-12)/PSO (13-14)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Balance rotating masses in single plane and multi planes.	1	2	-
CO-2	Conduct the experiment on gyroscope to verify gyroscope equation.	-	1,2	4
CO-3	Conduct the experiments using strain gauges and photo elastic bench to compute stresses and strains.	-	-	4
CO-4	Compare and determine the natural frequency in single degree freedom damped, undamped and torsional vibration systems and also in whirling of shafts.	1,2,3	-	9
CO-5	Analyse for forces in simple mechanisms using ADAMS software.	5	-	12
CO-6	Evaluate the performance of governors and comment on the stability of the governors.	-	1,2	10

POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
Mapping Level	2.5	2.3	3	1	3	-	-	-	1	1	-	1	-	-

Pre requisites: Theory of machines, Engineering Mechanics.

Part A

Course Contents:

1. Experiments on Balancing of Rotating masses in single and multiple planes.
2. Experiments on Porter Governors.
3. Experiments on Pressure distribution in Journal Bearing.
4. Experiments on Whirling of shafts.
5. Experiments on single degree vibrating systems.
6. Experiments on strain gauges.
7. Experiments on Photoelastic bench.
8. Experiments on Gyroscope.

PART B (dynamic simulation lab – Any two of the below)

Software used: MSC-ADAMS (Adams-View)

1. Modeling of crank-rocker, double lever and crank-crank mechanisms using Grashoffs law.
2. Kinematic analysis of slider crank mechanism.- 1 exercise
3. Kinematic analysis of four bar mechanism.- 1 exercise.
4. Static force analysis of slider crank mechanism – 2 exercises.
5. Static force analysis of four bar mechanism – 1 exercise.
6. Dynamic force analysis of slider crank mechanism – 1 exercise.
7. Dynamic force analysis of four bar mechanism – 1 exercise.
8. Modeling of single DOF spring mass system.
9. Modeling of multi DOF spring mass system.

Reference Books

1. Rattan S S -Theory of Machines; 2nd Edition, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2006.
2. Shigley and Uicker, Theory of Machines and Mechanisms, International edition, McGraw Hill.
3. Adams multi body dynamics tutorials.
4. Dynamic simulation lab manual.

15UMEL704	Project Phase – 1	(0-0-8) 4

Contact Hours: 60

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Practical significance of projects.
2. Engineering concepts and its application to real world problems.
3. Manufacturing problems associated with fabrication.
4. Creativity as an essential component of engineering application.

Course outcomes (COs):

ID	Description of the course outcome: At the end of the course the student will be able to:	Mapping to POs (1-12)/PSO (13-14)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Identify, formulate and solve a problem using basic engineering principles.	1,2	4	1,2
CO-2	Recognize the need and able to design and fabricate the machine parts, components of a system that meets particular requirement.	3	7	6,12
CO-3	Use the software tools to prepare and analyze models or prototypes and conduct simulation using it.	5, 13	2	-
CO-4	Use the machine tools to prepare models or prototypes.	5, 13	2	-
CO-5	Work in teams and communicate effectively for completion of projects in time.	10	8,11,12	-
CO-6	Prepare a report based on their project and present the concept using ppt.	13, 14	9,10,11	-

POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
Mapping Level	3	2.4	3	2	3	1	2	2	2	2.5	2	1.5	3	3

Pre requisites: Relevant discipline knowledge.

The student will take up a project in consultation with a guide of his choice in thrust areas of **Mechanical Engineering**. This project will be continued as **Phase II** in VIII semester. The evaluation will be made as per the departmental recommendation and guidelines.

Note: Activities/Topics for self-study to be decided by the guide.

15UMEE725	Non-conventional Energy Sources	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Principles of energy sources.
2. Performance of energy analysis and basic mechanism of energy transfer such as solar wind biomass and hydrogen energy.
3. Multidimensionality and dependence of variables on performance parameter.
4. Thermal conditions on surfaces and obtain mathematical relations such as temperature efficiency storage COP.

Course outcomes (COs):

ID	Description of the course outcome: At the end of the course the student will be able to:	Mapping to POs (1-12)/PSO (13-14)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Explainconcepts of non-conventional and renewable energy systems, solar instruments and solar radiation geometry.	1	-	7
CO-2	Compute solar geometrical angles, solar hourly radiations on horizontal surface, and power from wind machines	1	2	-
CO-3	Compute performance parameters of liquid flat plate collector and solar flux on inclined surface	1	2	-
CO-4	Explain the working of solar thermal devices, solar power generation, solar refrigeration and solar pond	1	-	7
CO-5	Explain the working principles of photovoltaics , wind machines and their characteristics	1	-	7
CO-6	Describe the working of biomass gasification and biogas generationand hydrogen energy production storage with applications.	1	-	7

PO s	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
Mapping Level	3	2	-	-	-	-	1	-	-	-	-	-	-	-

Pre requisites: Basic Thermodynamics, Heat Transfer, Fluid mechanics, Engineering mathematics.

Course Contents:

1. **Introduction:** Energy sources, India's production and reserves of commercial energy sources, need for non-conventional energy sources, energy alternatives, solar, thermal, photovoltaic, water power, wind, bio-mass, ocean temperature difference, tidal and waves, geothermal, tar sands and oil shale, nuclear (Brief descriptions). **5 Hrs**

2. **Solar Radiation:** Extra-Terrestrial radiation, spectral distribution of extra-terrestrial radiation, solar constant, solar radiation at the earth's surface, beam, diffuses and global radiation, solar radiation data. Measurement of Solar Radiation: Pyranometer, shading ring pyrheliometer, sunshine recorder, schematic diagrams and principle of working. **4 Hrs**

3. **Solar Radiation Geometry:** Flux on plane surface, latitude, declination angle, surface azimuth angle, hour angle, zenith angle, solar altitude angle, expression for the angle between the incident beam and normal to plane surface (no derivation) local apparent time. Apparent motion of sun, day length, numerical examples. **3 Hrs**

4. **Radiation Flux on A Titled Surface:** Beam, diffuse and reflected radiation, expression for flux on a titled surface (no derivations) numerical examples. **4 Hrs**

5. **Solar Thermal Conversion:** Collection and storage, thermal collection devices, liquid flat plate collectors, solar air heaters, concentrating collectors (cylindrical, parabolic, paraboloid) sensible heat storage, latent heat storage, application of solar energy water heating. Space heating and cooling; active and passive systems, power generation, and refrigeration.Distillation, solar cooker, solar pond, principle of working, operational problems. **7 Hrs**

6. **Performance Analysis of Liquid Flat Plate Collectors:** General description, collector geometry, selective surface (qualitative discussion), basic energy-balance equation, stagnation temperature, transmissivity of the cover system, transmissivity, absorptivity product, numerical examples. The overall loss coefficient, problems (all correlation to be provided). Temperature distribution between the collector tubes, collector heat removal factor, collector efficiency factor and mean plate temperature, instantaneous efficiency (all expressions to be provided). Effect of various parameters on the collector performance: collector orientation, selective surface, fluid inlet temperature, number covers, dust. **5 Hrs**

7. **Photovoltaic Conversion:** Description, principle of working and characteristics, types of PV cells and applications. **3 Hrs**

8. **Wind Energy:** Availability of wind energy in India, Power from wind; Site selection, wind machines; Types of wind machines and their characteristic, horizontal and vertical axis wind mills, elementary design principles; coefficient of performance of wind mill rotor, aerodynamic considerations of wind mill design, numerical examples. **7 Hrs**

9. **Energy from biomass: Biochemical route** – Biogas generation, factors, types of biogas plants and **thermo chemical route** .updraft, down draft and cross draft gasifier. **9 Hrs**

10. **Hydrogen Energy:** Production, storage and application. **5 Hrs**

Reference Books:

1. S.P.Sukatme 'Solar Energy' – TATA McGraw Hill, 1996
2. G.D.Rai 'Non-Conventional Energy Sources' 4th edition, Khanna Publishers, New Delhi, Dec 2011
3. Kreith&Goswami, Solar Energy, Taylor & Francis 1999

15UMEE726	Total Quality Management	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Theoretical concepts of Total Quality Management.
2. Importance of application of Total Quality management philosophy and concepts.
3. Analytical skills associated with the usage of tools and techniques of Total Quality Management.
4. Principles of experimental design.

Course outcomes (COs):

ID	Description of the course outcome: At the end of the course the student will be able to:	Mapping to POs(1-12) & PSO (13-14)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO1	List out the basic tools of quality control and experimental design	-	1,2	-
CO2	Describe scientific techniques and tools of total quality management	3	-	-
CO3	Demonstrate practical knowledge through case studies.	-	2	-
CO4	Formulate and solve engineering problems using experimental design and modern engineering tools	4	-	-
CO5	Construct the control charts and interpret to facilitate quality control	-	4	-
CO 6	Differentiate between Taguchi and Deming's philosophy of quality engineering	-	1	-

POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
Mapping Level	2	2	3	2.5	-	-	-	-	-	-	-	-	-	-

Pre requisites: Statistical Quality Control.

Course Contents:

1. **Overview of Total Quality Management:** Introduction – Definition, Basic Approach, Contribution of Gurus – Total Quality Management, TQM frame work, Historical Review, Benefits of TQM. **4 Hrs**

2. **Deming's Philosophy:** Customers' satisfaction, Customers' perception, using Customers complaints, Feedback, Employee involvement, Role of

Motivation, Suggestion system, Continuous Process Improvement- Juran's Trilogy PDSA Cycle, Problem solving methods, Imai's Kaizen. **10 Hrs**

3. **Tool & Techniques of TQM: Bench marking, Definition, Process of** bench marking, Quality Management Systems, Reengineering, six sigma ISO – 9000 series of standards, cases. **10 Hrs**

4. **Introduction to QFD & QFD** process, FMEA (Failure Mode and effect Analysis), Design FMEA and Process FMEA studies, Cases. **10 Hrs**

5. **Basic tools of quality control,** Control charts for variables, Construction, interpretation, Analysis using x –R control charts, Process capability estimation, Process capability indices, process improvement through problem analysis (Intensive coverage with numerical problems), Control charts for attributes, cases. **8 Hrs**

6. **Experimental Design:** One factor designs, two factor designs, Orthogonal design, Full factorial and factional factorial design, Taguchi's Philsophy of quality engineering, Loss function, Orthogonal array, Signal to noise ratio, Parameter design, Tolerance design (Basic Conceptual Treatment only), Cases. **10 Hrs**

Reference Books:

1. Douglos C. 'Statistical Quality Control' Mantego Mary, 2000
2. K. ShridharaBhat, Total Quality Management Texts cases, Himalaya Publishing House, 2010
3. P. L. Jain, Quality Control and Total Quality Management, Tata McGraw hill Publishing Co. Ltd., New Delhi 2001
4. Shoji Shiba, Alan Graham & David Walden, A New Amercian TQM – Four Practical Revolutions in Management, Productivity Press, Portland (USA) 2000.

15UMEE727	Computer Integrated Manufacturing	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Basics of Computer Integrated Manufacturing.
2. Automated assembly system.
3. Latest computerized manufacturing practices.
4. Shop floor control & quality.

Course outcomes (COs):

ID	Description of the course outcome: At the end of the course the student will be able to:	Mapping to POs (1-12)/PSO (13-14)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Explain the basic concepts of automation, flow lines, line balancingand high volume production systems.	1	2	-
CO-2	Analyze different Automated Assembly systems, Computerized Manufacturing & Planning Systems.	1	2	-
CO-3	Describe shop floor control systems in a factory environment with Automatic Identification System	1	2	-
CO-4	Analyze High volume production system, Automated Flow Line and line balancing in automation for production capacity and lead time.	1,2	-	-

Pos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
Mapping level	3	2.3	-	-	-	-	-	-	-	-	-	-	-	-

Pre requisites: CAD/ CAM, engineering mathematics.

Course Contents:

1. **Computer Integrated Manufacturing System:** Introduction, Types of Automation, Production concepts, Mathematical Models, Automation Strategies (Numerical). **6 Hrs**

2. **High Volume Production System:** Automated FLOW lines, Work Part Transport Mechanism, Buffer Storage (Numerical). **6 Hrs**

3. **Analysis of Automated Flow Line and line balancing:** Analysis of Transfer Lines without storage and with storage, Partial automation, Manual Assembly Lines, Methods of line balancing, Computerized line balancing (Numerical) **10 Hrs**

4. **Automated Assembly System:** Types, Parts feeding Devices, Analysis of single station assembly machine, Analysis of multi station assembly machine, automated material handling system, Automated guided vehicle system. **10 Hrs**

5. **Computerized Manufacturing Planning System:** Computer Aided Process Planning: Retrieval Type, Generative type. Material Requirement Planning, Fundamental concepts of MRP, Inputs to MRP, Capacitive Planning. **10 Hrs**

6. **Shop Floor Control:** Factory Data Collection System, Automatic Identification System. **6 Hrs**

7. **Computer Aided Quality Control:** Contact inspection methods, Non-contact inspection methods, Co-ordinate Measuring Machine. **4 Hrs**

Reference Books:

1. Mikell O. Groover, Automation, Production system and Computer Integrated Manufacturing, 3rd edition, PHI, New Delhi, 2010.

2. CAD/CAM by Mikell O. Groover, PHI, New Delhi, 2003

3. Zeid, CAD/CAM, 2nd edition, Tata McGraw Hill, 2010.

15UMEE728 Computational Fluid Dynamics (4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Governing equations of fluid flow
2. Methods of discretizing the governing equations.
3. Methods of solving discretized equations.
4. Fluid flow problems and solutions using commercial package.

Course outcomes (COs):

ID	Description of the course outcome: At the end of the course the student will be able to:	Mapping to POs (1-12)/PSO (13-14)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Explain the need, advantages and disadvantages and steps involved in CFD.	1	-	-
CO-2	Derive governing equations of fluid flow and explain the scope and applicability of such equations.	1	-	-
CO-3	Discretize governing equations of fluid flow using finite difference/finite volume method.	1	-	-
CO-4	Explain Maccormach's and SIMPLE Scheme of solving fluid flow problems.	1	-	-
CO-5	Solve set of algebraic equation using Thomas Algorithm, Jacobi or Gauss Siedel method.	1	-	-
CO-6	Use commercial software to solve simple flow problems.	-	5	9,12

POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
Mapping Level	3	-	-	-	2	-	-	-	1	-	-	1	-	-

Pre requisites: Fluid mechanics, Engineering mathematics, Numerical methods.

Course Contents:

1. **Introduction** to Computational Fluid Dynamics, Advantages, limitations and applications. **2 Hrs**
2. **CFD solution procedure**: Preprocessing, solving and post processing. **5 Hrs**
3. **Governing equations** for CFD-Continuity equation, momentum equation, Energy equation, physical boundary conditions, Introduction to Turbulence and *k-ε* turbulence model. **12 Hrs**

4. **Classification** of partial differential equations, general behavior of different classes of partial differential equations, well posed problems. **3 Hrs**
5. **CFD techniques:** Discretisation of governing equations, FDM, FVM, converting governing equations to algebraic equation system, implicit and explicit approaches, numerical solution of algebraic equations, direct and iterative methods, Thomas algorithm, Jacobi and Gauss-Siedel methods, Central difference and upwind schemes applied to 1-D situation involving convection and diffusion terms, Maccormack's technique applied to unsteady 2-D inviscid flow, pressure velocity coupling (SIMPLE scheme applied to incompressible viscous flow). **18 Hrs**
6. **CFD solution analysis:** Consistency, stability, convergence, accuracy and efficiency, sources of solution errors, verification and validation. **3 Hrs**
7. **Practical guidelines** for CFD simulation and Analysis: Guidelines on grid generation, Guidelines on boundary conditions **4 Hrs**
8. **Applications:** Indoor air flow distribution, heat transfer coupled with fluid flow (heat exchanger) **5 Hrs**

Reference Books:

1. JiyuanTu, Guan HengYeoh, and Chaoqun Liu, Computational Fluid Dynamics: A Practical Approach, Butterworth-Heinemann, 2008
2. Anderson, J.D.Jr., Computational Fluid Dynamics, The Basics with Applications, McGraw-Hill, New York, 1995
3. Suhas V. Patankar, Numerical Heat Transfer and Fluid Flow, Taylor & Francis, 2012
4. J.C. Tannehill, D.A. Anderson and R.H. Pletcher, Computational Fluid Mechanics and Heat Transfer, 2nd Edition, Taylor & Francis, 1997

15UMEE729 Experiment Stress Analysis (4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Stresses, strains, equilibrium and photo elastic analysis.
2. Stress separation holographic applications.
3. Solution of problems in plane stress, plane strain, torsion and bending using strain gauges.
4. Strain gauges, mounting techniques, coating techniques and recording.

Course outcomes (COs):

ID	Description of the course outcome: At the end of the course the student will be able to:	Mapping to POs (1-12)/PSO (13-14)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Explain concepts and methods of experimental stress analysis	1	-	-
CO-2	Explain theory of birefrengent coatings, sensitivity methods of separation of principal stresses, and principles of holography.	1	-	-
CO-3	Explain principle of brittle coating method and derive relation between state of stress in coating & that in the model	1	-	-
CO-4	Explain crack detection techniques & calibration procedure of brittle materials	1	-	-
CO-5	Explain theory & procedure of measuring strain using electrical strain gauges, including mounting technique.	1	-	-
CO-6	Analyse strain gauge data	1	-	4

POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
Mapping Level	3	-	-	1	-	-	-	-	-	-	-	-	-	-

Pre requisites: Engineering Mathematics, Engineering Physics, Theory of Elasticity.

Course Contents:

1. **Theory of photo elasticity:** Temporary double refraction, stress optic law, effect of Stressed model in a plane polariscope, fringe multiplication. **7 Hrs**
2. **Two dimensional photo-elasticity:** Isochromatic fringe patterns, isoclinic fringe patterns. **7 Hrs**
3. **Compensation techniques,** calibration methods, separation method. **6 Hrs**

4. **Birefrengent coatings:** Coating stresses and strains, sensitivity, application, effect of thickness. **7 Hrs**
5. **Stress separation, holographic applications. 6 Hrs**
6. **Brittle coatings methods:** Coating stress, brittle coating crack patterns, crack detection, test procedures, calibration procedures and analysis of data. **6 Hrs**
7. **Strain measurements methods:** Electrical resistance strain gauges, semiconductors strain gauges, strain gauge circuits. **7 Hrs**
8. **Recording instruments,** analysis of strain gauge data, mounting techniques **6 Hrs**

Reference Books:

1. James Dalley and William Ralley, Experimental stress analysis, McGraw Hill Publishers 1978
2. L.S.Srinath and others, Experimental stress analysis, TMH 1980
3. Sadhu Singh, Experimental stress Analysis, 4^{th} edition, Khanna Publishers, 2010

15UMEE730 Synthesis of Mechanisms (4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Synthesis of mechanisms deals with the theory of synthesis, linkages complex algebra mechanisms function generation.
2. Path generation and body guidance.
3. Basis for synthesis of slider crank and four bar mechanism study of transmission angle coupler curve and dwell mechanisms is made.

Course outcomes (COs):

ID	Description of the course outcome: At the end of the course the student will be able to:	Mapping to POs (1-12)/PSO (13-14)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Demonstrate the knowledge of type synthesis, number synthesis and dimension synthesis that satisfy the required function generation, path generation and body guidance and dwell in designing four bar mechanisms.	1	6	-
CO-2	Describe the positional synthesis by either 2 or 3 or 4 positions of the linkages to decide the sizes that satisfy the desired function of the mechanism,	4	1	2
CO-3	Determine the structural errors to realize the mechanism using chebychev spacing	3	1	2
CO-4	Analyze the four bar mechanism to satisfy function generation using overlay method/coupler curve method	4	5	2
CO-5	Identify cognate linkages in four bar mechanisms by using Robert Chebychev theorem	5	1	2
CO-6	Synthesize 4 bar mechanism to give required values of angular velocities and angular accelerations using Bloch's method / Freudenstein's equation	3	1	5

POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
Mapping Level	2.2	2	3	3	1.5	2	-	-	-	-	-	-	-	-

Pre requisites: Kinematics of machines, Engineering Mathematics

Course Contents:

1. **Introduction:** type, number and dimensional synthesis, function generation, path generation and body guidance. **10 Hrs**

2. **Precision point:** Che-chev spacing, position synthesis of general slider-crank and four bar mechanism with optimum transmission angle. Cognate linkages. **8 Hrs**
3. Three position synthesis, point position reduction, four precision points. **7 Hrs**
4. The Overlay method, Couplar curve synthesis using complex algebra. **7 Hrs**
5. Bloch's synthesis, Freudenstein's equation, **6 Hrs**
6. Synthesis of dwell mechanisms **6 Hrs**
7. Defects in synthesized mechanisms, solution rectification methods. **8 Hrs**

Reference Books:

1. Erdman and Sridhar Kota, Mechanism design, vol. I, Fourth Edition, Prentice Hall International Publications, 2001
2. NORTON, R.L. Design of Machinery: An Introduction to the Synthesis and Analysis of Mechanisms and Machines, 3rd ed. New York: McGraw-Hill, 2004.
3. NORTON, R.L. Machine Design: An Integrated Approach. 2nd ed. New York: Pearson, 2001.
4. SHIGLEY, J.E. Kinematic Analysis of Mechanisms. 2nd ed. New York: McGraw-Hill, 1969.
5. SHIGLEY, J.E. Dynamic Analysis of Machines. New York: McGraw-Hill, 1961.
6. WALDRON, K. J.; KINZEL, G. L. Kinematics, Dynamics, and Design of Machinery. 2nd ed. Hoboken: Wiley, 2004.

15UMEE731	Power Plant Engineering	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Working of steam power plants used for power generation and their auxiliaries.
2. Disposal of flue gas effluents into the environment.
3. Accessories used in a boiler to enhance efficiency of power generation.
4. Thermal power generation through coal and gas turbines.
5. Hydroelectric plants, Nuclear power plants in comparison with thermal power plants.
6. Waste disposal in Nuclear power plants.
7. Selection of site and economics of power plant.

Course outcomes (COs):

ID	Description of the course outcome: At the end of the course the student will be able to:	Mapping to POs (1-12)/PSO (13-14)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Identify the basic process of energy conversion of conventional and non-conventional energy sources	2	3	1
CO-2	Draw the schematic diagrams for process based steam power plant equipments such as fuel handling, combustion equipment, steam generating and ash handling equipment.	-	1	-
CO-3	Evaluate performance of Rankine and Bryton cycle power plants	-	1	-
CO-4	Evaluate size and heat transfer area of condenser, heat exchangers, cooling towers of thermal power plant		2,3	1
CO-5	Evaluate the cost of power generation and payback period and list the various pollution control strategies in power plant		2	1,14

POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
Mapping level	1.4	2.3	2.5	-	-	-	-	-	-	-	-	-	-	3

Pre requisites: Basic thermodynamics, Heat transfer.

Course Contents:

1. **Introduction to power generation:** Indian energy Scenario, energy resources used for power generation Conventional sources Need for alternatives for power generation. Non-conventional energy sources. **4 Hrs**
2. **Applied thermodynamics of power generation:** Rankine & Bryaton cycle/ Regenration & Reheat power cycle. **4 Hrs**

3. **Conventional power plants: Thermal power plants-**Introduction, Layout of Modern steam power plant, Fuel handling, Combustion equipments, Ash handling, Steam generators. **Gas turbine power plant-** Closed cycle and open cycle plants. **Nuclear Power Plant-** Nuclear fission and chain reaction, types of reactors, PWR, BWR, gas cooled reactor (GCR), Breeder reactor. **Combined Cycles-** steam and gas combined cycle power plant, a combined cycle for Nuclear power plants. Only qualitative discussion. **8 Hrs**
4. **Hydroelectric Power plant** Merits and demerits of water power, Essential elements of a hydroelectric power plant, classification of Hydro-electric power plants. Numericals **4 Hrs**
5. **Non-conventional Power Plants:** Solar power plants, Wind, **Direct energy conversion-** Photovoltaic. **6 Hrs**
6. **Thermal analysis of heat exchanger equipments in power plant:** Boiler condenser, super-heater, economizer, cooling tower calculations. Numerical problems. **12 Hrs**
7. **Economics of Power Generations: Conventional power plant economics-** Load duration curves, Location of Power plants, Power Plant Economics, Coal-Fuelled Electricity Generating Unit. Numerical problems Power plant economics. Numerical problem. **10 Hrs**
8. **Pollution and its control:** Various Pollution from thermal, nuclear power plants and their control strategies. **4 Hrs**

Reference Books:

1. P. K. Nag, Power Plant Engineering, 3rd edition, Tata McGraw Hill Publishing Co. Ltd., New Delhi, 2011
2. S. C. Arora and S. Dumkunadwar, A course in Power plant Engineering, DhanpatRai& Co., (P) Ld., NaiSarak, Delhi 2011.
3. G.D.Rai, Non Conversional Energy Sources, 3rd Edition K, Khanna Publishers, New Delhi. 2003
4. M MEL.Wakil, Power Plant Technology McGraw Hill Book-Coy. New York, 2010
5. R. K. Rajput, A text book of Power Plant Engineering, 4thLaxmi publications (p) Ltd., New Delhi, 2010
6. MOOC & NPTEL material.

15UMEE732	Value Engineering	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Theoretical concepts of value engineering.
2. Importance of application of cost and value.
3. Knowledge and analytical skills associated with the usage of tools and techniques in value engineering.
4. Principles of value engineering in project work and Industries

Course outcomes (COs):

ID	Description of the course outcome: At the end of the course the student will be able to:	Mapping to POs(1-12) & PSO (13-14)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Define concepts in value, costs, value analysis, value engineering and value assurance	-	1	14
CO-2	Employ function – cost matrix, brain storming in cost and value analysis.	-	14	1
CO-3	Specify elements of product cost and cost classification.	-	14	-
CO-4	Formulate product life cycle and value oriented efforts in value tests.	-	2	-
CO-5	Describe the techniques of value engineering, analysis, design tree and decision matrix.	-	2,5	-
CO-6	Apply concepts in purchase price analysis, evaluation of value alternatives and fast diagramming.	-	1,2	-

POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
Mapping Level	1.7	2	-	-	2	-	-	-	-	-	-	-	-	1.7

Pre requisites: Manufacturing Science, Engineering Design.

Course Contents:

1. Introduction concepts in value and costs, value analysis, value engineering and value assurance. **7 Hrs**
2. Product life cycle and value oriented efforts value engineering job plans value tests. **7 Hrs**
3. Techniques of value engineering. Value analysis and decision theory. Design tree and decision matrix. **7 hrs**

4. Purchase price analysis. Evaluation of value alternatives. FAST diagramming. **6 hrs**
5. Function-cost matrix. Matrix evaluation.Brain storming and creativity. **7 hrs**
6. Elements of product cost and cost classification. **6 hrs**
7. Investment criteria in value analysis. **6 hrs**
8. Case studies in value engineering. **6 hrs**

Reference Books:

1. Mudge, Arthur E., Value Engineering, Society of Value Engineers, 1981
2. Del Younker, Value Engineering, CRC, 2003
3. Krishnamurthy, Value Engineering.

15UMEE733 Introduction to Aircraft Industry & Aircraft Systems (4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Theoretical concepts of aircraft industry overview and aircraft systems.
2. Importance of basics of flight and components of an aircraft and different types.
3. Knowledge and analytical skills associated with the understanding of basics of flight mechanics.
4. Principles of flights to build aircraft models and to understand the mechanics of flight.

Course outcomes (COs):

ID	Description of the course outcome: At the end of the course the student will be able to:	Mapping to POs(1-12) & PSO (13-14)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Recognize the Requirements of aircraft industry-manufacturing, supply chain, materials technology & global scenario	1	2	-
CO-2	Explain basic components of aircraft & structural members, axis motion, and design configurations	1,3	9	-
CO-3	Explain different systems of aircraft.	1,4	12	-
CO-4	Analyze basic principles of flight, Influence of air speed, atmosphere, drag & lift.	1,2	3	5
CO-5	Explain aerofoil nomenclature and factors affecting lift & drag	1,2	3	5
CO-6	Explain basics of flight mechanics, mach waves, mach number, stability, power curves, landing & take off speeds, angles of bank	1,3	2	-

POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
mapping level	3	2.5	2.5	3	1	-	-	-	2	-	-	2	-	-

Pre requisites: Engineering Mathematics, Fluid Dynamics, Basic Thermodynamics.

Course Contents:

1. **Aircraft industry overview:** Evolution and History of Flight, Types Of Aerospace Industry, Key Players in Aerospace industry, Aerospace Manufacturing, Industry Supply Chain, Prime contractors, Tier 1 Suppliers, Key challenges in Industry Supply Chain, OEM Supply Chain Strategies, Mergers and Acquisitions, Aerospace Industry Trends, Advances in Engineering/CAD/CAM/CAE Tools and Materials technology, Global and Indian Aircraft Scenario. **11 Hrs**
2. **Introduction to Aircrafts:** Basic components of an Aircraft, Structural members, Aircraft Axis System, Aircraft Motions, Control surfaces and High lift Devices, Types of Aircrafts - Lighter than Air/Heavier than Air Aircrafts Conventional Design Configurations based on Power Plant Location, Wing vertical location, intake location, Tail Unit Arrangements, Landing Gear Arrangements. Unconventional Configurations-Biplane, Variable Sweep, Canard Layout, Twin Boom Layouts, Span loaders, Blended Body Wing Layout, STOL and STOVL Aircraft, Stealth Aircraft. Advantages and disadvantages of these Configurations. **11 Hrs**
3. **Introduction to Aircraft Systems:** Types of Aircraft Systems. Mechanical Systems. Electrical and Electronic Systems. Auxiliary systems. Mechanical Systems: Environmental control systems (ECS), Pneumatic systems, Hydraulic systems, Fuel systems, Landing gear systems, Engine Control Systems, Ice and rain protection systems, Cabin Pressurization and Air Conditioning Systems, Steering and Brakes Systems Auxiliary Power Unit, Electrical systems: Avionics, Flight controls, Autopilot and Flight Management Systems, Navigation Systems, Communication, Information systems, Radar System. **10 Hrs**
4. **Basic Principles of Flight:** Significance of speed of Sound, Air speed and Ground Speed, Properties of Atmosphere, Bernoulli's Equation, Forces on the airplane, Airflow over wing section, Pressure Distribution over a wing section, Generation of Lift, Drag, Pitching moments, Types of Drag, Lift curve, Drag Curve, Lift/Drag Ratio Curve, Factors affecting Lift and Drag, Center of Pressure and its effects. Aerofoil Nomenclature, Types of Aerofoil, Wing Section- Aerodynamic Center, Aspect Ratio, Effects of lift, Drag, speed, Air density on drag. **10 Hrs**
5. **Basics of Flight Mechanics:** Types of Structural members of Fuselage and wing section Ribs, Spars, Frames, Stringers, Longeron, Splices, Stability and Control Degree of Stability- Lateral, Longitudinal and Directional Stability and controls of Aircraft. Effects of Flaps and Slats on Lift Coefficients, Control Tabs, Stalling, Landing, Gliding Turning. **10 Hrs**

The assignments for Electives could include the following,

- Seminars from the topics related to Aerospace Industry
- Report preparation on Aerospace industries which could involve. History and Evolution of major players, the OEM's and in Aerospace and related businesses

Reference Books:

1. A.C Kermode, Flight without Formulae, 10th edition, Pearson Education,
2. A.C Kermode, Mechanics of Flight, 11th edition, Pearson Education, 2009
3. Dave Anderson, Introduction to Flight, Shevell, Fundamentals of Flight, 2nd edition, Pearson Education

15UMEE734	Project Management	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Concepts and different aspects related to projects.
2. Importance of application of different aspects of management of projects.
3. Knowledge of analytical skills associated with techniques of managing projects.

Course outcomes (COs):

ID	Description of the course outcome: At the end of the course the student will be able to:	Mapping to POs(1-12) & PSO (13-14)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Define Project, Project management and Categorize Projects	11	-	1
CO-2	Identify project stakeholders, Project life cycle phases and tools and techniques used in project management	11	-	5
CO-3	Analyze the influence of project organizational structures and on project management.	11	-	-
CO-4	Realize the importance of Contracting and Tendering in project management.	11	-	-
CO-5	Use tools of like Critical Path Method(CPM) and Project Evaluation Review Technique (Pert) to evaluate project time and cost trade- off	11	5,14	1,2
CO-6	Apply the concepts of economics and project finance to estimate project feasibility	11, 14	-	1

POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
Mapping Level	1	1	-	-	1.5	-	-	-	-	-	3	-	-	2.5

Pre requisites: Management and entrepreneurship, Basic mathematics.

Course Contents:

1. **Concepts of Projects /Project Management**: Definition of Projects, Categories, Comparison of Project management with routine management. Overview of project management .Objectives and goals of project. Project stake holders, some tools and techniques used in project management. **8 Hrs**

2. Project management Knowledge areas and Processes. Project phases, Project life cycle, Software development life cycle, Project management processes, Process interactions. **6 Hrs**
3. **Organizing and Staffing:** Roles and responsibilities of project leader, Skills and abilities required. Organizational systems, Line and staff functions, project manager as a staff assistant, as a consultant, as a specialized function in an organization, Matrix organization, Task force organization. Influence of Organizational structures on projects. **7 Hrs**
4. **Contracts**: Need, 3R's of Contracts, Factors affecting number of contracts, Types of re-imbursement. Risk: To the owner and to the contractor. Tendering and selection of contractor sequential steps. **6 Hrs**
5. **Project Design**: Project work system, Work packaging, Work break down structures-examples, advantages. Project execution plan, Systems and procedure plan. **5 Hrs**
6. **Project Time management**: Bar (Gantt)chart, Networks, Types, Critical Path method (CPM), Program Evaluation Review Technique(PERT), construction of network, Estimation of completion time, Computation of slack, Crashing of network. Numerical examples. **10 Hrs**
7. **Estimation of Project Viability**: Project cost elements, Means of Finance, Project cost management, Financial Ratio, Evaluation of profitability: Breakeven Analysis, Pay- back period, Return on Investment, Net Present Value, Benefit cost ratio. Numerical examples. Feasibility report need and contents. **10 Hrs**

References:

1. Patel B 'Project Management' 2nd Edition, 2010
2. S. Choudhary, "Project Management" TMH publication, 2010.
3. A Guide to project Management Project Management Body of Knowledge" Project Management Institute. Published 2012.
4. L.S.Srinath, "PERT & CPM" principles & applications, 3rd Ed., EWP Pvt. Ltd.,2000

VIII Semester

15UMEC800	Control Engineering	(3-2-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Various mathematical models, methods and limitations of physical models and their mathematical equivalents.
2. Transfer functions of various systems such as thermal, hydraulic and pneumatic systems.
3. Transient and steady state analysis for step, ramp, impulse and sinusoidal inputs.
4. RH criterion for system stability.
5. Different types of plots used for analysis of stability of control systems.
6. Types of compensators and controllers.

Course outcomes (COs):

ID	Description of the course outcome: At the end of the course the student will be able to:	Mapping to POs (1-12)/PSO (13-14)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Outline different aspects of control systems.	1	-	-
CO-2	Convert different control systems into mathematical model.	2	4	-
CO-3	Express control systems as block diagrams and signal flow graphs using transfer functions.	2	1	3
CO-4	Determine & Analyze the time responses of control systems to various inputs.	1, 2	4	5
CO-5	Construct various plots for different control system& analyze for stability.	1, 2, 4	3	5
CO-6	Predict the stability & performance of control systems by using various controllers / tools.	3, 4, 5	2	1

POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
Mapping Level	2.4	2.8	2	2.5	1.7	-	-	-	-	-	-	-	-	-

Pre requisites: Engineering Mathematics, Laplace Transforms, Mechanical vibrations.

Course Contents:

1. **Introduction:** Introduction to control systems, Classification of control systems, open loop & closed loop control systems, elements of Control systems, Characteristics, advantages & disadvantages of control system. **3 Hrs**

2. **Mathematical modelling:** Mechanical systems (translation & rotational), Electrical systems, servos, D.C Motors, A.C Servomotors, Hydraulic (liquid level, Fluid power), Thermal systems, Hydraulic servomotor, Temperature control, Error detectors. **5L+2T Hrs**

3. **Representation of control systems:** Block diagram representation of system elements**,** reduction of block diagrams; Signal flow graphs, basic properties, transfer function, Masons gain formula. **4L+2T Hrs**

4. **System response:** First and second order response to step, ramp and sinusoidal inputs, concept of time constant, and speed of response. **6 Hrs**

5. **System design:** Routh's stability criterion, Root locus Method, Definition, construction of root loci, Graphical relationship for setting system gain. **4 Hrs**

6. **Analysis using logarithmic plots:** Bode attenuation diagrams, stability using Bode diagrams, simplified Bode diagrams. **5L+2T Hrs**

7. **Frequency response:** Polar and rectangular plots for frequency response, analysis using Nyquist Diagrams, Relative stability, gain and phase margin, M and N circles. **5 Hrs**

8. **Design in frequency Domain:** Control action & system compensation: Types of controllers, proportional, integral, and differential, PID Controllers (basic concepts), series and feedback compensation design of control parameters, Physical devices for system compensation. **6 Hrs**

Reference Books:

1. K.Ogatta, Modern Control Engineering, 5th edition, Prentice Hall (India), Pearson Education, 2010.

2. I.J Nagarath and M. Gopal, Control systems Engineering, 5th edition, New Age International Publishers, 2010.

3. B.C.Kuo, Automatic Control Systems, 8th edition, Prentice Hall (India), 2010

4. Schaum's series, Feedback Control Systems, McGraw Hill, 2001

15UMEC801	Mechatronics	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Various elements of Mechatronics
2. Concurrent design concepts for mechanical products
3. Modeling and simulation concepts of various mechanical systems.
4. Synergistic integration of electrical and electronic systems along with computer intelligence.

Course outcomes (COs):

ID	Description of the course outcome: At the end of the course the student will be able to:	Mapping to POs (1-12)/PSO (13-14)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	List and explain various mechatronic elements.	1	--	--
CO-2	Discuss different sensors/ transducers and their working principle.	1	--	--
CO-3	Formulate and analyze mathematical models of various physical systems.	2	--	--
CO-4	Explain various machine tool elements and electrical actuators.	1	--	--
CO-5	Describe different hydraulic and pneumatic components used in mechatronic systems and predict behavior of the system.	1	--	--
CO-6	Evaluate the best method of signal conditioning systems and compare with existing systems	1	4	--

POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
Mapping Level	3	3	-	2	-	-	-	-	-	-	-	-	-	-

Pre requisite: Basic electrical and electronics engineering, Basic mechanical engineering.

Course Contents:

1. **Introduction:** Definition of Mechatronics, Multi-disciplinary scenario, over view of mechatronics systems. Design of mechatronics system. Measurement system and function of main elements of measurement systems. Need for mechatronics in industries. 'Objectives, advantages and disadvantages of mechatronics. Microprocessor based controllers. Principle of working of automatic camera, engine management system, automatic washing machine.

6 Hrs

2. **Review of Transducers and Sensors:** Definition and classification of transducers. (No detailed discussions on different type of transducers) Definition and classification of sensors. Principle of working and applications of light sensors, proximity sensors and Hall effect sensors. **8 Hrs**

3. **Modeling and Simulation of Physical Systems:** Operator notations and transfer functions, Block diagrams, Manipulations and Simulation, Block diagram modeling – Director method, Analogy approach, Electrical Systems Mechanical Translational Systems, rotational systems, Electrical mechanical coupling, Fluid systems. **10 Hrs**

4. **Elements of CNC Machines:** Structure, guideways - Friction, Autifriction and Frictionless guideways, Merits and demerits. Drives - Recirculating ball screw and nut. Advantages and disadvantages over Conventional screw and nut. Concept of stick-slip phenomenon, Concept of Preloading of ball nuts.Roller screw – planetary roller screw, recirculating roller serew. Spindle and spindle bearings in machine tool. Various types of loads encountered - spindle and spindle bearing. Types of bearings- friction, antifriction and frictionless bearing.Merits and demerits of each.Selection of spindle and spindle bearing, preloading of bearings, different method of preloading in detail. **8 Hrs**

5. **Electrical Actuators:** Actuator and actuator system. Classifications of actuator system with examples. Mechanical switches.Concept of bouncing Methods of Preventing bouncing of mechanical switches.Solenoids, Relays. Solid state switches - Diodes, Thyristors, Triacs, Transistors, Darlington pair. Electrical actuator.Principle, construction and working of AC, DC motors, stepper motors, permanent magnet motors, servomotors, Servo systems and control. **8 Hrs**

6. **Hydraulic Actuators – Valves:** Classifications, Pressure Control Valves - Pressure relief valves, Pressure regulating/reducing valves, Pressure sequence valve. Flow control valves - Principle, needle valve, globe valve. Direction control valve -Sliding spool valve, solenoid operated. Symbols of hydraulic elements.Hydraulic cylinders - constructional features, classification and applications. Hydraulic motors - Types, vane motors and piston motors, applications. **8 Hrs**

7. **Signal Conditioning:** Concept, necessity, op-amps, protection, filtering, wheat stone bridge - Digital Signals - Multiplexer. Data acquisition - Introduction to digital signal processing - Concepts and different methods. **4 Hrs**

Reference Books:

1. Nitaigour and Premchand Mahilik, Mechatronics - Principles, Concepts & applications, Tata McGraw Hill, 2003
2. W. Bolton, Mechatronics, 4th edition, Pearson Education Asia, 2013
3. David G, Alciatore & Michel BiHistand, Introduction to mechatronics and Instrument systems, 3rd edition, Tata McGraw Hill- 2010.
4. H.D. Ramachandra, Mechatronics, Sudha Publication, 2003

15UMEL802	Seminar	(0-0-4) 2

Contact Hours: 40

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Latest trends in engineering and research.
2. Presentation skills.
3. Communication skills.
4. Art / techniques of Report preparation.

Course outcomes (COs):

ID	Description of the course outcome: At the end of the course the student will be able to:	Mapping to POs (1-12)/PSO (13-14)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Refer to the learning resources, recognize and collect the required information.	2	4	12
CO-2	Describe the usefulness of information and make effective oral presentation using ppt.	10	2	4
CO-3	Compile the information published and prepare a technically sound report.	10	5	-
CO-4	Justify the technical solutions presented and draw the concluding remarks.	4	10	6

POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
Mapping Level	-	2.5	-	2	2	1	-	-	-	2.7	-	1	-	-

Every student has to present a seminar on thrust areas in Mechanical Engineering suitably selecting the topic in consultation with a guide. The seminar will be evaluated by a faculty committee.

15UMEL803	Project phase-2	(0-0-16) 8

Contact Hours: 100

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Practical significance of projects.
2. Engineering concepts and its application to real world problems.
3. Manufacturing problems associated with fabrication, design related analysis and numerical concepts.
4. Creativity as an essential component of engineering application.

Course outcomes (COs):

ID	Description of the course outcome: At the end of the course the student will be able to:	Mapping to POs (1-12)/PSO (13-14)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Identify, formulate and solve a problem using basic engineering principles.	1,2	4	1,2
CO-2	Recognize the need and able to design and fabricate the machine parts, components of a system that meets particular requirement.	3	7	6,12
CO-3	Use the software tools to prepare and analyze models or prototypes and conduct simulation using it.	5, 13	2	-
CO-4	Use the machine tools to prepare models or prototypes.	5, 13	2	-
CO-5	Work in teams and communicate effectively for completion of projects in time.	10	8,11,12	-
CO-6	Prepare a report based on their project and present the concept using ppt.	13, 14	9,10,11	-

POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
Mapping Level	3	2.4	3	2	3	1	2	2	2	2.5	2	1.4	3	3

Pre requisites: Manufacturing Technology, Machine Design-I & II, Strength of Materials, Thermal Engineering, Basic computer knowledge, Literature review.

The student will take up a project in consultation with a guide of his choice in thrust areas of **Mechanical Engineering**. This project is continued as **Phase II** in VIII semester. The evaluation will be made as per the departmental recommendation and guidelines.

Note: Activities/Topics for self-study to be decided by the guide.

15UMEE825	Design of Heat exchangers	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Fundamentals of heat transfer concepts and laws of governing different modes of heat transfer.
2. Significance of heat transfer and applications of heat exchangers.
3. Theory of heat exchangers and their performance analysis based on LMTD and NTU methods.
4. Process of boiling and condensation and the correlation used for the governing process.
5. Design and development of heat exchangers and utilization of heat transfer data available for solving the problems
6. Energy balances and understand basic mechanism of heat transfer such as conduction convection and radiation or simultaneously.
7. Use of Heat transfer Data Hand Book to solve the problems. Using Heat transfer data handbook and in engineering practices.

Course outcomes (COs):

ID	Description of the course outcome: At the end of the course the student will be able to:	Mapping to POs (1-12)/PSO (13-14)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Classify heat exchangers based on different criteria	1,2	-	-
CO-2	Explain different methods of analysis for different heat exchangers.	1,2	-	-
CO-3	Compute size and rate of heat transfer in double pipe, shell & tube type heat exchangers.	-	1,2,3	-
CO-4	Evaluate the rate of heat transfer and area for different heat exchanger configurations.	-	1,2,3	-
CO-5	Compute size and rate of heat transfer in Furnaces and combustion chambers.	-	2,3	-

POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
Mapping Level	2.5	2.4	2	-	-	-	-	-	-	-	-	-	-	-

Pre requisites: Basic Thermodynamics, Engineering mathematics, Heat Transfer, Fluid Mechanics.

Course Contents:

1. **Introduction to Heat Exchanger Design:** Types of heat exchangers and their applications: Flow arrangements and temperature distributions in transfer type of heat exchangers. Overall heat transfer coefficient: - Clean overall heat transfer coefficient, dirt factor, Dirt overall heat transfer coefficient, dirt factors for various process services. Basic design equation. Mean temperature difference Concept: LMTD for parallel flow and counter flow arrangement, correction factor for LMTD for cross flow and multi-pass heat exchangers. Effectiveness-NTU method for heat exchanger design /analysis.Rating and sizing problems**.** **8 Hrs**

2. **Double Pipe Heat Exchangers:** Constructional features. Applications, Design Parameters Tube side and shell side film coefficients, cut and twist factor, fin efficiency, overall heat transfer coefficient, mean temperature difference, available surface area, fin geometry, fin height , number of fins, tube side and shell side pressure drop, calculation procedure for the design/analysis of double pipe heat exchanger. **7 Hrs**

3. **Shell and Tube Heat Exchangers:** Constructional features. Applications, Correlations for tube side pressure drop and heat transfer coefficients. Pressure drop and heat transfer Coefficient correlations for shell side flow:- Effect of By - pass and leakage. Calculation procedure for Shell and Tube Heat Exchanger:- Heat balance equations; LMTD; Reference temperature calculation; evaluation of fluid properties; flow assignments; tube side flow parameters calculations; viscosity correction factor; Shell side How area calculations:-shell side equivalent diameter, calculation of shell side heat transfer coefficient, evaluation of wall temperature. Evaluation of overall heat transfer coefficient, calculation of surface area, calculation of tube side and shell side pressure drops, specifications of other details as per TEMA standards. Flow arrangement for increased heat recovery:- lack of heat recovery in 1-2 exchangers, true temperature difference in a 2-4 heat exchanger, calculation procedure for a 2-4 heat exchanger. Calculation procedure for steam condensers. **16 Hrs**

4. **Compact Heat Exchangers:** Introduction; Definition of Geometric Terms: Plate fin surface geometries and surface performance data; correlation of heat transfer and friction data; Goodness factor comparisons; specification of rating and sizing problems; Calculation procedure for a ruling problem. **7 Hrs**

5. **Air-Cooled Heat Exchangers:** Air as coolant for industrial processes; Custom- built units; Fin-tube systems for air coolers; Fin-tube bundles; Thermal rating; tube side flow arrangement; cooling air supply by fans; cooling air supply in natural draft towers. **6 Hrs**

6. **Furnaces and Combustion Chambers:** Introduction; Process heaters and boilers; Heat transfer in furnaces: - Heat source; Heat sink; Refractory surfaces; Heat transfer to the sink; Design methods: - Method of Lobo and Evans; Method of Wilson, Lobo and Hottel; the Orrok-Hudson equation; Wohlenberg simplified method. **8 Hrs**

Reference Books:

1. Donald Q. Kern, "Process Heat Transfer" Tata McGraw-Hill, 1997
2. W.M.Kays& A.L. London, "Compact Heat Exchangers", McGraw-Hill co. 1997
3. NecatiOzisik, "Heat Transfer-A Basic Approach" McGraw-Hill International edition (1985) for Chapter 1
4. Ernst U Schlunder et.al, "Heat Exchanger Design Hand Book", Volumes 2 and 3, Hemisphere Publishing Co. 1983.

15UMEE826	Machine Tool Design	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Principles of machine tool design, design process and requirements.
2. Drives and mechanisms for transmission of motion.
3. Force and the power requirements of machine tools.
4. Designing the machine tool structure, power transmission elements and associated elements.
5. Concepts of dynamic cutting process, vibrations, chatter, stability of machine tools.
6. Principles of control of motion and the use of automatic control system.
7. Principles of computer integrated manufacturing systems and CNC m/c tools.

Course outcomes (COs):

ID	Description of the course outcome: At the end of the course the student will be able to:	Mapping to POs (1-12)/PSO (13-14)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Identify the machine tool requirements and design features	1	-	-
CO-2	Design the machine tool parts satisfying kinematic and strength requirement.	1, 3	2	-
CO-3	Explain the need/features/advantages and disadvantages of NC and CNC machine tools.	1	-	-
CO-4	Analyze the design for optimum values/functional suitability.	1	2,3	-
CO-5	Write programming for CNC machine tool.	1, 3	2	-

POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
Mapping Level	3	2	2.6	-	-	-	-	-	-	-	-	-	-	-

Pre requisites: Elements of Mechanical Engineering, Theory of machines, Machine design, Manufacturing processes.

Course Contents:

1. **Requirements of machine tools:** Identification and quantification of Objectives and constraints in machine tool design. **4 Hrs**
2. **Power requirements:** Estimation of power requirements and selection of drives for machine tools spindles. **6 Hrs**

3. **Design & Machine tool relationships:** Static strength, stiffness, rigidity, fatigue and Dynamic characteristics. **6 Hrs**

4. **Design of gearbox and feed box:** spindle speeds and ray diagrams, number of gears, design of Gears, requirements of an ideal gearbox, shafts, bearings and lubrication. **8 Hrs**

5. **Design of spindle and guide ways and power screws for lathe. 6 Hrs**

6. **Design principles:** Principles of design of structural components namely head stock, tailstock, carriage, beds, base, table, cross rail, saddle, rams, knee, and column to achieve desired static strength, fatigue strength and stiffness. **7 Hrs**

7. **Control systems in machine tools:** Functions, requirements, classification, control systems for changing speeds and feeds. Manual, automatic and adaptive control systems. **4 Hrs**

8. Numerical control of machine tools: Introduction to NC technology, types of NC system, structure of NC machines. **3 Hrs**

9. **CNC machine tools**: Introduction, types, advantages, drives, spindle drives, types, feed drives, types, design, servo mechanism. Design of CNC machine tool elements, machine structure, LM guides, ball screws, timer belts, flexible belts, stroke spindle bearings. Introduction to CNC programming. **8 Hrs**

Reference Books:

1. N.K.Mehta, Machine tool design, Tata McGraw Hill, 2001.

2. N. Archerkan, Machine tool design, vol 2&3, Mir publications, Moscow, 1969

3. Sen and Bhattacharya, Principles of Machine, Tools Oxford I.B.M Publishing, 2000

15UMEE827	Energy Management	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Energy management, energy patterns audit and utilization.
2. Analysis and thermodynamics of energy conservations.
3. Energy conservation and electrical utility.
4. Cogeneration and performance evaluation.
5. Utilization of electrical energy.

Course outcomes (COs):

ID	Description of the course outcome: At the end of the course the student will be able to:	Mapping to POs (1-12)/PSO (13-14)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Explain energy use pattern of various sectors in India, and the terms used in energy conservation.	1	2	7
CO-2	Carry out economic analysis for energy systems based on life cycle costs/benefits.	1	11	14
CO-3	Apply heat transfer and thermodynamic concepts to waste heat management of energy systems.	1	2	-
CO-4	Apply basic electrical concepts to conserve energy in electrical systems.	1	2	-
CO-5	Determine number of electrical illumination systems required for a building and financial benefits of using energy efficient lighting.	1	2	-
CO-6	Compute and compare two part and three part tariffs systems.	1		14

PO s	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
Mapping Level	3	2	-	-	-	-	1	-	-	-	2	-	-	1

Pre requisites: Elements of Mechanical Engineering, Thermodynamics, Power Plant and Heat Transfer.

Course Contents:

1. **Introduction General energy problem Energy use patterns:** Sectors such as domestic, industrial, agriculture and commercial and energy saving opportunities and scope of conservation. Need of Energy management program, Organizing, Initiating Managing an Energy Management program.

6 Hrs

2. **Energy Audit:** Elements and concepts Types of energy audits mini, maxi audit preliminary and detailed energy audits procedure involved. Instruments used in energy auditing of various sectors. **6 Hrs**

3. **Economic Analysis:** Cash flows diagram, Time value of money, Formulae relating present and future cash flows, single amount and uniform series. Numerical Problems. Financial appraisal methods, Payback period, Net present value, Benefit-cost ratio, Internal-rate of return Life cycle costs/benefits. **10 Hrs**

4. **Energy Efficiency in Thermal Utilities:** Energy efficiency of utilities, Oil coal & gas combustors, FEC boilers, Steam & condensate system, Furnaces. **6 Hrs**

5. **Cogeneration:** Concepts of cogeneration Types of cogeneration systems, Waste heat recovery equipment, Turbines & heat exchangers, Problems on Rankine cycle for cogeneration plants. **6 Hrs**

6. **Industrial Insulation & Refractories;** Types and applications, economic and critical insulation thickness, Heat saving criteria, Applications of refractories, Heat loss. **6 Hrs**

7. **Utilization of Electrical energy**: Heating methods, Types of light sources incandescent bulbs, Fluorescent tube, Dielectric Heating, Space heating in buildings, Illumination Engineering, Energy conservation in illumination systems, and Economic aspects. **6 Hrs**

8. **Energy Conservation in Electrical Utility:** Industry energy costs and two – part tariff, Energy conservation in utility by improving load factor, Load curve analysis, Energy efficient motors, Importance of Power factor in energy conservation Power factor improvement methods. **6 Hrs**

Reference Books:

1. S.C.Tripathy, Electric Energy Utilization and Conservation, Tata McGraw Hill, New Delhi, 1991.
2. Energy Management Proceedings published under AICTE Continuing Education Program New Delhi. 1998
3. B.L.Theraja, Electric Energy Utilization 2nd edition, Tata McGraw Hill New, Delhi, 1999
4. P.K. Nag, Applied Thermodynamic, 2nd edition, Tata McGraw Hill New Delhi, 2010.
5. T.C Kandpal and H.P.Garg, Financial evaluation of renewable energy technologies, Macmillan publications India Ltd Delhi, 2003

15UMEE828	Cryogenics	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Principles of cryogenics and applications.
2. Low temperature properties of engineering materials.
3. Gas separation and gas purification and production of ultralow temperature.
4. Vacuum technology cryogenics insulation fluid storage and applications.

Course outcomes (COs):

ID	Description of the course outcome: At the end of the course the student will be able to:	Mapping to POs (1-12)/PSO (13-14)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Explain different cryogenic terms and processes.	1,2	-	-
CO-2	Explain various cryogenic systems and thermodynamics of ideal refrigeration systems.	1,2	-	-
CO-3	Solve the problems related to effectiveness of heat exchanger used in cryogenics.	1,2	-	-
CO-4	Explain cryogenics applications in the field of food preservation, medicine, super conductors and space technology.	1,2	-	-
CO-5	Compare various insulation systems, vacuum pumps and suspension systems.	1,2	-	-
CO-6	Explain various methods of measurements in cryogenics.	-	1,2,3	-

POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
Mapping Level	2.8	2.8	2	-	-	-	-	-	-	-	-	-	-	-

Pre requisites: Fundamental knowledge of thermo dynamics, Basic Science Engineering, heat transfer, Principles of refrigeration systems and fluid flow dynamics.

Course Contents:

1. **Introduction:** Cryogenic Systems.Applicationsand Areas of Cryogenic Engineering. **2 Hrs**

2. **Low temperature properties of engineering materials:** Mechanical properties, Thermal properties, Electrical properties. **3 Hrs**

3. **Gas liquefaction Systems:** Introduction The thermodynamically Ideal system Production of low temperatures- joule Thomson Effect Adiabatic expansion Liquefaction systems for Air/Nitrogen/Oxygen- Simple Linde - Hampson System, Pre cooled LH System, Claude System, Heylandt System, Dual pressure Systems, Claude System, Kapitza System. Comparison of Liquefaction Systems, Liquefaction Systems for hydrogen, and Neon (precooled lindehampson and precooled Claude systems), helium liquefaction systems (collin'ssystem and Simon's system) Heat exchanger effectiveness (with the simple numerical Problems). **12 Hrs**
4. **Gas separation and gas purification systems:** Thermodynamics ideal separation system, Principles of gas separation. Linde single column air separation. Linde double column air separation Argon and Neon separation systems. Adsorption Process Combined purification method. **8 Hrs**
5. **Cryogenic refrigeration systems:** Ideal Refrigeration system (Isothermal source), Joule Thomson Refrigeration systems, Gifford Mc Mahon Refrigerator, Solvay Refrigerator. **6 Hrs**
6. **Ultra low temperature Cryo:** Refrigerators Magnetic Refrigeration systems, He3_He4 Dilution refrigerator. **3 Hrs**
7. **Measurement systems for low temperatures:** Resistance thermometers Thermocouples Thermistors Gas Thermometry. Liquid level sensors. (No numerical Problems). **4 Hrs**
8. **Vacuum Technology:** Fundamental principles, Mechanical vacuum pumps, Ion Pumps, Diffusion pumps, Cryo pumping. **3 Hrs**
9. **Cryogenic Insulation:** Heat transfer due to conduction, Evacuated porous insulationpowder& Fibers, Opacified powder insulation, Gas filled powders & Fibrous materials, Multilayer super-insulation, Composite insulation. **3 Hrs**
10. **Cryogenic fluid storage and suspension systems:** Design of cryogenic fluid storage vessels Inner vessel Outer vessel Insulation Suspension system. **4 Hrs**
11. **Application of cryogenic systems:** Cryogenic applications for food preservation, Biology and Medicines, Super conductive devices, space technology. **4 Hrs**

Reference Books:

1. Randal Barron, Cryogenics Systems, oxford Press, 1985.
2. Marshall Sitting D.VanNostrand, Cryogenics, Research and application co.inc Princeton New Jersy, 1989
3. Klaus D. Timmerhaus& Thomas M. Flynn, Cryogenic process Engineering, Plenum Press, New York & London, 1989
4. Thomas M Flynn, Marcel Dekker, Cryogenic Engineering Inc. N.Y.Basal, 1997.

15UMEE829	Fracture Mechanics	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Applicability of fracture mechanics concepts.
2. Governing equations of plane linear elasticity and plasticity in Cartesian and polar coordinates, explain the conditions under which they can be used and how to solve plane problems involving them.
3. Crack tip stress, strain and displacement fields.
4. Crack tip results to understand and determine limitations on various fracture criteria.
5. Determination of stress intensity factors for several important example cases via superposition and other methods such as the J-integral.
6. Estimation of size and shape of crack tip plastic zones in Modes I, II and III.

Course outcomes (COs):

ID	Description of the course outcome: At the end of the course the student will be able to:	Mapping to POs (1-12)/PSO (13-14)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Explain the fundamentals of fracture mechanics.	1	-	2
CO-2	Identify different failure modes and test specimen for finding fracture toughness.	1	-	2,3
CO-3	Apply principles of fracture mechanics to solve real life problems.	1	2	3
CO-4	Compare standard design procedure with modern design procedure	1,3	2	4
CO-5	Explain the different experimental techniques to find fracture toughness.	1	2	4
CO-6	Explain the principles of crack arrest and various theories of fatigue crack growth.	1	-	2

POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
Mapping Level	3	1.5	1.7	1	-	-	-	-	-	-	-	-	-	-

Prerequisites: Engineering Mathematics, Engineering physics, Strength of Materials, Materials Science, Machine Design, theory of elasticity.

Course Contents:

1. Fracture Mechanics Principles: Introduction, Mechanism of fracture, a crack in structure, Griffith criteria, classic design, modern design-strength, stiffness and toughness, stress intensity approach. **7 Hrs**

2. **Stress Analysis for members with crack:** Introduction, LEFM, relation between SIF and Fracture toughness, crack tip plastic zone estimation, Dugdale's approach and Irwin's approach, concepts of plane stress and plane strain, effect of plate thickness. **7 Hrs**

3. **Elastic Plastic fracture Mechanics:** Relevance and scope, EPF criteria, R-Curve-Integral, COD, CTOD, importance of R-curve in fracture mechanics. **5 Hrs**

4. **Experimental determination of J-integral, COD, CTOD. 5 Hrs**

5. **Dynamics of Crack Arrest:** Introduction, dynamic SIF and elastic energy rate, crack branching, principles of crack arrest, dynamic fracture toughness. **7 Hrs**

6. **Fatigue and Fatigue crack growth rate:** Introduction, terminology fatigue loading, fatigue crack growth laws. **6 Hrs**

7. **Computational Fracture Mechanics:** Overview of numerical methods, traditional methods in computational fracture mechanics, limitations of numerical fracture analysis. **7 Hrs**

8. **Fracture Toughness Testing of Metals:** specimen size requirements, CT specimen, three bend and four bend specimen, plane stress testing, fracture testing in shear modes and fatigue testing, effect of temperature and loading rate on toughness, thickness effect on fracture toughness. **8 Hrs**

Reference Books:

1. David Broek, Martins Fracture Mechanics, Nijhoff Publishers, 1987
2. KRY Simha, Fracture Mechanics, University Press 2001
3. Prashantkumar, Elements of Fracture Mechanics, Wheeler Publications 1999.
4. J.F.Knott, Fracture mechanics, Butterworth Publishers 1976
5. Stress concentration formula data hand book.

15UMEE830	Industrial robotics	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Various elements of Robotics.
2. Concurrent design concepts for robotics products.
3. Modeling and analysis concepts of various robotics systems.
4. Synergistic integration of electrical, electronic systems along with computer intelligence for the purpose of producing highly versatile, efficient, compact robotics systems.

Course outcomes (COs):

ID	Description of the course outcome: At the end of the course the student will be able to:	Mapping to POs (1-12)/PSO (13-14)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Explain basic structure, performance characteristics and programming concepts of an industrial robot.	1	-	2
CO-2	Illustrate different types of sensors and vision system in a robot.	1	-	2
CO-3	Develop a mathematical model to represent a robot.	1	2	3
CO-4	Analyze kinematically serial manipulators.	1	2	3,5
CO-5	Derive equations of motion for a robot.	1	-	2,5
CO-6	Plan the motion of robot using different trajectory planning schemes.	1	2	3,5

POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
Mapping Level	3	1.4	1	-	1	-	-	-	-	-	-	-	-	-

Pre requisites: Basic electronics, Basic mathematics and Dynamics.

Course Contents:

1. **Introduction:** Definition: manipulators, Robotics, Brief history of robotics, Overview of robots, social & economic aspects of robots, Advantages of using robots in industries, Future applications. **2 Hrs**

2. **Structure of robotic systems:** Classification, Geometrical configuration, wrist & its motions, Degrees of freedom, work Envelop, Links and joint, effectors and its type, Robot drive system: Hydraulic, electric selection of drive system, Resolution, accuracy & repeatability, Specifications of robots. **4 Hrs**

3. **Sensors:** State and Transducers, Classification, Internal & External sensors, Interlocks, Tactile and non- tactile sensors, Proximity and range sensing, force – torque, Static and dynamic characteristics, Selection of sensors, Elements of computer vision, Sensing and digitizing, Lighting techniques, A/D conversion, sampling quantization, Image storage, Image processing and analysis, Feature Extraction &object Recognition. **8 Hrs**

4. **Control Systems and Components:** Basic control system concepts and models, Transformation function with block diagram of spring mass system, Transient response to second order systems, controllers on/off, proportional and integral, PID, Digital, Adoptive control, AI. **6 Hrs**

5. **Robot Motion Analysis:** Kinematics, Introduction, Direct & inverse kinematics, Classification, Transformations homogenous transformations, Rotation, matrix, Composite rotation matrix, Rotation matrix about an arbitrary axis, Euler angle representation, Links, joints and their parameters D-H representation, Geometrical approach to direct and Inverse kinematics. **12 Hrs**

6. **Robot Arm Dynamics:** Lagrange Euler formulations, Joint velocities, K.E., P.E, motion equations of a robot manipulator. **8 Hrs**

7. **Trajectory Planning:** Introduction, General considerations on trajectory planning, Joint interpolated trajectories, 4-3-4 trajectory example, Planning of Cartesian path Trajectories. **8 Hrs**

8. **Robot Programming:** Introduction, Types robot programming, Teach pendant, Lead through programming, Programming languages VAL, RAIL, AML, Programming with graphics, storing & operating. **4 Hrs**

Reference Books:

1. Grover, Industrial Robots, Mc Grew Hill 2003.
2. R. C. Gongales& Lee, Robotics – K. S. Fu McGraw Hill, International, New Delhi 2001.
3. Yorem Koren, Robotics for Engineers, Mc Grew Hill, International, New Delhi 2001.
4. Richard Paul, Robot manipulators, Mathematics, Programming and control 2000.

15UMEE831	Automotive Engineering	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Basic knowledge about automobile engine & its construction.
2. Different aspects of automotive engineering including working of the automobile engine, fuel supply systems, ignition systems, transmission, suspension, brakes and emission control systems.
3. Calculation procedure for the design and analysis of gear ratios in transmission, drive to wheels, suspension, springs and brakes.
4. Basic knowledge in automotive emission control systems, emission standards, controlling the combustion process and emissions.

Course outcomes (COs):

ID	Description of the course outcome: At the end of the course the student will be able to:	Mapping to POs (1-12)/PSO (13-14)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Explain the construction and working principles of different automobile parts.	1	2	-
CO-2	Discuss various fuel supply systems used in IC engines.	1	2	12
CO-3	Describe the construction and working of transmission, steering and suspension systems.	1	2, 3	-
CO-4	Describe the construction and working of braking, lubrication and cooling systems used in automobiles.	1	2	-
CO-5	Discuss materials, trouble shooting, real life problems and advanced technologies in automobiles.	1	-	7

POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
Mapping Level	3	2	2	-	-	-	1	-	-	-	-	1	-	-

Pre requisites: I. C. Engines, Thermodynamics, Element of Mechanical Engineering.

Course Content:

1. **Engine Components:** Principle working of SI & CI engines – Constructional details of cylinder block, head, piston, piston rings, Camshaft connecting rod – crankshaft and their material composition. Valve actuating mechanism. Engine layout with relative characteristics. Types of Combustion Chambers for SI & CI engines. **10 Hrs**

2. **Fuel Supply Systems in SI engines:** Fuel mixture strength requirements for SI Engines types of carburetor – Fixed jet & variable jet. Mechanical AC pump & Electrical pump. Nozzles used for fuel injection, Engines with MPFI systems. **5 Hrs**
3. **Fuel supply System in CI Engines:** Requirements, functions, types of injection system – Air injection, Airless injection. Fuel pump – Fuel injector, Nozzles used for fuel injection, CRDI systems. **5 Hrs**
4. **Transmission System:** Clutches – Single plate- Multi-plate- Diaphrgam clutch-centrifugal & cone clutch- Necessary of gear box – 4-speed sliding mesh – Constant mesh- Synchromesh gear boxes – Automatic gear box-working of overdrive unit – Fluid Coupling- Torque Converter – Calculation of gear ratio – Numerical problems. Rear Axle Drive**:** Propeller shaft, differential gear box – rear axle arrangements- Hotch kiss drive. **10 Hrs**
5. **Steering System:** Stub axle arrangement- steering geometry – camber – caster –king pin- toe – in – toe out. Condition for exact steering – over steer-under steer, steering gear boxes. **5 Hrs**
6. **Suspension System:** Requirements, arrangement. Independent front system – double wishbone, McPherson strut type. Independent rear suspension – swinging half axle, trailing arm & semi trailing arm, McPherson strut type.Air suspension telescopic damper. **6 Hrs**
7. **Braking System:** Principle of hydraulic braking system, Drum brake & disc brakes, power brakes – air brake, Vacuum brake. Construction and working of master cylinder & wheel cylinder – Minimum stopping distance with brakes on front, rear and all wheels- heat dissipation during braking numerical problems. **7 Hrs**
8. **Cooling and Lubrication System:** Constructional details of water cooling system –thermostat – air cooling – different lubrication systems. **4 Hrs**

Reference Books:

1. A Book of car, Drive Publications Ltd., for the Automobile Association
2. Dolon, Motor Vehicle Technology, ELBS-Great Britan, 1978.
3. Heitner, Automotive Mechanics, Affiliated East-west Press Pvt. Ltd., New Delhi - 1987.
4. Newton Steeds and Garratte Butterworth, Automotive Engineering, 2nd edition 1989.

15UMEE832	Design of Aircraft structures	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Aerodynamics, aerospace materials, aircraft and spacecraft structures, aircraft and space propulsion, flight mechanics, stability and control systems, orbital mechanics, space environment
2. Determination and control, telecommunications and design competence of aircraft and spacecraft using systems engineering principles;
3. Independent research opportunities, involving teamwork and exposure to modern engineering analytical and computational tools;
4. Application based analysis and innovation.

Course outcomes (COs):

ID	Description of the course outcome: At the end of the course the student will be able to:	Mapping to POs (1-12)/PSO (13-14)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Recognize the requirements & functions of aircraft structural analysis & design process	1,3	2	-
CO-2	Explain Airworthiness & aircraft certification.	1,3	9	8
CO-3	Explain aircraft structural damage & repair.	1,4	-	10
CO-4	Analyze design of components in a aircraft structure.	1,2	3	5
CO-5	Estimate aircraft loads.	1,3	2	5
CO-6	Justify Usage Of Proper Materials, & manufacturing processes	12	2	-

POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
Mapping level	3	2.3	2.8	3	1	-	-	1	2	1	-	3	-	-

Pre requisites: Engineering Mathematics, Fluid Dynamics, Basic Thermodynamics.

Course Contents:

1. **Overview of the Aircraft Design Process:** Introduction, Phases of Aircraft Design, Aircraft Conceptual Design Process, Conceptual Stage, Preliminary Design, Detailed Design, Design Methodologies. **4 Hrs**
2. **Fundamentals of Structural Analysis:** Review of Hooke's Law, Principal stresses, Equilibrium and Compatibility, Determinate Structures, St Venant's Principle, Conservation of Energy, Stress Transformation, Stress Strain

Relations, Numerical problems on principle stresses, critical stresses in structural members of the aircraft etc. **5 Hrs**

3. **Introduction to Aircraft Structures:** Sectional Properties of structural members and their loads, Types of structural joints, Type of Loads on structural joints. **5 Hrs**
4. **Aircraft Loads:** Aerodynamic Loads, Inertial Loads, Loads due to engine, Actuator Loads, Maneuver Loads, VN diagrams, Gust Loads, Ground Loads, Ground conditions, Miscellaneous Loads. **5 Hrs**
5. **Aircraft Materials and Manufacturing processes:** Material selection criteria, Aluminum Alloys, Titanium Alloys, Steel Alloys, Magnesium Alloys, copper Alloys, Nimonic Alloys, Non Metallic Materials, Composite Materials, Use of Advanced materials Smart materials, Manufacturing of A/C structural members, Overview of Types of manufacturing processes for Composites, Sheet metal Fabrication, Machining, Welding, Superpiastic Forming And Diffusion Bonding. **5 Hrs**
6. **Structural Analysis of Aircraft Structures:** Theory of Plates- Analysis of plates for bending, stresses due to bending (No derivation), Plate deflection under different end conditions, Strain energy due to bending of circular, rectangular plates, Plate buckling, Compression buckling, shear buckling, Buckling due to in plane bending moments, Analysis of stiffened panels in buckling, Rectangular plate buckling, Analysis of Stiffened panels in Post buckling, Post buckling under shear, Sample Exercises. Theory of Shells- Analysis of Shell Panels for Buckling, Compression loading, Shear Loading / Shell Shear Factor, (No derivations) Circumferential Buckling Stress, sample exercises Theory of Beams-Symmetric Beams in Pure Bending, Deflection of beams, Unsymmetrical Beams in Bending, Plastic Bending of beams, Shear Stresses due to Bending in Thin Walled Beams, Bending of Open Section Beams, Bending of Closed Section Beams, Shear Stresses due to Torsion in Thin Walled Beams. Sample Exercises. Theory of Torsion- Shafts of Non-Circular Sections, Torsion in Closed Section Beams, Torsion in Open Section Beams, Multi Cell Sections, Sample Exercises. **20 Hrs**
7. **Airworthiness and Aircraft Certification:** Definition, Airworthiness Regulations, FAR-25, Regulatory Bodies, Type certification, General Requirements, Requirements Related to Aircraft Design Covers, Performance and Flight Requirements, Airframe Requirements, Landing Requirements, Fatigue and Failsafe requirements, Emergency Provisions, Emergency Landing requirements. **4 Hrs**
8. **Aircraft Structural Repair:** Types of Structural damage, Nonconformance, Rework, Repair, Allowable damage Limit, Repairable Damage Limit, Overview of ADL Analysis, Types of Repair, Repair Considerations and best practices. **4 Hrs**

Tutorials/Assignments

The assignments for Electives could include the following,

Hands-on calculation on Exercises related to Fundamentals of Structural Analysis Hands-on Calculation on Exercises involving, plate theory, beam theory and shell theory, Panel buckling, Shear flow Exercises in Aircraft Structures.

Reference Books:

1. Ian moir, Allan Seabridge, Aircraft Systems: Mechanical, Electrical and Avionics Subsystems Integration
2. Daniel P.Raymer, Aircraft Design-A Conceptual Approach, AIAA education series, 6th edition
3. Michael Niu, Airframe Structural, 2nd edition, Design Conmilit Press, 1988
4. Michael Niu, Airframe Stress Analysis and Sizing, 3rd edition, Conmilit Press, 1999

15UMEE833	Advanced Finite Elements Method	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Concepts of finite element methods.
2. Wider capabilities of finite element method.
3. Solving real life problems using commercial software.

Course outcomes (COs):

ID	Description of the course outcome: At the end of the course the student will be able to:	Mapping to POs (1-12)/PSO (13-14)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Identify the right type of element required for structural FEA.	1	-	-
CO-2	Derive stiffness matrix for advanced elements like space truss element. 3D frame elements and plate elements.	1	-	-
CO-3	Carry out structural analysis of 3-D trusses & frames and plates	1	2	-
CO-4	Carry out vibration analysis of structures for natural frequencies and mode shapes.	1	2	-
CO-5	Use commercial software to solve small real life problems on structural and vibrational analysis.	-	5	9, 12
CO-6	Prepare a small report on finite element analysis.	-	10	-

POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
Mapping Level	3	2	-	-	2	-	-	-	1	2	-	1	-	-

Pre requisites: Finite Element Analysis basic concepts

Course Contents:

1. **Advanced 1D element**: Space truss element, 2D and 3D frame elements, multipoint constraints using Penalty method. **6 Hrs**
2. **Isoparametric elements**: Gauss quadrature (1 or 2 point formulae in 1 and 2 dimensions), Plane 4 node quadrilateral element, axisymmetric 3-node triangular isoparametric element. **8 Hrs**
3. **Three-Dimensional Finite Elements**: Linear tetrahedron and brick elements. **6 Hrs**

4. **Bending of flat plates:** Summary of plate bending theory, Kirchhoff theory (deformation and moment-curvature relations), Kirchhoff finite elements for plates, boundary conditions. **8 Hrs**
5. **Analysis of free Vibration:** Computation of Eigen Values and vectors, Dynamic equation, concept of mass matrix (consistent mass matrix and HRZ lumping scheme), Application of FEM in determination of natural frequency and mode shape of axial and transverse vibrations in 1-D problems. **9 Hrs**
6. **Transient vibration Analysis:** Mode superposition scheme and direct integration method. **8 Hrs**
7. **Miscellaneous topics:** Convergence requirements, Pascal triangle, Pascal tetrahedron Variational crimes, patch test. **7 Hrs**

Reference Books:

1. R.D.Cook et al, “Concepts and Applications of Finite Element Analysis” 4th edition, Joln Wiley & Sons, inc, 2005.
2. T.R.Chandrapatla and A. D. Belegundu, “Introduction to finite Elements in Engineering”, 2nd edition, Prentice Hall of India, New Delhi, 2001.
3. P.Seshu, “Text book of Finite Element Analysis”, Prentice Hall of India Pvt. Ltd.,New Delhi, 2009
4. Rao S.S., The finite Element Method in Engineering, Butterworth-Heinemann, 4th edition, 2005, Delhi, 4th edition, 1997-98.