Academic Program: UG

Academic Year 2019-20

Syllabus

V & VI 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 V& VI 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)

Engineering Graduates will be able to:

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)

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

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

V Semester

Course code	Course title	Teaching		Examination				
				CIE	Theory (SEE)		Practical (SEE)	
		L-T-P (Hrs/week)	Credits	Max. Marks	*Max Marks	Duration in hours	Max. Marks	Duration in hours
15UMEC500	Management, Economics & Intellectual Property Rights.	4-0-0	4	50	100	3		
15UMEC501	Kinematics of Machines	3-2-0	4	50	100	3	-	-
15UMEC502	Turbo machines	3-2-0	4	50	100	3	-	-
15UMEC503	Machine Design – II	3-2-0	4	50	100	3	-	-
15UMEL504	Fluid Mechanics and Fluid Machinery Lab	0-0-2	1	50	-	-	50	3
15UMEL505	Machine shop Practice	0-0-2	1	50	-	-	50	3
15UMEEXXX	Elective – 1	4-0-0	4	50	100	3		
15UMEEXXX	Elective – 2	4-0-0	4	50	100	3		
	Total	21-6-4	26	400	600	-	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	Elective Courses
15UMEE525	Refrigeration & Air conditioning
15UMEE526	Internal Combustion Engines
15UMEE527	Tool Design Engineering
15UMEE528	CAD / CAM (Computer aided design/Computer aided manufacturing)
15UMEE529	Theory of elasticity
15UMEE530	Deign of IC engines

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L: Lecture **T**: Tutorials **P**: Practical
*SEE for theory courses is conducted for 100 marks and reduced to 50 marks

VI 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
15UMEC600	Finite Element Methods	3-2-0	4	50	100	3	-	-
15UMEC601	Heat Transfer	3-2-0	4	50	100	3	-	-
15UMEC602	Dynamics of Machinery	3-2-0	4	50	100	3	-	-
15UMEL603	Heat Transfer Lab	0-0-2	1	50	-	-	50	3
15UMEL604	CEA / CAM Lab (Computer Aided Engineering Analysis / Computer Aided Manufacturing)	0-0-2	1	50	-	-	50	3
15UMEL605	Mini Project	0-0-6	3	50	-	-	50	3
15UMEEXXX	Elective – 3	4-0-0	4	50	100	3	-	-
15UMEEXXX	Elective – 4	4-0-0	4	50	100	3	-	-
	Total	17-6-10	25	400	500	-	150	-

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

Elective courses

Course Code	Elective Courses
15UMEE625	Engineering System Design
15UMEE626	Organizational Behavior
15UMEE627	Jet Propulsion
15UMEE628	Solar Energy
15UMEE629	Advanced Fluid Dynamics
15UMEE630	Tribology & Bearing Design
15UMEE631	Design and Analysis of experiments
15UMEE632	Design & Drawing of Assemblies

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: Industrial visit/internship for every student during the vacation after VI semester and assessment of the report to be done during the VII semester with 02 credits.

V Semester

15UMEC500	Management, Economics & Intellectual Property Rights	(4-0-0) 4

Contact Hours: 52

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

1. Patent, copyright and trade secret protection.
2. Role and importance of intellectual property rights in contemporary business environment.
3. Historical development of software patents.
4. Consequences of software piracy on software developers and the role of relevant enforcement organizations.
5. Role of entrepreneurship in modern economy and entrepreneurial opportunities.

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	Trace the historical development of management thought and approaches to management.	-	1	-
CO-2	Identify the functions of a manager and critically analyze their importance in organizations.	11	2	-
CO-3	Demonstrate the ability to recognize a business opportunity that fits the individual student and launch entrepreneurial career.	10	11	8
CO-4	Explain characteristics of SSI and identify the various Government agencies supporting SSI.	11	6,13	-
CO-5	Define problems and the present environment for existing business and carry out the feasibility studies.	10,11	8	13
CO-6	Explain different forms of intellectual properties rights.	8	-	-

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	2.7	-	1.5	-

Pre requisites: English, Communication skills.

Course Contents:

I) Management:

1. Engineering and Management: Historical Development of Engineering, Management, Engineering, Management and Engineering & Management a synthesis. **3 Hrs**
2. Planning, Forecasting and Decision Making: Nature of Planning, the foundation of planning, some planning concepts, forecasting, nature of decision making, management science, tools for decision-making. **3 Hrs**
3. Organizing and staffing: nature of organizing, traditional organizational theory, technology and modern organization structures, staffing technical organization, authority and power; delegation, meeting & committees. **3 Hrs**
4. Motivating: Motivation, leadership, motivating and leading technical professionals. **3 Hrs**
5. Controlling: process of control, financial controls and non-financial controls. **3 Hrs**

II) Entrepreneurship and Economics:

1. Foundations of Entrepreneurship: Meaning of entrepreneur, functions of entrepreneur, types of entrepreneur, concept of entrepreneurship, role of entrepreneurs in economic development, barriers of entrepreneurship. **3 Hrs**
2. Small Scale Industry: Definition, characteristics, objects, role of SSI in economic development, advantages of SSI, steps to start a SSI, impact of liberalization, privatization, and globalization on SSI, definition of ancillary and tiny industry. **3 Hrs**
3. Government and Institutional Support: Nature of support of government, objectives and functions of SISI, SIDBI, DIC, single window agency, KIADB, KSSIDC, KSFC. **3 Hrs**
4. Basic Costs: Material, Labour, Overheads, Fixed and Variable costs, Break Even Analysis, Make or Buy, Buy or Process, shut down or continue decisions. (Numericals) **4 Hrs**
5. Time value of Money: Future and Present value of single sum and Annuities and their Applications like EMI calculation, Net Present Value of an Investment. (Numericals) **5 Hrs**
6. Concept of depreciation: Straight line method, Written down value, Simple problems. **3 Hrs**
7. Preparation of Project: Meaning of project identification, project report, contents and formulation, identification of business opportunities, feasibility studies, types and purpose. **2 Hrs**

III) Protection of Intellectual Property:

1. Introduction: Meaning and forms of intellectual property right, competing rationale for protection, international conventions, world court. **2 Hrs**

2. Copyright: Meaning of copyright, content of copy right, ownership and rights, period of copyright, assignment and relinquishment of copyright, license, infringement of copy right, fair use, offenses and penalties. **2 Hrs**
3. Patents: Concept of patent, patentable inventions, procedure for obtaining patent, rights and obligations of patent holders, infringements and remedies, offenses and penalties. **3 Hrs**
4. Industrial Designs: Definition of design, procedure for registration, rights conferred by registration, infringements, Value of creating Design. **3 Hrs**
5. Trademarks – concept, significance, Functions, Features. **2 Hrs**
6. Term Paper on commercializing a hypothetical product/process/software by proper evaluation of relevant existing patents/copy rights. **2 Hrs**

Reference Books:

1. Thomas W. Zimmers - Essentials of Entrepreneurship & small business management, 5th edition, PHI, 2011.
2. Daniel L. Babcock – Managing Engineering and Technology, 4th edition, PHI.
3. Peter Drucker – The Practice of Management
4. Cost Accounting by Khan & Jain .TMH -2013, Edition
5. N.K. Acharya – Text book on Intellectual Property Rights, 4th edition, Asia LawHouse.

15UMEC501	Kinematics of Machines	(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 mechanisms, their applications and kinematic analysis.
2. Solving problems involving kinematic analysis of mechanisms.
3. Different types of cams/followers/follower motion pattern and their application & to draw the cam profile.
4. Types of gears/gear trains, their terminology and derivations connected to gears, law of gears and application of gears/gear trains and to solve related problems.
5. Basics of synthesis of mechanism.

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 types of mechanisms/inversions of four bar chain and slider chain and their applications.	1	-	-
CO-2	State the laws/theorems/terminology connected to the various mechanisms.	1	-	-
CO-3	Calculate the velocity/accelerations of various members of the mechanism/cam followers by graphical or analytical method.	1	2	-
CO-4	Design and draw cam profiles for different follower motions and calculate the velocity and accelerations of followers.	1	2	3
CO-5	Calculate the various gear parameters and estimate speeds and torques in gear trains.	1	2	-
CO-6	Explain the rudiments of synthesis of mechanism.	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	1	-	-	-	-	-	-	-	-	-	-	-

Pre requisites: Basics of Mechanical Engineering, Basic Science, Engg. Mechanics

Course Contents:

1. **Introduction:** Mechanisms and machines, Kinematic pairs-types, degree of freedom, Kinematic chains and their classification, Kinematic inversions of 4-bar chain, single slider, double slider crank chains, Special mechanisms – Quick return motion, intermittent motion mechanisms, Straight line mechanisms. Steering mechanisms used in automobiles. Ackermann steering gear mechanism, Davies steering gear mechanism, condition for correct steering. **8L+2T Hrs**
2. **Velocity and acceleration in mechanisms:** *Velocity analysis by* Instantaneous center method, *Aronhold-Kennedy Theorem of three centers*, Relative Velocity Method and vector method. Acceleration analysis – Tangential and normal components, Corioli's component of acceleration.(One term work sheet of minimum 4 problems). **9L+4T Hrs**
3. **Cams:** Definitions, types of cams and followers, *follower motion analysis*, Layout of cam profiles for different follower motions.Cams with specified contours.(One term work sheet of minimum 4 problems). **7L+3T Hrs**
4. **Gears:** Involutes Spur Gears – Terminology, Law of gearing, Velocity of sliding, contact ratio, path of contact, arc of contact, interference in gears, Involutometry, comparison between involute and cycloidal gears, minimum number of teeth to avoid interference. Helical gears, Interference in rack and pinion. Helical bevel gear terminology and applications. **6L+2T Hrs**
5. **Gear trains:** Types of gear trains, epicyclic gear trains, Speed and direction of different gears in gear trains, *Torques in epicyclic gear trains*, Differential gear box. **6L+3T Hrs**
6. **Introduction to synthesis of mechanisms:** Type, Number and dimensional synthesis, Function generation, Path generation and rigid body guidance. **2 Hrs**

Reference Books:

1. Shigley, J.V and Uicker JJ, Theory of Machines and Mechanisms, 2nd edition, Mc-Graw Hill, 1995.
2. John J Uicker, Gordon R Pennock, Joseph E Shigley, Theory of Machines and Mechanisms, 3rd edition, Oxford publisher, 2009.
3. Dr. R K Bansal and Dr. J S Brar, Theory of Machines, 5th edition, Laxmi Publications, 2015.
4. S.S. Rattan, Theory of Machines, 4th edition, Tata Mc-Graw hill, 2014.
5. R.S. Khurmi, Theory of Machines, 14th edition, S.Chand Publications, 2005.

15UMEC502	Turbo-machines	(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 in fluid mechanics of turbo machinery.
2. Principles for all types of turbo machines. Dimensional analysis, Euler's turbine equation and velocity diagrams will be used to correlate, classify and predict machine performance.
3. Principles and techniques in velocity diagrams for turbines and pumps.
4. General mechanisms for flow through turbo machine rotors and stators.

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 of turbo machines and differentiate turbo machines & positive displacement machines.	-	1	-
CO-2	Derive Euler equation for turbo machines with velocity triangles.	-	1,2	-
CO-3	Analyze different performance parameters and characteristic curvesof turbo-machines.	-	1,2	-
CO-4	Explain steady flow of steam through nozzles and solve problems using Mollier diagram & steam tables.	-	1,2	-
CO-5	Analyze different performance parameters of steam turbines.	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	2.2	2.3	-	-	-	-	-	-	-	-	-	-	-	-

Pre requisites: Basic Thermodynamics concepts, Fluid Mechanics

Course Contents:

1. **Introduction:** Classification of Turbo machines, Positive displacement machines and comparison, Static & stagnation properties- efficiencies of expansion & compression processes (with numerical problems). **10 Hrs**

2. **Energy Exchange in a Turbo machine:** Euler's equation for a Turbo machine-Impulse & Reaction machines- Axial flow and radial flow machines-

utilization factor, degree of reaction & efficiencies of Turbo machines (with numerical problems). **5L+ 2T Hrs**

3. **Hydraulic Turbines:** Classification of hydraulic turbines- Pelton wheel - Francis turbine- Kaplan turbine .Draft tubes. Cavitation, characteristic curves. **8L+ 4T Hrs**
4. **Centrifugal Pumps:** Main Parts of centrifugal pump, basic terms and definitions, work done, minimum speed for starting centrifugal pump, Classifications- Performance characteristics of centrifugal pumps. Multistage pumps characteristic curves. **6 Hrs**
5. **Flow Through Nozzles & Blade Passages:** Steady flow through nozzles- area changes- effect of friction- characteristics of converging- diverging nozzles (with numerical problems). **5 Hrs**
6. **Steam Turbines:** Impulse turbines, Staging - expression for work done in a 2 stage velocity compounded turbine- effect of blade & nozzle losses- Reaction staging- reheat factor- performance characteristics, problems using Mollier's chart & introduction to gas turbines. **4L+2T Hrs**
7. **Centrifugal Blowers & Compressors:** Centrifugal blower - types- size & speed- vane shape & efficiency- vane shape & stresses- vane shape & characteristics- actual performances characteristics- slip. **4L+2T Hrs**

Reference Books:

1. V Kadambi & Manohar Prasad, Energy conversion- vol 3,Turbomachinery, Tata McGraw Hill, 2008
2. S. M.Yahya, Turbines - Compressors & fans, 2nd edition, Tata McGraw Hill, 2000
3. Dixon S.L, Fluid Mechanics & Thermodynamics of Turbo machinery, 5th edition, Elsevier, 2005.
4. Dr. G. Gopalkrishnan & Dr. D. Prithviraj, A Treatise on Turbo machines, Scitech, 1st edition, Publications, 2005

15UMEC503	Machine Design-II	(3-2-0) 4

Contact Hours: 52

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

1. Different types of engineering materials used in power transmission elements.
2. Concepts of designing various machine elements and also power transmission elements
3. Use of design data handbook and BIS standards.
4. Designing commonly used power transmission elements such as gears, belts, chains and bearings.

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 design data book for choosing suitable standard materials and appropriate formulae/ standards for a given machine design applications	1,3,10	-	-
CO-2	Design helical and leaf springs subjected to various conditions of static loading and fatigue loading	2,10	-	-
CO-3	Solve problems on design of curved beams of different cross sections	2,3,10	12	-
CO-4	Design spur, helical, bevel and worm gears used for power transmission	2,3,10	12	-
CO-5	Design/select power transmitting machine elements like- flat belt, V-belt, chain drives, clutch drives and brakes	1,3,10	9,12	-
CO-6	Design and select suitable bearing(journal/ball) based on various loading conditions of hydrodynamic lubrication	1,2,3,10	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	3	3	-	-	-	-	-	2	3	-	2	-	-

Prerequisites: Strength of materials, Machine design I, Theory of machines.

Course Content:

1. **Design of springs:** Types, classification, terminology, expression for load and deflection for helical springs of round wire section (with derivations). Design of helical springs for static load & for variable loads, leaf springs (no

derivation) – expression for stress & deflection concept of uniform stressed beams leaf springs pre stressed springs – problems. **4L+2T Hrs**

2. **Curved beams:** Comparison between straight and curved beams, problems in crane hook and C-clamp (No derivations) – expression for stress. **1L+1T Hrs**
3. **Gears:** Classification, Force analysis for spur gears basic Lewis equation, (Derivation) concept of weaker gear. Dynamic load, Wear load & Endurance load concepts – problems. **6L+2T Hrs**

   Helical gears: Terminology formative number of teeth, Design of Helical gears – Problems. **2L+1T Hrs**

   Bevel gears: Terminology – Final design equations (No derivation) problems. **2L+1T Hrs**

   Worm gears: Terminology Strength equations, Heat dissipation considerations Efficiency, design problems. **3L+2T Hrs**
4. **Belt & Chain drives**:

   Flat belt: problems – (no derivations) calculations of width & thickness with centrifugal tension. **1L+1T Hrs**

   V-Belt: Selection of V – belt **1L+1T Hrs**

   Chain drives: Selection of chains – Power transmitting chains **1L+1T Hrs**
5. **Clutch drives:** Concept of uniform pressure & wear – determination of Torque & Power for single & multiplate clutches – *Cone clutches* (no derivation) – problems. **1L+1T Hrs**
6. **Brake:** Band brake for different configurations –*Shoe brake*- problems. **1L+1T Hrs**
7. **Bearings:** Journal bearings - Mechanism of Hydrodynamic Lubrication – Heat generated & Heat dissipated, Sommerfield number, bearing modulus – problems. **4L+2T Hrs**
8. **Ball bearings:** Classification – concept of equivalent load, life determination, problems. **1L+1T Hrs**
9. **Power Screw:** Screw jack design & drawing. **1L+1T Hrs**
10. **Engine parts:** Connecting rod for an IC engine design & drawing. **3L+2T Hrs**

Note: Activities/Topics for self-study to be decided by course instructor.

Reference Books:

1. Robert L. Norton, Machine Design an integrated approach; 2nd edition, Pearson Education Asia University Press, 2013
2. Joseph Edward Shigley, Machine Design; 6th Edition, TMH, 2006.
3. Black and Adams, Machine Design, McGraw Hill, 1968
4. Malleev and Hartman, Machine Design, CBS Publishers, 1983

15UMEL504 Fluid Mechanics and Fluid Machinery Lab (0-0-2) 1

Contact Hours: 25

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

1. Knowledge of the fluid mechanics and turbo machinery.
2. Fluid flow measuring devices
3. Performance assessment, main and operating characteristics of Turbo machines

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	Conduct experiments on flow measuring devices to determine the rate of flow.	2	4	1,3
CO-2	Determine experimentally the different losses in pipe flow.	2	4,1	3
CO-3	Conduct the experiment on turbines, blowers and pumps to draw performance curves and interpret results.	2	4	1,3,9
CO-4	Study the force exerted on different types of vanes by a jet.	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	1.5	3	1	2	-	-	-	-	1	-	-	-	-	-

Course Content:

Fluid Mechanics & Machinery Lab

1. Measurement of pressure using Manometers (high and low pressure measurements).
2. Determine the co-efficient of discharge of Venturimeter.
3. Determine the co-efficient of discharge of Orifice meter.
4. Determine the co-efficient of discharge of Notch.
5. Determine the minor losses & major losses.
6. Impact of Jet.
7. Performance test on Reciprocating Pump.
8. Performance test on centrifugal pump (table top).
9. Performance test on centrifugal pump (high discharge).
10. Performance test on Pelton turbine.
11. Performance test on Kaplan turbine.
12. Performance test on Francis turbine.
13. Performance test on centrifugal blower.
14. Flow visualization using Wind tunnel.

15UMEL505	Machine Shop Practice	(0-0-2) 1

Contact Hours: 25

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

1. The basics of metal cutting
2. The basics of various machine tools
3. The basics of various modern machining processes
4. The basics of cutting tool materials
5. Fundamentals of machining, machine tools & their elements
6. Theory of metal cutting, single point cutting tool nomenclature in various systems, orthogonal & oblique cutting and tool wear.
7. Different cutting tool materials & their properties and machinability aspects.
8. Different machine tools like lathes, milling machine drilling, grinding, broaching machines and various modern machining processes
9. Introduction to CNC Machines

Course outcomes (COs): Upon the completion of the course, the student should be able to

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	Perform basic operations in Lathe, Milling, Shaper & grinding machines.	1	9	--
CO-2	Select proper machining process or combination of machining processes to get a required product.	1	9	3
CO-3	Determine the time required for conversion of raw material into finished product as per the product drawing.	1	--	4
CO-4	Select a proper tool based on the type of material to be machined and the machine.	1	--	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	3	--	1	1	--	--	--	--	2	--	--	--	--	--

Pre requisites: Manufacturing Technology

Course Contents:

1. **Lathe**: Plain Turning, Taper Turning. Step Turning, Thread Cutting. Facing, Knurling, Eccentric Turning. (Demo)

2. **Milling machine:** Key way and gear teeth using horizontal or vertical milling machines.
3. **Shaping machine:** Cutting of V-groove / Dovetail /Rectangular groove.
4. Demonstration of Cylindrical and Surface grinding.
5. Demonstration on CNC machine – setup of the machine and exercises comprising of Drilling, Step milling, Profile milling etc.

15UMEE525	Refrigeration and Air-Conditioning	(4-0-0) 4

Contact Hours: 52

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

1. Vapour compression systems of single stage and multi stage and carnot Vapour compression cycle and effect of volumetric efficiency and pressure change and optimum inter mediate pressure, sub-cooling and super heating on COP.
2. Principles of Vapour absorption and water, air refrigeration.
3. Uses and properties of refrigerants also application of secondary refrigerants.
4. Principles of psychrometry and basic processes of air conditioning.
5. Cooling and heating load calculation for air-conditioning and refrigeration.
6. Applications of refrigeration.

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 method and cycles of refrigeration and air conditioning systems with applications	-	1, 2	-
CO-2	Explain air, water, VAR, VCR & Non-conventional refrigeration systems and basic air-conditioning processes	1,2	-	-
CO-3	Calculate COP of air, single & multi stage VCR and basic air conditioning systems.	-	1,2	-
CO-4	Discus refrigerants used & their property, applications and classifications with the nomenclature.	1	-	-
CO-5	Estimate heating, cooling loads calculation for basic design of refrigeration and air conditioning systems.	1,2	-	-
CO-6	Demonstrate use of P-H , refrigeration table, Psychrometry chart for design / analysis of basic refrigeration and A/C systems	-	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	2.5	3	-	-	-	-	-	-	-	-	-	-	-	-

Pre-requisites: Basic and applied thermodynamics and basic Engineering mathematics

Course Contents

1. **Introduction:** Definition, Necessity, Methods and refrigeration of refrigeration & air conditioning. Carnot refrigeration cycle.vapour compression cycle- Use of p-h chart, Refrigeration property tables. **6 Hrs**

2. **Air Refrigeration:** Brayton refrigeration cycle- Aircraft refrigeration system – necessity Classification- Basic aircraft refrigeration cycle- Boot strap air refrigeration system Regenerative air refrigeration system- reduced ambient air refrigeration system. **7 Hrs**

3. **Single and Multi stage VCR:** Single stage systems - Effect of pressure changes on COP- Effect of sub-cooling and super heating- actual vapour compression cycle. Two stage with given intermediate pressure- Effect of volumetric efficiency on multi staging- optimum inter stage pressure- Cascade refrigeration system- multi evaporator system- Booster system. **10 Hrs**

4. **Water Refrigeration:** Introduction- principle of operation- Centrifugal refrigeration- Steam jet refrigeration. **Vapour Absorption system:** Simple and Improved Ammonia absorption systems- Maximum COP- Lithium Bromide absorption system- Electrolux system. **5 Hrs**

5. **Vortex, Pulse tube &Thermoelectric refrigeration system:** Theory and thermodynamic analysis basic principle of operation, advantages, disadvantages and comparison with VCR& VAR with Vortex, pulse tube and thermoelectric refrigeration. **Refrigerants:** Introduction**,** Classification- Nomenclature- Desirable properties- Common refrigerants- Application- Secondary refrigerants. **6 Hrs**

6. **Psychrometry of Air Conditioning Processes:** Mixing process- Basic processes in conditioning of air- Psychrometric process in Air conditioning equipment- Simple air conditioning system- State and mass rate of supply air- summer air conditioning – Apparatus dew point- winter air conditioning. **6 Hrs**

7. **Cooling and Heat load Calculations:** Selection of design temperatures- Sources of heat load- Capacity of Refrigeration system- Cooling load calculations- Heat transfer through structure- Solar radiation- Electrical appliances- Infiltration and Ventilation- Heat generation inside the conditioned space- Air conditioning and cooling loads and apparatus selection- Heating load calculations. **6 Hrs**

8. **Applications: Food preservation:** Cold storage- Freezers- Ice- Ice cream manufacture and Dry ice- water coolers- Liquefaction- All the year–round air conditioner- Poultry products- Fishery products- Bakeries- Freeze drying. **6 Hrs**

Reference Books:

1. Manohar Prasad, 'Refrigeration and Air-conditioning', 2nd edition, Wiley Eastern Publication, 2010
2. C. P. Arora, 'Refrigeration and Air-conditioning', 2nd Edition, Tata McGraw Hill Publication, 2000.
3. L. N. Mishra - Vani, Refrigeration and Air-conditioning, Educational Books, New Delhi- 1985
4. Jordon and Priester, Refrigeration and Air conditioning, PHI Publication- 1995

15UMEE526	Internal Combustion Engines	(4-0-0) 4

Contact Hours: 52

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

1. Different types of internal combustion engines, principles of operations, parameters that define engine performance and efficiency aspects.
2. Thermodynamics of theoretical cycles.
3. Importance of fuel-air mixture preparation processes and fuel supply system in gasoline and diesel engines.
4. Spark-ignition (SI) and compression ignition (CI) engine combustion, SI and CI engine knock, and combustion chambers.
5. Diesel combustion and diesel engine emissions formation and control.
6. Overall engine operating characteristics: supercharging, turbo-charging, variable-valve-timing, gasoline direct injection, multifuel and dual fuel engine and Low Temperature Combustion (LTC) systems.
7. Understanding the need and working of Electric, Hybrid and Autonomous vehicles.
8. Theoretical and practical problems faced in IC engines.

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	Acquire the knowledge of combustion phenomena in IC engines and factors affecting the combustion.	1	2	---
CO-2	Discuss various combustion chambers of IC engines and highlight their importance.	1	2	---
CO-3	Describe the need for different air-fuels ratios and predict their effects on the performance and fuel economy trends of IC engines.	1, 3	2	---
CO-4	Describe the need and working of Electric, Hybrid and Autonomous vehicles	1	---	---
CO-5	Compare effect of alternative fuel properties on the performance of IC engine and fossil fuels.	1	---	7
CO-6	Evaluate emission characteristics and methods used to reduce them.	1	2, 6	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	3	---	---	2	1	---	---	---	---	1	---	---

Pre-requisites: Basic thermodynamics, applied thermodynamics, Basic Science, Flow analysis

Course Contents:

1. Introduction: Fuel Air Cycles, Variations in specific heat, Dissociation, Simple problems. **4 Hrs**
2. Combustion in S. I. Engines: Ignition limits- Stages of combustion in S. I. Engine, Effect of engine variables on ignition lag and flame propagation , Detonation – theory of detonation, Effect of engine variables on detonation, Octane number, Control of detonation, S.I. engine combustion chambers. **7 Hrs**
3. Combustion in C.I Engine: Stages of combustion in C. I. engine, Variables affecting delay period, Diesel knock, Effect of engine variables on knocking, methods of controlling knocking, Cetane number, Diesel engine combustion chambers, Difference between SI and CI Engine. **8 Hrs**
4. **Carburetion and Fuel Injection:**
   SI Engines: Properties of air fuel mixture, mixture requirements for steady and transient operations, Fuel consumption loop, carburetor, Petrol injection– numerical problems,
   C. I. Engines: Requirements of a diesel injection system, Types of injection system, Fuel pump, Fuel injectors, fuel nozzles, quantity of fuel per cycle, Size of orifice, Effect of orifice diameter, Fuel spray behavior, Overall spray structure, Spray penetration, Droplet size distribution, spray formation, Injection pressure, and spray direction. **8 Hrs**
5. Testing of an I.C Engines: Performance parameters, Measurement of air and fuel consumption, Heat balance sheet. **6 Hrs**
6. **Electric, Hybrid and Autonomous vehicles:**
   Meaning of Electric, Hybrid and Autonomous vehicle, Architecture of series, parallel and combined series-parallel hybrid electric merits and demerits, Components of Electric and hybrid vehicles, Regenerative braking, Drive systems, AC and DC motors, Motor Controllers and Control System, Automotive Battery Requirements, Classification of Batteries, type of Batteries (Li-Ion, Metal-hydride, Ni-Cd etc), Battery materials. **8 Hrs**
7. Alternative Fuels for I. C. engine: SI and CI Engine fuels properties. Alternative fuels for SI and CI engine. Performance of SI and CI engine when operated on alternative fuels. Dual fuel engine, factors affecting combustion of dual fuel engine, Advantages of Dual fuel engine. **6 Hrs**
8. Pollution from I. C. Engines: Pollutants from I.C engines, effect of mode of operation, Emission control devices, Diesel emissions – Diesel smoke and control, diesel odour and control, Comparison of diesel and gasoline emissions. **5 Hrs**

Reference Books:

1. John B Heywood, IC Engine Fundamentals, International Editions, Automobile Technology Series, McGraw hill, 2010.
2. M. L. Mathur& R. P. Sharma, I.C. Engines, DhanpatRai& Sons, New Delhi, 2011
3. Edward F.Obert, I. C. Engines and Air pollution, Harper & Row Publishers, Newyork, 1973.
4. V. Ganesan, I.C. Engines and Combustion 2nd edition, Ninth reprint, TMH Publishing Co. Ltd, New Delhi,1999
5. Willard W. Pulkrabek, Engineering fundamentals of the I. C. Engines, PHI Pvt. Ltd., New Delhi, 2002

15UMEE527	Tool Design 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. Special class of manufacturing methods such as sheet metal component manufacturing and plastic components manufacturing
2. Designing of press tools and moulds.
3. Designing of Jigs & Fixtures.
4. Economics of Jigs & Fixtures
5. Importance of Drafting and drafting procedure
6. Requirements of Production Drawings

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 tool operations, tool related parameters.	1	-	-
CO-2	Illustrate the design for working of jigs/fixtures/press tools/moulds/gauges or their parts with sketches.	1	-	-
CO-3	Design the Jigs/Fixtures/Press tools/moulds and draw or sketch the assembly depicting the functional aspects.	1	3	-
CO-4	Draw the strip layout required to design press tools.	1	3	-
CO-5	Calculate the design parameters for various press tools using relevant formulae.	1	2	-
CO-6	Explain the principles leading to the design of jigs/fixtures/press tools/moulds/gauges or their parts.	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	3	2	2	-	-	-	-	-	-	-	-	-	-	

Pre-requisites: Basics of Engineering Drawing, Machine Drawing, Machine Design, Machining methods.

Course Contents:

1. **Introduction to tool design:** Tooling, requirements of a tool designer, General tool design procedure, Drafting and Design techniques, Tool Making practice, Tool materials and heat treatment. **4 Hrs**

2. **Locating and clamping methods:** Introduction, Basic principles of location, Locating methods and devices, Basic principles of clamping, Types of clamps. **8 Hrs**

3. **Design of drill Jigs**: Introduction, definition of drill jig, Types of drill jigs- Latch/leaf jig, Plate jig, Channel jig, Box jig, Tumble jig, Post jig, Indexing jig, Drill bush, Design of drill jig for the given component(One term work sheet for any one jig design). **8 Hrs**

4. **Design of Fixtures:** Introduction, Types of fixtures- Vise fixture, Milling fixture, Lathe fixture, Boring and Broaching fixture, Grinding fixture, Economics of fixtures (One term work sheet for any one fixture design). **8 Hrs**

5. **Design of sheet metal Blanking and Piercing Dies:** Introduction, Die cutting operations, Power press types, Cutting action in punch and die operation, Die clearance, Cutting force and Press force calculation, Types of Press tools- Progressive, Compound, Combination, Inverted dies, Die design fundamentals, Blanking and Piercing die design construction, Pilots, Strippers and pressure pads, Strip layout, Economy factor Design exercises on blanking and piercing dies for simple components **(One term work sheet on design of progressive die/ compound die).** **10 Hrs**

6. **Design of sheet metal Bending, Forming and Drawing Dies:** Introduction, Bend allowance-formula, Spring back, Methods to overcome spring back, Blank length calculation, Bend force calculation, Principle of V bending- Air bending and bottoming out, Edge bending, U- bending, Drawing Dies, Drawing operations, Meta flow, Variables affecting metal flow, Determination of blank size and drawing force, Single action and double action draw dies. **8 Hrs**

7. **Design of Moulds:** Moulding process, Types of Plastics-Thermoplast and Thermoset resins, Classification of moulding- Injection moulding, Compression moulding, Injection Moulding machine set up, Details of Injection Moulding Tool (single cavity, two cavity and multi cavity). **6 Hrs**

Reference Books:

1. C. Donaldson, G.H. LeCain, V.C. Goold, Tool design, 3rd edition, Tata McGraw Hill Pub. 2010
2. M H A Kempster, Introduction to Jig and Tool Design, ELBS, 1974.
3. J.R. Paquin& R.E. Crowley, Die Design Fundamentals, Industrial Inc Press
4. R.G.W. Pye, Injection Mould Design, 3rd edition, Godwin Books, Feb 1983

15UMEE528	CAD/CAM (Computer aided design/Computer aided 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 CAD/CAM.
2. Automation concepts, graphics & modeling.
3. Latest CAD/CAM technologies and FEA.

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 CAD, CAM, product cycle in CAD/CAM environment, automation and hardware for CAD.	1,	--	--
CO-2	Compare network topologies, various graphic standards and geometric modelling techniques.	1,2	--	--
CO-3	Demonstrate the 2-D transformations, 3-D transformations, windowing, viewing transformations with appropriate examples.	1,2	4	--
CO-4	Analyze engineering problems for structural, dynamic, thermal, fluid loading conditions using finite element method.	2,3	--	1
CO-5	Discuss the various NC, CNC, DNC, CNC tooling systems and develop CNC programs for milling and turning operations.	1,2	--	--
CO-6	Assess the best robot configuration for the material handling systems and select an appropriate sensor for the given case.	3	--	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	2.3	2.6	3	2	-	-	-	-	-	-	-	-	-	-

Pre requisites: Basic Manufacturing Process, Engineering mathematics.

Course Contents:

CAD

1. **Fundamentals of CAD:** Definition of CAD/- Product cycle in conventional and CAD/CAM environment- Automation & CAD/CAM- Design Process (Application of computers for design) - Advantages & Disadvantages of CAD.

3 Hrs

2. **Hardware for CAD and Networking:** Design Workstation-Architecture of typical graphics workstation, Network and its topologies. **4 Hrs**

3. **Computer Graphics:** Software configuration of a Graphic system- Graphical Kernel System- Graphic standards- Function of Graphics package. **5 Hrs**

4. **Geometric Modeling:** Construction of Geometry- Data structures- Data base for Graphic modeling- CSG- Boundary representation- parametric modeling variant approach- Wire frame- surface & solid modeling advantages and disadvantages. **5 Hrs**

5. **Transformations:** 2-D Transformation- 3-D Transformation- Concatenation- Homogeneous Transformation- Clipping & Windowing- Viewing Transformations- Windowing Transformation. 3-D modeling Concepts. **4 Hrs**

6. Introduction to FEA: Preprocessing- Analysis- Post processing- Discreatization- Element types- Nodes- Degrees of freedom- constraints- Loads. **5 Hrs**

CAM

7. Introduction NC- CNC- DNC- & CNC- Elements- CNC machining centers- CNC Turning Centers- High speed machine tools- MCU & Supporting Systems. **4 Hrs**
8. **CNC Tooling -** Turning Tool geometry- Milling tooling- systems- Tool presetting - ATC Work-holding devices. **4 Hrs**
9. **CNC Programming -** Part program fundamental- Manual part programming a) milling b)Turning- Advanced part programming Methods- Parameters- Looping & Jumping- Subroutines and Macros. **10 Hrs**
10. **Computer Aided part programming -** Introduction to CAM simulation packages. **3 Hrs**
11. **Material handling systems –** Introduction to Robots-Anotomy, Congifurations, Work volume, Robot end effectors, Robotic Sensors, applicatrions.AGVs - Introduction to FMS & CIM- GroupTechnology& CAPP. **5 Hrs**

Reference Books:

1. P.N. Rao, CAD/CAM Principles and Application, Tata Mc Grew Hill 2010.
2. Grover, CAD/CAM, Tata Mc Grew hill, 2003.
3. Ibrahim Zeid, CAM/CAM, 2nd edition, Tata Mc Grew hill- 2010
4. Newman and Sproull, Principles and Interactive Computer Graphics, Tata Mc. Grew Hill, 1995.

15UMEE529	Theory of Elasticity	(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 stresses, strains, equilibrium, compatibility and governing equations.
2. Solving problems in plane stress, plane strain, torsion and bending.
3. Concepts of three-dimensional 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	Analyze stress, strain & boundary conditions, derive 2-D equations of equilibrium, compatibility conditions & compute stresses.	1,2	3	5,12
CO-2	Solve simple problems in Cartesian co-ordinates using Biharmonic Equation and Airy's Stress Function.	1,2	6	5
CO-3	Solve problems on Thick cylinders & shrink fits using polar coordinates	1,3	4	10
CO-4	Compute Stress concentration in an infinite plate with circular hole subjected to uniaxial load & Stresses in rotating Hollow and solid discs and cylinders.	1,2	7	--
CO-5	Derive equations & solve problems in Torsion of solid circular and elliptical bars- , torsion in thin tubes & describe membrane analogy	1,2	--	10
CO-6	Describe Uniqueness theorem- Saint Venant's Principle - Principal of super position & Reciprocal theorem	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	3	2	2	1	2	2	-	-	1	-	2	-	-

Pre requisites: Engineering Mathematics, Strength of Materials.

Course Contents:

1. Stress: Definition notation and sign convention of stress; Equilibrium equations; Stress components on an arbitrary plane; Principle stresses- maximum shear stress, octahedral stresses- boundary conditions. **8 Hrs**

2. Strain: Definitions – strain - displacement relations - compatibility equations Principal strains- Generalized Hooke's law. **7 Hrs**

3. Two dimensional problems in Cartesian co-ordinates: Plane stress and plane strain conditions- Bi-harmonic equation- Investigation of Airy's stress function for simple beam problems- Solution for cantilever beam under end load and simply supported under uniformly distributed load. **6 Hrs**

4. General equations in polar co-ordinates: Thick cylinder under pressure – Analysis of shrink fit. **6 Hrs**

5. Stress concentration in an infinite plate with circular hole subjected to uniaxial load. **8 Hrs**

6. Stresses in rotating Hollow and solid discs and cylinders. **7 Hrs**

7. Torsion of solid circular and elliptical bars- torsion in thin tubes, membrane analogy. **5 Hrs**

8. Uniqueness theorem- Saint Venant's Principle- Principle of super position - Reciprocal theorem. **5 Hrs**

Reference Books:

1. S. P. Timoshenko and J. N. Goodier, "Theory of Elasticity", 3rd edition- McGraw Hill- New York- 2010
2. C. T. Wang, "Applied Elasticity" McGraw Hill Book Co., 1953
3. L. S. Srinath, Advanced Mechanics of solids", 3rd edition, Tata Mcgraw-Hill book Company, 2014
4. T. G. Sitharam&L. GovindaRaju, "Applied Elasticity",Interline Publishing 2008

15UMEE530	Design of IC Engines	(4-0-0) 4

Contact Hours: 52

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

1. Different types of internal combustion engines and different parts of SI and CI engine.
2. Design of crack shaft, piston, connecting rod, camshaft, piston rings, fly wheel, combustion chambers and clutches.
3. Different conventional and modern type of fuel injection systems used in SI & CI Engines.
4. Design of effective cooling systems used in IC engines and heat exchanges.
5. Designing suitable emission control systems to meet stringent emission norms.

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	Design combustion chamber and cylinder head for both SI & CI Engines.	3	1,2	-
CO2	Design crank shaft, cam shaft, connecting rod, piston for different types of automobiles.	3	1,2	-
CO 3	Design clutch, flywheel and cooling systems.	3	1,2	-
CO 4	Explain the use of fuel injector, carburetor & cooling system.	1	-	-
CO 5	Demonstrate the knowledge about hazards and control of emission control.	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	3	-	-	-	-	-	-	-	-	-	-	-

Pre requisites: Strength of materials, fundamentals of machine design, Elements of Mechanical Engineering.

Course Contents:

1. **I C Engine I:** Classification of I C Engines, SI & CI Engines. **4 Hrs**
2. **Design of I.C. Engine:** Combustion fundamentals, combustion chamber design, cylinder head design for both SI & C. I. Engines. **10 Hrs**

3. **Design of I.C. Engine II:** Design of crankshaft, camshaft, connecting rod, piston & piston rings for small family cars (max up to 3 cylinders). **14 Hrs**
4. **Fuel Injection & Carburettor:** Spray formation, direct injection for single cylinder engines (both SI & CI) and energy audit. Design of venture. **6 Hrs**
5. **Design of Clutch:** Single & multi-plate Clutches, Dry and wet clutches. **6 Hrs**
6. **Design of Flywheel – Single and multi-cylinder engines. 4 Hrs**
7. **Cooling System:** Heat exchangers, application to design of cooling system (water cooled). **5 Hrs**
8. **Emission Control:** Common emission control systems, measurement of emissions, exhaust gas emission testing. **3 Hrs**

Reference Books:

1. Newton Steeds &Garratte, The Motor Vehicle Lliffee& Sons Ltd., London
2. Kolchin, I.C.Engines, MIR Publications, Moscow
3. Turns, Introductions to Combustion
4. N.K.Giri, Automobile Mechanics, Khanna Publications, 1994

VI Semester

15UMEC600	Finite Element Methods	(3-2-0) 4

Contact Hours: 52

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

1. Numerical methods used to solve engineering problems.
2. Skills associated with the principles of FEM.
3. Skills in applying the basic matrix operation to form a global matrix equation and enforce the concept of steps in obtaining solutions for a truss Structures.
4. Interpolation functions to solve beam problems.
5. Skills in applying FEM solution to structural and thermal 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	Explain basic terminology, methods, need & applications of FEM	-	1,2	-
CO-2	Identify, formulate the stiffness matrix, apply boundary conditions & load vector to solve problems for bar & truss element.	1,2	-	-
CO-3	Identify, formulate the stiffness matrix, apply boundary conditions & load vector to solve problems for beam & CST element.	1,2	-	-
CO-4	Identify, formulate the stiffness matrix, apply boundary conditions & solve problems on heat conduction & convection.	1,2	-	-
CO-5	Use commercial software to solve problems.	-	-	5,13

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	-	-	1	-	-	-	-	-	-	-	1	-

Pre requisites: Engineering Mathematics, Strength of Materials, Theory of Elasticity

Course Contents:

1. **Introduction:** Need for use of FEM, Advantages, disadvantages and applications of FEM; Matrix Algebra-(Terminology and operations), Gaussian elimination method. **Numerical Integration**- Gauss quadrature, one point and two point formula,1D and 2D integrals. **10L+2T Hrs**

2. **Basics of Theory of Elasticity:** Definitions of stress and strain, strain-displacement relations, stress-strain relations in 2D Cartesian and polar co-ordinates. **5 Hrs**

3. **Continuum methods:** Principal of minimum potential energy; Rayleigh – Ritz method applied to simple problems on axially loaded members, cantilever and simply supported beam; Galerkin method and its application to simple axially loaded problems. **6L+2T Hrs**

4. **Finite Element Method:** Direct approach to discrete systems (Derivation of stiffness matrix by direct method for 2 node bar, 2D truss and beam elements), transformation law, Displacement method; Different co-ordinate systems, Shape functions, Formulation of 2 node bar element, CST element using variational method, stress recovery, Boundary conditions (Single point Constraints only), Elimination and penalty methods of handling boundary conditions. **17L+5T Hrs**

5. **One dimension steady state heat conduction:** formulation of 2 node, 1-D element, using Galerkin method. **4L+1T Hrs**

Reference Books:

1. T. R. Chandrupatla and A. D. Belegundu, 'Introduction to finite Elements in Engineering', 2nd edition, Prentice Hall of India, New Delhi, 2001.

2. R. D. Cook et al, "Concepts and Applications of Finite Element Analysis" 4th edition, Joln Wiley & Sons, inc, 2005.

3. Rao S.S., The finite Element Method in Engineering, 5th edition, Butterworth-Heinemann, 2013.

15UMEC601	Heat Transfer	(3-2-0) 4

Contact Hours: 52

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

1. Basic principles and modes of heat transfer.
2. Energy balances and understand basic mechanism of heat transfer such as conduction convection and radiation or simultaneously.
3. Multidimensionality and time dependence of heat transfer, obtain the differential equation of heat conduction in various coordinate system.
4. Thermal conditions on surfaces and obtain mathematically as boundary and initial conditions.
5. Heat conduction in solids that involve heat generation, and heat conduction in solids with temperature-dependent thermal conductivity.
6. Physical mechanism of convection and visualize the development of velocity and thermal boundary layers during flow over a surface.
7. Radiation intensity and clear understanding of the properties emissivity, reflectivity and transmissivity on directional and total basis

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 of modes of heat transfer, velocity &thermal boundary layers, boiling &condensation and solve related problems	-	1,2	-
CO-2	Derive 1-D conduction equation for different co-ordinate systems and solve related problems.	1,2	-	-
CO-3	Derive equation for unsteady heat flow (lumped system) and solve related problems using charts.	-	1,2	-
CO-4	Derive equations and solve problems related to radiation and perform dimensional analysis for convective heat transfer.	-	1,2	-
CO-5	Classify heat exchangers and determine different performance parameters.	1,2	-	-
CO-6	Analyze heat transfer using correlations in convection, boiling and condensation.		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	2.4	2.4	-	-	-	-	-	-	-	-	-	-	-	-

Pre requisites: Basic Thermodynamics, Engineering mathematics.

Course Contents:

1. Introductory Concepts and definition : Modes of heat transfer ; Basic laws governing conduction, Convection, and Radiation heat transfer ; Thermal conductivity, convective heat transfer coefficient; Radiation heat transfer coefficient; combined heat transfer mechanism. **4L +1T Hrs**

2. Conduction-Basic Equations: General form of one dimensional heat conduction equation in rectangular, cylindrical and spherical coordinates. Discussion on three dimensional conduction in rectangular, cylindrical and spherical coordinates systems (No derivation). Boundary conditions of first, second and third kinds; illustrative problems on mathematical formulation of conduction problems. One dimensional Steady state conduction: Steady state conduction in a slab, in a cylinder and in a sphere without heat generation; Steady state conduction in a slab, in a cylinder and in a sphere with heat generation (no derivation only discussion); overall heat transfer coefficient for a composite medium; thermal contact resistance; critical thickness of insulation; One dimensional Transient conduction: Conduction in solids with negligible internal temperature gradients (lumped system analysis) Use of transient temperature charts (Heisler's charts) for Transient conduction in slab, long cylinder and sphere. **12L + 4T Hrs**

3. Concepts and Basic Relations in Boundary layers: Flow over a body- Velocity boundary layer, General expression for drag coefficient and drag force; Thermal boundary layer; general expression for local heat transfer coefficient ; Average heat transfer coefficient; Forced Convection: Application of dimensional analysis for forced convection problems. Physical significance of Dimensionless numbers used. Use of various Correlations for hydro dynamically and thermally developed flows; Use of correlations for flow over a flat plate, over a cylinder. Inside the duct. Free or Natural Convection: Application of dimensional analysis for free convection physical significance of dimensionless numbers. Use of correlations for free convection from or to vertical, horizontal and inclined flat plates, vertical and horizontal cylinders. **10L + 3T Hrs**

4. Radiation Heat transfer: Thermal radiation: Definitions of various terms used in radiation heat transfer; Stefan-Boltzman law, Kirchoff's law, Planck's law and Weins displacement law, Radiation heat exchange between two parallel infinite black surfaces, between two parallel infinite gray surfaces; Effect of radiation shield; Intensity of radiation and solid angle; Lamberts Law; Radiation heat exchange between two finite surfaces – configuration factor or view factor. **5L + 2T Hrs**

5. Application of heat transfer: Fins; Steady state conduction in fins of uniform cross section long fin, fin with insulated tip and fin with convection at the tip; fin efficiency & effectiveness. Heat Exchangers; Classification of heat exchangers; Overall heat transfer coefficient, Fouling, Scaling factors; LMTD and NTU methods of analysis of heat exchangers. Boiling and Condensation; Film, Dropwise condensation theory, Pool boiling regimes, Use of correlations for film and dropwise condensation on tubes. **7L + 4T Hrs**

Reference Books:

1. Heat Transfer–A basic approach - M.N.OsisikMcGraw Hill International ed 1988.
2. Engineering Heat and Mass transfer - Mahesh M.RathoreLaxmi Publications 2nd edition 2006.
3. Heat Transfer A Practical approach -Yunus A Cengel Tata McGraw Hill 2002.
4. Fundamentals of Engineering Heat and Mass transfer - R.C SachdevaWieley Eastern Ltd. 1995

15UMEC602	Dynamics of Machinery	(3-2-0) 4

Contact Hours: 52

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

1. Tangent and circular cam geometry and the calculation for follower motion parameters.
2. Principles of static & inertia force analysis of various mechanisms and identification of forces acting on different links of the mechanisms.
3. Importance of flywheel and its use.
4. Effect of unbalancing in machinery & methods of balancing of rotary and reciprocating systems.
5. Concept of gyroscope and gyroscopic effect in automobiles. aero-planes& ships.
6. Gear force analysis.

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	Analyze forces in planar mechanisms/gear trains.	1	2	-
CO-2	Calculate the necessary balancing masses and assess the magnitude of imbalance in rotary/reciprocating systems.	1	2	3
CO-3	Design flywheel and check the suitability of flywheels for the given prime mover.	1	2	3
CO-4	Calculate the gyroscopic couples, forces and analyze the effects on vehicles/ mechanical systems.	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	1	-	-	-	-	-	-	-	-	-	-	-

Pre-requisites: Kinematics of Machines, Engineering Mechanics

Course Contents:

1. **Static Force Analysis:** Free Body Diagram- Force Polygon- Effect of sliding friction- Friction in turning pairs (one term work sheet of two problems).**8L+2T Hrs**

2. **Inertia Force Analysis:** Rigid Body- Rectilinear translation of rigid body. Rotation of rigid body about fixed axis. Plane motion of rigid body. Inertia

force analysis of Four bar mechanism and slider crank mechanism. (One term work sheet of two problems). **6L+2T Hrs**

3. **Fly wheels:** Turning moment diagrams, Fluctuation of energy, Flywheels. **4L+2T Hrs**

4. **Balancing-** Balancing of rotating masses in single plane and multi plane. Balancing of reciprocating masses- multi-cylinder engine- In-line engine and V- engine balancing. (one term work sheet of two problems). **10L+4T Hrs**

5. **Gyroscope:** Gyroscopic forces and couples. Gyroscopic stabilization - Aero plane -Four wheel Drive - Two wheel Drive - Ship**.** **8L+2T Hrs**

6. **Gear Forces-** Force analysis in gear trains with spur and helical gears. **3L+1T Hrs**

Reference Books:

1. S.S.Rattan, Theory of Machines, Tata McGraw-Hill, New Delhi.
2. Joseph Shigley, Theory of Machines, McGraw Hill Publications, 1999
3. John J Uicker, Gordon R Pennock, Joseph E Shigley, Theory of Machines and Mechanisms, 3rd edition, Oxford publisher, 2009.
4. Dr. R K Bansal and Dr. J S Brar, Theory of Machines, Laxmi publications, 5th edition,2015

15UMEL603	Heat Transfer Lab	(0-0-2) 1

Contact Hours: 25

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

1. Basic principles of heat transfer.
2. Theoretical aspects of heat transfer and physical approaches and measuring parameters significance.
3. Importance of effectiveness of heat exchangers.
4. Validation of natural convection and forced convection with theoretical values of heat transfer coefficients.
5. Working and performance of vapor compression refrigeration and air-conditioning.

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	Determine experimentally thermal conductivity, convection heat transfer coefficients, emissivity & Stefan Boltzmann constant.	-	1,2	4, 5
CO-2	Determine the efficiency (η) of fin's through experiments	-	1,2	4, 5
CO-3	Carryout experiment on film & drop wise condensation	-	-	1,2, 3
CO-4	Conduct experiment on transient heat transfer to determine heat transfer coefficient and Biot number	-	-	1,3 5
CO-5	Carry out performance test on VCR refrigeration, heat exchanger and air conditioning	-	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	1.4	1.8	1	1	1	-	-	-	-	-	-	-	-	-

Pre-requisites: Basic and applied thermodynamics, Fluid mechanics principles and basic engineering mathematics

Heat transfer lab

1. Determine the thermal conductivity of composite wall.
2. Determine the thermal conductivity of lagged pipe.
3. Determine the thermal conductivity of insulating powder in sphere.

4. Determination of (natural) convection heat transfer coefficient for air.
5. Determination of (forced) convection heat transfer coefficient for air.
6. Pin-fin (Natural convection).
7. Pin-fin (Forced convection).
8. Determine the critical Heat flux of a wire.
9. Heat exchanger Parallel flow and counter flow.
10. Determination of the Stefan boltzman constant.
11. Boiling and condensation.
12. Transient heat transfer.

15UMEL604	CEA / CAM lab (Computer Aided Engineering Analysis / Computer Aided Manufacturing)	(0-0-2) 1

Contact Hours: 25

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

1. Basics of CAD/CAM and packages.
2. Automation concepts.
3. Latest CAD/CAM technologies & problems.
4. CAD & CAM simulation & Analysis.

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 terminology, methods, needs and applications of FEM.	1	-	-
CO-2	Use modern tools to model and solve problems for bar, truss, beam, plate, heat conduction and convection.	5	9	4
CO-3	Analyze the given problem by applying the basic principles to solve problems for bar, truss, beam, plate, heat conduction and convection.	2	9	4
CO-4	Convert raw material to finished product using NC lathe.	5	9	3
CO-5	Convert raw material to finished product using NC milling machine.	5	9	3
CO-6	Write program for NC machines to perform machining.	1	-	3, 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	1	1	3	-	-	-	2	-	-	-	-	-

Prerequisites: Understanding of basics of hardware and software requirements of computer, engineering mathematics

Course Contents:

PART A - COMPUTER AIDED ENGINEERING ANALYSIS

Static Finite Element Analysis of Bars, Trusses, Beams, shafts.Plates and any other mechanical structure. 6-Exercises

PART B - COMPUTER AIDED MANUFACTURING

Modelling of simple machine parts and generating machine codes for CNC production using standard CAM packages. Simulation of Cutting / Milling Operations on a Computer using CAM packages. 8-Exercises

Machining of Simple parts on CNC Lathe / Milling Machines. 2-Exercises

Reference Books:

1. A primer on Finite Element Analysis by Anand V Kulkarni&Venkatesh K Havanur, Laxmi Publications (University Science Press) New Delhi 2011
2. Finite Elements Analysis- using ANSYS-11.0, PavetiSrinivas, Krishna ChaitanyaSambana, Rajesh Kumar Dalli, PHI Publication New Delhi.

15UMEL605	Mini Project	(0-0-6) 3

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 & solve a problem using basic engineering principles.	1,2	4	12
CO-2	Design the machine parts, components of a system that meets particular requirement.	3	7	6,12
CO-3	Use the software tools to prepare & analyze models or prototypes and conduct simulation using it.	5,13	2	-
CO-4	Use the machine tools to prepare models or proto types.	5,13	2	-
CO-5	Work in teams and communicate effectively for in time completion of projects.	10	8,11,12	-
CO-6	Prepare a report based on their work content 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

Every student is advised to conduct a mini project covering relevant thrust areas of Mechanical Engineering and to device and analyze the problem in consultation with a faculty guide of his choice. There will be atleast 3 presentation phases culminating with a final project presentation to the examiners.

Note: Activities for self-study to be initiated by the guide.

15UMEE625	Engineering System 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. Concept of system, product design, system modeling and aspects in product/ system.
2. Phases in design with relevant examples in a real life scenario.
3. Process of idealization and factors affecting it.
4. Systems with realistic constraints and modeling.
5. Role of decision making, reliability, man-machine interaction.

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	Describe the concepts of Systems, Product Design and System Modeling.	1, 2	4	3
CO-2	Discuss the phases in Design with relevant examples in a real life scenario.	2, 4	1	6
CO-3	Illustrate the process of idea generation and the factors affecting it.	2, 3	1, 10	4
CO-4	Compare and model the systems in different disciplines making use of system analogy.	2, 3	1, 4	7
CO-5	Develop the methods to quantify physical reliability, reliability, utility for decision making.	3	1, 2	7
CO-6	Defend the role of standardization, optimization and the human factors in design	2, 3	1	7, 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	2.2	2.8	2.6	2	-	1	1	-	-	1.5	-	-	-	-

Pre requisites: Engineering Mathematics, Machine Design.

Course contents:

1. **Introduction:** What is designing? Man as designer. Design by evolution, inadequacies of traditional design method, design history of small and large scale existing systems. Systems approach to engineering design problems, Morphology of design,the three phases of design process, the structure of design process, decision making and iteration. **8 Hrs**

2. **Identification and analysis of need:** Preliminary need statement, analysis of need, specifications, standards of performance and constraints. Origination of design conceptprocess of ideation, mental fixity, creativity, some design methods like morphological analysis, AIDA, brainstorming, lateral thinking. **8 Hrs**

3. **A generalized approach to system modeling:** The principles of conservation and analogy: Introduction, Modeling Mechanical systems, Electrical and electromechanical systems, Fluid systems, Thermal systems. **12 Hrs**

4. **Reliability considerations in Design:** Bath Tub Curve, exponential reliability function, system reliability. **5 Hrs**

5. **Evaluation of alternatives and design decisions :** Physical reliability, Decision Theory and design decision tree, Concept of utility, Quality of design, multi criteria decisions, decisions under uncertainty and risk, Economics in engineering design, Fixed and variable costs, break – even analysis. **6 Hrs**

6. **Standardization:** Designing for manufacture and assembly (DFMA), Role of standardization in design, Benefits of standardization, Achieving part standardization, Group Technology. **5 Hrs**

7. **Optimization:** Optimization by Differential Calculus, Search Methods, Non-linear Optimization Methods, Design Optimization. **6 Hrs**

8. **Human Factors in Engineering Design:** Man – Machine Interaction cycle, Design of displays and controls, work station design. **2 Hrs**

Reference Books:

1. George E. Dieter and Linda C. Schmidt, Engineering Design, Fourth Edition, McGraw Hill International, 2009.

2. I. J. Nagrath and M. Gopal, System Modeling and Analysis, Tata McGraw Hill Publishing Co. Ltd., New Delhi. 2000.

3. Vijay Gupta and P. N. Murthy, An introduction to Engineering Design Method, Tata McGraw Hill, 2000.

4. D.D.Meredith, K. W. Wong, Design and Planning of Engineering systems, R. W. Woodhead and K. K. Worthman, 2000.

15UMEE626	Organizational Behavior	(4-0-0) 4

Contact Hours: 52

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

1. Human behavior when working in groups.
2. Scientific methods of motivation.
3. Theories of leadership.
4. Managing self and managing teams.
5. Developing the Proficiency in managing different activities in any organization.

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 various basic and related terminology of organizational behavior.	-	8	-
CO-2	List out various concepts and techniques of organizational behavior.	-	-	8
CO-3	Describe various theories pertaining to individual and group behaviors.	9	8	-
CO-4	Discus organizational change & stress management, team building, organizational change OD and quality of working life(QWL), effect of information technology and globalization on organizational behavior.	-	9	-
CO-5	Explain conflict process, different bargaining strategies, and organizational structures.	-	9	-
CO-6	Interpret how individuals, groups and organization affect the behaviors in organization.	-	9	-

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	1.7	-	-	-	-	-

Prerequisites: Basic Knowledge of Management and organization.

Course Contents:

1. **Introduction:** Definition of O.B., Historical development of O.B., functions of a manager, Fields contributing to the development of O.B, Information Tech & Globalization with respect to O.B, Challenges and opportunities to O.B. Diversity & ethics. **6 Hrs**
2. **The Individual:** Foundations of individual behavior, Ability. Learning – theories of learning, Individual decision making. Reinforcement types, aptitude and interests of the individual. **5 Hrs**
3. **Values, Attitudes & Job Satisfaction:** Definitions, Types of values and their importance Attitude survey. Types of attitudes – Job satisfaction Job involvement and organizational commitment. Measurement of Job satisfaction. **6 Hrs**
4. **Perception:** Definition, Factors affecting perception, making judgments about others, selective perception, projection and stereotyping. **4 Hrs**
5. **Motivation:** Definition, Early theories of motivation – Maslow's hierarchy of needs theory, McGregor's Theory X and Theory Y, Herzberg's two factor theory, Contemporary theories – David McClelande's three needs theory, Equity theory, Goal setting theory. MBO – Relation between MBO and goal setting theory. **10 Hrs**
6. **The Group:** Definition and classification of groups, Factors affecting group formation, Stages in group development, Group norms Hawthorne studies, Groupshift & Groupthink, Group decision making and its techniques. **7 Hrs**
7. **Leadership:** Definition, Theories of leadership – Blake and Mouton managerial grid, Heresy – Blanchard's situational theory, Fiedler's model. Path – Goal theory. Leadership style. **6 Hrs**
8. **The Organisation:** Definition of conflict, conflict process. Functional and Dysfunctional conflict, Negotiation – Bargaining strategies. Mechanistic and Organic structures. Mintzberg's basic elements of organization, Organizational change and stress management, Organizational development, QWL (Quality of Work Life), Team building. **8 Hrs**

Reference Books:

1. Stephen Robbins and SeemaSanghi, Organizational Behavior, 13th edition 2009 – Pearson educational publications New Delhi ISBN 0131914359
2. Fred Luthens, Organizational Behavior, 11th International Edition, McGraw Hill publications New York 2011 ISBN 0-07-124762-9 2008
3. Jit S. Chandan, Organizational Behavior, 1995 Edition Vikas publishing house New Delhi
4. K. Ashwathappa, Organizational Behavior, 9th Edition, Himalaya publishers Mumbai, 2010.

15UMEE627	Jet Propulsion	(4-0-0) 4

Contact Hours: 52

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

1. Knowledge of principles of operation and applications of energy conversion systems.
2. Uses of thermodynamic relations and the property tables and charts for the analysis of energy conversion systems in the course of their operation.
3. Thermodynamic cycle and the parameters affecting efficiency and the concept of air-breathing and non-air breathing engines.
4. Uses of Diffuser, nozzle and combustion chamber.
5. Rotary components and concept of velocity diagrams.
6. Computation of pulse jet, Ram jet, turbo jet mechanisms and to understand the efficiency and power of propulsion.
7. Analysis of convergent – divergent nozzle and different devices associated with rockets. So in total the students should understand the principles of rockets propellants.

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 principles governing fluid mechanics and gas dynamics.	1	-	-
CO-2	Analyze the rotating and non-rotating components used in the jet propulsion	3	2	-
CO-3	Formulate and analyze different types of jet propulsion systems	-	1	-
CO-4	Design various jet propulsion components.	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	2	-	-	-	-	-	-	-	-	-	-	-

Pre requisite: Basic thermodynamics, applied thermodynamics, heat transfer.

Course Contents:

1. **Basic principles of thermodynamics:** Fluid mechanics and Gas dynamics.

9 Hrs

2. **Momentum principle and thrust of an engine:** Thermodynamic cycle analysis (ideal and real) including variants for inter cooling, reheat etc. Efficiency parameters Description of air-breathing and non-air-breathing engines. **6 Hrs**

3. **Non – rotating component analysis:** Diffuser, nozzle, combustion chamber. **7 Hrs**

4. **Rotary components:** Compressor and turbine including velocity diagrams, matching, surge and stall etc. **10 Hrs**

5. **Jet propulsion types:** Pulse jet, Ram jet, Turbo jet. Efficiency and power of propulsion. **6 Hrs**

6. **Principles of Rockets Propellants:** Analysis of Convergent – divergent nozzle internal ballistics of solid propellant rockets Liquid propulsion devices Hybrid propulsion devices. **14 Hrs**

Reference Books:

1. Hill P.G. – Mechanics and Thermodynamics of Propulsion, Addison Wesley, 1988.
2. Sutton G.P., Rocket Propulsion Elements, John Wiley, 1967.
3. Kerreprock S.I., Aircraft Engine and Gas Turbine, MIT, 1977.
4. Huze! And Huang, Liquid Propellant Rocket Engines, NASA, SP 125, 1971

15UMEE628	Solar Energy	(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 principles of energy sources.
2. Energy analysis and understanding the 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 connected to temperature, efficiency and conversion.

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	Describe solar energy prospectus, radiation geometry, measurements, thermal collectors and their applications	-	1,2	-
CO-2	Estimate solar radiation on flat plate, tilted surfaces and carryout thermal analysis of flat plate collectors.	1,2	-	-
CO-3	Explain solar energy conversion devices, thermal & PV Systems	-	1,2	-
CO-4	Outline the use of solar energy for space heating, refrigeration, conversion into electric/mechanical energy.	-	1,3	-
CO-5	Explain the conversion of biomass's thermo -chemical energy to useful form of energy	-	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	2.2	2.3	2	-	-	-	-	-	-	-	-	-	-	-

Pre requisites: Thermodynamics, Heat Transfer, Fluid Mechanics.

Course Contents:

1. **Solar energy Fundamentals:** Introduction essential subsystems in solar energy plant, solar energy roots and their prospects**,** units of solar power and solar energy basic approach and objectives. Light an energy solar constants component of sun light. **Solar Radiation:** Extra-Terrestrial radiation, spectral distribution of extraterrestrial 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. **8 Hrs**

2. **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.**Radiation Flux On A Titled Surface:** Beam, diffuse and reflected radiation, expression for flux on a titled surface (no derivations) numerical examples. **6 Hrs**

3. **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. **9 Hrs**

4. **Performance Analysis of 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**

5. **Solar Applications:** Solar Desalination, Solar power plant, Solar Refrigeration, Solar drying Solar Pond, Passive and active solar heating of buildings. Numericals. **9 Hrs**

6. **Photovoltaic Conversion:** Description, principle of working and characteristics, types of PV cells and applications. Sizing of PV cells. **5 Hrs**

7. **Biomass:** Introduction, types of biomasses, resources, Raw materials for conversion to biogas, aquatic biomass, Anaerobic fermentation, process used in biogas plants, types of biogas plants. **6 Hrs**

8. **Biomass thermo chemical route:** updraft, down draft and cross draft gasifier. **4 Hrs**

Reference Books:

1. S.P.Sukatme, Solar Energy, TATA McGraw Hill, 1996
2. G.D.Rai, Non-Conventional Energy Sources, Khanna Publishers, New Delhi, Dec 2004.
3. Kreith&Goswami, Solar Energy, Taylor & Francis 1999
4. S. Rao, Dr B.B Parulekar, Energy Technology, 3rd edition, Khanna Publishers, Delhi, 2007

15UMEE629	Advanced 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. Fluid and its properties, laws governing fluid flow and mathematical interpretation.
2. Fluid flow concepts, velocity potential, ideal fluid flow concepts and stream functions.
3. Fluid dynamics continuity equation, Navier stokes equation and application of it.
4. Low Reynolds number flow and viscous flow.
5. Compressible flow, sonic velocity Mach number isentropic flow.

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 fluid properties and derive governing equations of fluid flow.	1,2	-	-
CO-2	Analyze viscous flow through circular pipe, between parallel plates and compressible flow through nozzles.	1,2	-	-
CO-3	Derive equations for velocity and thermal boundary layer thickness and solve related problems.	1,2	-	-
CO-4	Analyze low Reynolds's number flows past cylinder and solve problems related to lift and drag.	1,2	-	-
CO-5	Explain integral flow equation and flow measuring devices.	-	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: Basic thermo dynamics, Basic Science, Engineering Mechanics, Fluid mechanics and fluid flow dynamics, Applied Mathematics.

Course Contents:

1. **Introduction to fluid mechanics:** Fluid properties, Continuity equation 2D & 3D (Cartesian, cylindrical and spherical co-ordinates derivation and problems) Nevier Stokes equation (3D Cartesian co-ordinates) **12 Hrs**

2. **Viscous flow:** flow inside a circular pipe, flow between two parallel plates, Power transmission through pipes. **8 Hrs**

3. **Compressible flow:** Introduction, Sonic velocity, mach number, stagnation properties, flow through nozzles. **6 Hrs**

4. **Boundary Layer theory:** Definitions, Hydrodynamic boundary layer, boundary layer thickness, displacement, momentum & energy thickness, (Derivations and problems) von karman integral separation, Thermal boundary layer. **8 Hrs**

5. **Low Reynolds number flow:** Lubrication theory (Reynolds equation), flow past immersed bodies; lift & drag. **6 Hrs**

6. **Integral flow:** Reynolds transport theorem, continuity, momentum, moment of momentum, Energy equations. **4 Hrs**

7. **Flow measuring devices:** Notches, flow meters, pressure probes, Hot wire Anemometer & Wind tunnels. **8 Hrs**

Reference Books:

1. K Muralidhar& G. Biswas, Advanced Engineering Fluid Mechanics, 2nd edition, Narosa Publisher, 2013
2. S.W Yuan, Foundation of fluid mechanics, SI Unit Edition 1988.
3. Dr. R.K.Bansal, A text book of Fluid Mechanics and Hydraulic machines, 9th Edition, Laxmi Publications, 2005

15UMEE630	Tribology and Bearing 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. Surface topography, physico-chemical aspects of solid surfaces, and surface interactions.
2. Mechanics of solid elastic and elastoplastic contacts.
3. Laws of friction, mechanisms of friction and **lubrication** friction space, stiction, stick slip, and surface temperature.
4. Various modes of wear: adhesive, delamination, fretting, abrasive, erosive, corrosive, oxidational (mild and severe), melt, and the wear-mechanism maps.
5. Applications of sliding contacts, rolling contacts, **Magnetic bearing and elimination of leakage using seals.**
6. Design of tribological surface, and how to troubleshoot tribology 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	Explain laws of fluid flow and appreciate different lubrication schemes.	1	-	2
CO-2	Compute power losses and frictional forces in bearings.	1	2	-
CO-3	Compare different wear mechanisms and measurement techniques.	1	1	-
CO-4	Explain different fluid film formation mechanisms in bearings.	1	-	2
CO-5	Appreciate the concept and applications of advanced bearings and its components.	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	3	1.5	1	-	-	-	-	-	-	-	-	-	-	-

Pre requisites: Engineering Mathematics, Strength of Materials, Machine Design-II

Course Contents:

1. **Introduction:** Properties of oil, equation of flow, absolute viscosity, Hagen Poiseullie's law, flow between parallel stationary plates, apparatus for measuring viscosity, factors that affect viscosity. **8 Hrs**
2. **Hydrodynamic Lubrication:** Tower's experiments, Petroff's equation, friction forces, power losses in lightly loaded bearings, mechanism of pressure development in an oil film, numericals on Petroff's equation and oil flow through capillary. **8 Hrs**
3. Reynolds equation in two dimensions, idealized journal bearing friction forces, power losses, pivoted shoe bearing, friction forces, power losses, collar thrust bearing with end leakage, thermal equilibrium. **8 Hrs**
4. **Hydrostatic Lubrication:** Application of hydrostatic lubrication, hydrostatic thrust bearing, introduction to hydrostatic journal bearing and numericals. **8 Hrs**
5. **Wear and abrasion:** Wear mechanism, Mechanism of wear in elastomers, wear Measurements. **6 Hrs**
6. **Introduction on magnetic and foil bearings. 4 Hrs**
7. **Introduction to seals and types of seals. 4 Hrs**
8. **Failure of Tribological components:** Failure analysis of plain bearings, rolling bearings, gears, seals. **6 Hrs**

Reference Books:

1. E.I. Radzimovsky, Lubrication of Bearings, TheRonold Press Company, 1959
2. SushilkumarSrivastava, Industrial Tribology, S.C. Chand And Company, 2001
3. B.C Muzumdar, Lubrication of Bearings, Wheeler Publishers1996
4. K.Lingaiah, Design Data Hand book, Vol2, Suma publishers 1984

15UMEE631 Design and Analysis of Experiments (4-0-0) 4

Contact Hours: 52

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

1. Design of experiments and orthogonal array.
2. Statistical analysis is an appropriate modeling framework and statistical models that consider the key elements of the real world problem.
3. Optimal solutions for models; interpret the models' solutions and infer solutions to the real-world problems.
4. Results of the analysis process to adhere to quality.
5. Capabilities and limitations of deterministic experimental models as applied to industry using design of experiments, ANOVA and such other techniques.

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 fundamental concepts of quality and modeling.	1	3	2
CO-2	Articulate the fundamentals of statistical analysis, hypothesis testing and variance analysis	1, 2	2, 3, 4	5
CO-3	Describe the basics of design of experiments and orthogonal array experiments.	1, 3	2, 4	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	2	2.3	2	1	-	-	-	-	-	-	-	-	-

Pre requisites: Engineering Mathematics, Strength of Materials and Metrology and Measurements

Course Contents:

1. **Introduction to Quality:** Quality of Design, Quality of Conformance, Quality Costs. Robust Design: Principle and Meaning; Progressive steps to achieving Conformance to Quality Standards. **4 Hrs**
2. **Fundamentals of Statistical Analysis:** Frequency Distributions, Probability Distributions, Normal Distribution, Other distributions. Illustration through numerical exercises. **7 Hrs**
3. **Fundamentals of Hypothesis Testing:** Concepts of Noise and EFFECT, Testing of Equality of Means, Z test, t-Test, F-Test. Generalised process of Hypothesis Testing. Illustration through numerical exercises. **9 Hrs**

4. **Fundamentals of Analysis of Variance:** One Way Analysis, Two Way Analysis, Multi-Factor Analysis of Variance. Main Effect, Interaction Effect, Illustration through numerical exercises. **8 Hrs**
5. **Introduction to Design of Experiments:** Parameters, Factors, Noise Variables, 2 level and 3 level experimentation, identification of Critical Factors, Factorial Experiments, 2 Power Series Experimentation, YATES technique of analysis. Understanding of higher order interactions, Incomplete Block, Designs, Confounding in Factorial Experiments, CCD, RCBD, BOX-BEHNKEN Design Illustration through numerical exercises. **12 Hrs**
6. **Orthogonal Array Experimentation:** and methodology, Generation of 2 power series Orthogonal Arrays; working with linear Graphs, Taguchi's Concept, Orthogonality Test: Least Cost Experimentation Route. Introduction to 3 level Orthogonal Arrays, Multi-Level Technique Introducing 3 level, 4 level, 5 level and 8 level factors in experimental designs. Illustration through numerical exercises. **12 Hrs**

Reference Books:

1. Douglas Montgomery, Design and analysis of experiments, V Ed, Willey India Pvt. Ltd., 2007

15UMEE632	Design & Drawing of Assemblies	(4-0-0) 4

Contact Hours: 52

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

1. Types of engineering materials used in power transmission elements.
2. Concepts of designing various machine elements and assemblies.
3. Usage of design data handbook and BIS standards and draw to dimensions.

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	Interpret the Geometrical dimensioning and tolerance symbols and apply them to Technical drawings.	10	5	-
CO-2	Design components of IC Engines, Power transmission &Material handling equipment components.	1,3	2	6
CO-3	Use standards & codes for designing /selecting and drawing of parts and assemblies	3,	10	1
CO-4	Apply standards & codes for drawing of parts and assemblies	10	-	1
CO-5	Select materials and configurations based on manufacturing , cost and assembly criteria	1	-	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	2	2.3	-	2	1	-	-	-	2.7	-	-	-	-

Pre requisites: Strength of Materials, Machine Design- I, Machine Design- II.

Course contents:

1. Drawing & sketching conventions & standards – BIS **2 Hrs**
2. Design & drawing of engine components **10 Hrs**
   - (a) Piston
   - (b) Connecting rod
   - (c) Valve gear mechanism
   - (d) Cylinder block & cylinder head
3. Design and drawing of load handling equipment **10 Hrs**
   - (a) Screw jack
   - (b) Crane hook

(c) Lifting ropes & winches
(d) Overhead crane hoist

4. Design & drawing of piping assemblies **12 Hrs**
   (a) Hydraulic pipes & connections
   (b) Fluid lines & oil pipe lines with hydraulic elements (Symbolic representation)
5. Assembly drawings – (Any 3 of the below) **18 Hrs**
   (a) Couplings – (any one)
   (b) Clutches & brakes (any one)
   (c) Gear box (3 speed max)
   (d) Automobile differential
   (e) Claim drive assembly
   (f) Flat/V-belt drive assembly

Examination pattern (3 Hrs – 100 marks)
Any two question to be answered out of four questions each question carries 50 marks and should include complete design and drawing to dimension on the drawing sheet.

Reference books:

1. Prof. N.D. Bhatt & V.M. Panchal, '**Engineering Drawing**' 50th edition, Charotar Publishing House, Gujarat, 2010.
2. Prof. K.R. Gopalakrishna, '**Machine Drawing**', Subash Publishers, Bangalore, 2005