DEPARTMENT OF MECHANICAL ENGINEERING

INDIAN INSTITUTE OF TECHNOLOGY(ISM) DHANABD

SYLLABUS

OF

B.TECH (MECHANICAL ENGINEERING)

2ND YEAR (3RD SEM) COURSE TEMPLATE						
Course Type	**Course Code**	**Name of the Courses**	**L**	**T**	**P**	**Credit Hrs.**
DC1	MEC201	Kinematics of Machines	3	0	0	9
DC2	MEC202	Fluid Mechanics	3	0	0	9
DC3	MEC203	Applied Thermodynamics	3	0	0	9
E/SO1			3	0	0	9
E/SO2	MEE 201	Engineering Materials	3	0	0	9
DP1	MEC 204	Applied Mechanics Lab	0	0	2	2
DP2	MEC205	Thermodynamics and fluid mechanics Lab	0	0	2	2
Total						**49**
Contact Hrs.			**15**	**0**	**4**	**19**

MEC 201 (DC1) - Kinematics of Machines

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	MEC 201	Kinematics of Machines	3	0	0	9

Course Objective

- to learn how to analyze the motions of mechanisms, design mechanisms to have given motions, and analyze forces in machines.
- To understand the operating principles of different parts of mechanical system gears, gear trains, cams and linkages.
- To provide a foundation for the study of machine design and for interpretation of computer-aided design and analysis data.

Learning Outcomes

Upon successful completion of this course, students will:

- have a broad understanding of different mechanism, motion of machines.
- have an understanding about degree of freedom of a mechanical system.
- be able to find velocity and acceleration of kinematic pair if input is known to a mechanical system.
- have a broad understanding about designing part of different mechanical system like gear, cam, break, clutch etc.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Kinematic pairs, inversion, mobility and range of movements, degree of freedom, equivalent mechanism.	6	Understanding of kinematics of motion, degree of freedom of a mechanism.
2	Displacement, velocity analysis, I-Centre method: angular velocity ratio theorem	4	Understanding of linear velocity and numerical to solve velocity of different kinematic pair in a mechanism.
3	Acceleration analysis of planar linkages, Coriolis acceleration component	6	Understanding of acceleration and numerical to solve acceleration of different kinematic pair in a mechanism.
4	Lower pairs: Simple Mechanism: Pantograph, Straight-line mechanisms, Engine Indicators, Automobile steering gears: Devis and Ackermann steering mechanisms, Hooke joint. Mechanical Couplings	6	Understanding of different lower pair mechanism, their dimensional synthesis for motion.
5	Higher Pairs: Types of Cam, Types of follower, Follower motion: Velocity and Acceleration, Layout of Cam profiles.	4	Understanding of different types of cam and follower movement and their applications. Design of a cam for a certain motion outcome.
6	Higher Pairs: Types of gears, Gear terminology, Law of Gearing, motion and synthesis of simple gear, Gear Train: Simple, compound, reverted and planetary gear trains.	5	Understanding of different types of gear and gear train mechanism and their applications.
7	Brakes: Types, Analysis, Dynamometers	5	Understanding of different types of break and dynamometer and their applications.
8	Clutches: Types, Analysis.	3	Understanding of different types of clutch and their applications.

Text Books:

1. Theory of Machines-S.S.Rattan

Reference Books:

1. Theory of Machines and Mechanisms-John Uicker, Gordon Pennock, Joseph Shigley
2. Theory of Machines-Khurmi and Gupta

MEC 202 (DC2) - Fluid Mechanics

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	MEC 202	Fluid Mechanics	3	0	0	9

Course Objective

- To understand the kinematics and dynamics of fluid motions.
- To understand the governing equations dictating various types of flow problems.
- To develop an idea on the effects of pressure (and its gradient), viscosity, fluid stress, strain rate and their mutual relationship.

Learning Outcomes

Upon successful completion of this course, students will:

- Understand the kinematics and dynamics of fluid motions as opposed to deformable solids.
- Develop a first-hand understanding of various types of flow problems: potential, irrotational, inviscid, viscous, incompressible and compressible.
- Understand the logic behind the derivations of Bernoulli's, Euler's and Navier-Stokes Equations governing specific fluid flows.
- Develop a clear understanding of the constitutive relationship between stress and strain rate for fluid motions.
- Develop a clear understanding of Boundary Layer Approximations and Boundary Layer Theory.
- Develop the understanding on the importance and application of Dimensional and similarity Analysis.
- Develop an understanding on the laminar and turbulent flows.

Module	Topics	Lectures	Learning Outcomes
1	**Fluid and their properties:** Concept of fluid, difference between solids, liquids and gases; ideal and real fluids; properties of fluid, Newtonian and non-Newtonian fluids.	3	• Develop concepts of fluids as opposed to deformable solids, • Understanding of characteristics of various types of fluids: Their mutual similarities and differences.
2	**Fluid Statics:** Pressure and its measurement, Pascal's law and its engineering applications, Hydrostatic force on a plane and curved submerged surfaces, resultant force and center of pressure, Buoyancy and flotation, stability of floating and submerged bodies, metacentric height and its determination, pressure distribution in a liquid subjected to constant horizontal/ vertical acceleration, rotation of liquid in a cylindrical container.	6	• Develop the ideas of pressure and hydrostatic force. • Understanding the cause of Buoyancy and its effects on floating objects and their stability.
3	**Fluid Kinematics:** Classification of fluid flows, velocity and acceleration of fluid particle, local and convective acceleration, normal and tangential acceleration, streamline, path line and streak line, continuity equation; Rotational flows, rotation velocity and circulation, stream and velocity potential functions, flow net.	6	• Develop in-depth ideas of kinematics of fluid flows for various types of flow problems. • Understand difference between streamlines/ path lines and streak lines. • Develop understanding of the kinematics of the vorticity and potential flows.
4	**Fluid Dynamics:** Reynolds Transport Theorem, Euler's equation, Bernoulli's equation and steady flow energy equation;	6	• Understanding of how various fluid-dynamical equations is derived.

	applications of Bernoulli's equation, Siphon, Venturimeter, Orificemeter, impulse momentum equation, flow along a curved streamline, free and forced vortex motions		• Understand the application of Bernoulli's Equation to specific flow problems. • Understand the Impulse-Momentum equation for flows around curved boundaries (This idea is essential for understanding the future course on Fluid Machines (MEC204)).
5	**Boundary Layer Flow:** Navier-Stokes equation, Boundary layer concept, displacement, momentum and energy thickness, Von-Karman momentum integral equation, laminar and turbulent boundary layer flows, drag on a flat plate	6	Develop an understanding of Boundary Layer approximation and various aspects of boundary layer flows.
6	**Viscous Flow:** Relationship between shear stress and pressure gradient, flow through pipes, flow between two parallel plates; Kinetic energy and momentum correction factor.	4	Develop an understanding on the effects of flow viscosity, fluid stress and the constitutive relationship between stress and strain rate.
7	**Dimensional Analysis and Similitude:** Fundamental and derived units and dimensions, dimensional homogeneity; Rayleigh's and Buckingham's Pi method for dimensional analysis; Dimensionless numbers and their significance; model studies.	4	Develop an understanding on the Dimensional Analysis and Similitude and their applications in solving various fluid-flow problems.
8	**Flow Through Pipes:** Major and minor losses in pipes, hydraulic gradient and total energy lines, series and parallel connection of pipes, branched pipes; equivalent pipe, power transmission through pipes.	4	Develop an understanding on the laminar and turbulent flows through pipes and various kinds of subsequent losses due to friction.

Text Book:

1. Introduction to Fluid Mechanics by Robert W. Fox, Alan T. McDonald, Philip J. Pritchard, Wiley, 2009

Reference books:

2. F.M. White, Fluid Mechanics, McGraw-Hill (India) Ltd., 8th edition
3. Fluid Mechanics, Kundu and Cohen, Academic Press.
4. Foundations of Fluid Mechanics by Shao Wen Yuan, Prentice-Hall Publications.
5. S.K. Som and G. Biswas, Introduction to Fluid Mechanics and Fluid Machines, Tata McGraw-Hill, 3rd edition.

MEC 203 (DC3) - Applied Thermodynamics

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	MEC203	Applied Thermodynamics	3	0	0	9

Course Objective

The course will give a brief overview of basic concept of Thermodynamics followed by applications of the Laws of Thermodynamics for understanding the different Thermodynamic cycles. The course will also focus on Steam generator, Steam turbine, Gas Turbine, Refrigeration cycles. The course has been designed taking into the need of fulfilling the further course like IC Engines, Power Plant Engineering and Refrigeration and Air conditioning.

Learning Outcomes

Upon successful completion of this course, students will:

- understand the basic requirements of Thermodynamics
- learn the different types of Steam generators, I C Engines, Steam Turbine and Gas Turbine
- be able to develop an in-depth understanding of Combustion of fuel

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	**Basic Thermodynamics:** Definition of Thermodynamics, thermodynamic system, open system, closed system and isolated system, surroundings, control volume, state point, properties, extensive and intensive properties, thermodynamic processes and cycles, thermodynamic equilibrium, Quasi-static process, concept of continuum, Different laws of Thermodynamics, 1^{st} Law of Thermodynamics, 2^{nd} Law of Thermodynamics, Steady flow energy equations, Carnot Theorem, Inequality of Clausisu, Internal Energy, enthalpy, Principle of Increase entropy.	6	Understanding of basic Thermodynamics
2	**Fuels and Combustion**: Types of fuels, calorific values of fuels and their determination, combustion equations, flue gas analysis, Orsat apparatus, excess air, determination of actual quantity of air from from combustion analysis	5	Understanding the pollutant in the exhaust gas and selection of good fuel based on Calorific value
3	**Steam generators:** Classification, study of fire tube and water tube boilers, Boiler mountings and accessories, boiler efficiencies, equivalent evaporation, Boiler draught, natural and artificial draught,	5	Knowledge of different types of boilers

	forced, induced and balance draught		
4	Properties of a pure substance, p-v, p-T, T-s and h-s diagrams	3	Knowledge of quality of steam
5	Vapour Power Cycles: Carnot cycle, Rankine cycle, Reheat and Regenerative cycles, work, power, efficiency	5	Understanding about the vapour power cycles.
6	**Air standard cycles:** Otto cycle, Diesel cycle, Dual cycles, Stirling and Ericsson cycles, work, efficiency	4	Knowledge of theoretical air standar cycles
7	**Refrigeration cycles:**Vapour compression refrigeration cycle, COP	3	Understanding different methods of lowering the temperature of the ststems
8	**Gas Turbine:** open cycle and closed cycle gas turbine, Brayton cycle, work, power and efficiency	5	.Basic knowledge of Gas Turbine cycle used in jet engines
9	**Internal Combustion Engines:** 2-S and 4-S Diesel and Petrol Engines, Principles of working of 2- S and 4-S I C Engines.	3	Knowledge about 2-S and 4-S Petrol Engine ,and 4-S Diesel Engines

Text Books

1. Engineering Thermodynamics : P.K.Nag, Mc Hill Education(India) Pvt Ltd, New Delhi,Sixth edition (2017)
2. Thermodynamics-An Engineering Approach : Y A Cengal and M A Boles, Tata McGraw Hill

Reference Books:

3. Engineering Thermodynamics : C.P.Arora, Tata Mc Graw Hill
4. Fundamentals of Thermodynamics: Sonntag, B and Van Wylen, John

E/SO1: Mechanics of Solid offered by Civil Engineering Dept

MEC 204 Applied Mechanics Lab

(Part-I)

(Any 5 experiments+ 1 Project)

1. Tensile Strength Testing of a given mild steel on UTM
2. Compressive Strength testing of a given specimen on UTM
3. Hardness testing of given specimen using Rockwell and Vickers / Brinell testing
4. Torsional rigidity test of shaft
5. Young's Modulus (E) of M.S and Timber beam by flexure of beam method.
6. Impact testing on Impact testing Charpy and Izod.
7. Project

(Part-II)

(5 experiments+ 1 Project)

8. Coefficient of friction between sliding belt (rope) and a fixed pulley
9. Efficiency of a screw jack by raising & lowering conditions
10. Cam profile and follower movement
11. Coriolli's component of acceleration
12. Speed of gear in the output shaft of a compound gear train
13. Project

MEC 205 Thermodynamics and Fluid Mechanics Lab

1. Determination of Calorific value of solid/liquid fuel
2. Volumetric analysis of pollutants in flue gas by Orsat apparatus
3. Performance study of Single cylinder 4-S Petrol Engine
4. Performance study of single Cylinder 4-s Diesel Engine
5. Determination of Dryness fraction of steam
6. Darcy's friction coefficient
7. Verification of Bernoulli's theorem
8. Reynold's apparatus for laminar and turbulent flow
9. Determination of C_d, C_v, and C_c

2ND YEAR(4TH SEM) COURSE TEMPLATE						
Course Type	**Course Code**	**Name of the Courses**	**L**	**T**	**P**	**Credit Hrs.**
E/SO3	E/SO3		3	0	0	9
DC4	MEC206	Fluid Machines	3	0	0	9
DC5	MEC207	Dynamics of Machinery	3	0	0	9
DC6	MEC208	Heat and Mass Transfer	3	0	0	9
DC7	MEC209	Production Technology	3	0	0	9
DP3	MEC210	Heat transfer and Fluid Machines Lab	0	0	2	2
DP4	MEC211	Machine Dynamics and Solid Modeling Lab	0	0	2	2
Total						**49**
Contact Hrs.			**15**	**0**	**4**	**19**

MEC 206 (DC4) - Fluid Machines

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	MEC 206	Fluid Machines	3	0	0	9

Course Objective

- To understand kinematic and dynamic behaviour of fluid while passing through different fluid machines.
- To understand working and performance characteristics of various hydraulic machines.
- To provide knowledge about in field application and operational aspects of various hydraulic machines.

Learning Outcomes

Upon successful completion of this course, students will:

- have a broad understanding of classification of fluid machines used to handle different types of fluid for different purpose.
- have an understanding about basics of rotodynamic machines.
- be able to design different types of fluid machines based on dimensional analysis.
- be able to understand operation principle of different fluid machines, design or select it for particular purpose and identify the reasons for faults during operation.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Introduction to incompressible and compressible flow. Classification and field of application of fluid machines, Jet Striking Plates	7	Understanding basics of fluid flow. Classification of fluid machines and types of fluid handled by the machines.
2	Water Turbines: Theory of Rotodynamic Machines-Euler's Equation, components of energy transfer, Classification – Impulse and Reaction Turbines, Construction, Operation, Head and efficiencies, Power calculation and governing of Pelton, Francis and Kaplan turbines; Draft tube; Surge tank.	10	Basics of rotodynamic machines. Detailed introduction and operation of different hydraulic turbines.
3	Application of dimensional analysis in fluid machines - Unit quantities and Specific speed.	3	Utility of dimensional analysis to design and analyze the performance of fluid machines.
4	Centrifugal Pumps: Types; Heads and efficiencies; Construction of impeller and casing; Multi-stage pumps; Specific speed; Model testing; Characteristic curves; NPSH; Cavitations; Selection of centrifugal pump.	6	This unit demonstrates the operation principle of centrifugal pump handling water.
5	Reciprocating Pumps: Classification with constructional details; Theory; Indicator diagram; Effect of acceleration of piston; Effect of friction in pipes; Air vessel and its effects; NPSH. Rotary Positive Displacement Pumps: Types and constructional details.	5	This unit demonstrates the operation principle of reciprocating pump handling liquid.
6	Air compressors, selection steps and testing procedure of fluid machines.	8	This unit demonstrates the operation principle of air compressor.

Text Books:

1. Introduction to Fluid Mechanics, S.K. Som, Gautam Biswas and Suman Chakraborty, 3rd Edition, 2011, McGraw Hill Publication

Reference Books:

1. Fluid Mechanics, Victor L Streeter, E. Benjamin Wylie and K.W. Bedford, 9th Edition, McGraw Hill Publication
2. Mechanics of Fluids, I.H. Shames, 3rd edition, 2013, Tata McGraw Hill Publication

MEC 207 (DC5) - Dynamics of Machinery

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	MEC 207	Dynamics of Machinery	3	0	0	9

Course Objective
The course aims to equip the students with basic understanding of dynamics of common moving parts of a machine.
Learning Outcomes
Upon successful completion of this course, students will be able to: • Solve three dimensional rigid body problems • Do the dynamic analysis of mechanisms • Design flywheel for engines. • Analyze and modify the design of cams. • Understand the dynamic part of an internal combustion engine. • Solve balancing problems

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	**Introduction:** Rigid body dynamics and Gyroscopes	07	Students will be able to solve engineering problems in rigid body dynamics
2	Static force analysis: free-body diagram, static equilibrium, analysis of multi-force member, force analysis with friction.	06	Students will learn to do static force analysis of mechanism
3	Dynamic force analysis: shaking effect, dynamic equilibrium, dynamic analysis of mechanisms, Dynamics of reciprocating and rotary machines	06	Students will learn to find out shaking forces, shaking moments in machines
4	Turning moment diagram, fluctuation of energy, flywheel, Governors	06	Students will understand the concept of regulating speed in machines
5	Balancing of reciprocating and rotary machines, single and multi-cylinder engine balancing.	05	Students will be able to balance the reciprocating and rotary machines
6	Cam dynamics, analysis of disc cam with reciprocating roller follower, analysis of elastic cam system.	03	Students will be able to do dynamic analysis of CAM-Follower system
7	Introduction to free and forced vibrations, critical speed of shaft, vibration measuring instruments	06	Students will understand the basics of mechanical vibration

Text book:

1. Kinematics and Dynamics of Machinery, C. L. Wilson, J. P. Sadler, Pearson, 3rd Ed. 2016

Reference books:

1. Vector Mechanics for Engineers: Statics and Dynamics, F. P. Beer, E. R. Johnston, P. J. Cornwell, S. Sanghi, Tata McGraw Hill, 10th Ed. 2017

2. Kinematics, Dynamics and Design of Machinery, K. J. Waldron, G. L. Kinzel,. Wiley 2nd Ed, 2007.

3. Theory of Machines, S. S. Rattan, McGraw Hill, 4th Ed. 2007

MEC 208 (DC6) - Heat and Mass Transfer

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	MEC 208	Heat and Mass Transfer	3	0	0	9

Course Objective

The objective of the course is to develop the fundamental concepts and principles for various modes of heat and mass transfer processes with derivations and applications of rate equations under various operating condition.

Learning Outcomes

Upon successful completion of this course, students will:

- have a broad understanding of different rate equations related to various modes of heat transfer
- be able to determine heat and mass transfer rates under various operating conditions.
- have the concept to solve heat and transfer equations both analytically and numerically.
- be able to model systems involving heat and mass transfer
- be able to design and optimize the thermal systems to maximize or minimize heat transfer.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	**Introduction:** Definitions, Mechanisms and rate equations of conduction, convection and radiation, conservation of energy for a control volume	3	Understanding mechanism for different modes of heat transfer and the basic rate equations.
2	**Conduction:**General heat conduction equation in different coordinate systems, one-dimensional steady state heat conduction for plane wall, cylindrical and spherical systems with and without heat generation – temperature distribution, thermal resistance, composite systems, Critical thickness of insulation. Heat transfer through extended surface with uniform cross-sectional area, fin performance; Transient heat conduction: lumped capacitance method, Spatial effects, plane wall with convection – exact and approximate solutions, Heisler and Grober charts.	10	Derivation of general heat conduction equation and its applications. Determination of 1-D heat transfer for different types of systems Use of boundary conditions, Estimations of enhancement of heat transfer through extended surfaces Methods of finding heat transfer rate when heat flow is dependent on time.
3	**Convection**: Basic concept, natural and forced convection, hydrodynamic and thermal boundary layers, Mass, Momentum and energy equations in forced convection, dimensionless numbers, Solution of laminar flow over a flat plate; momentum and energy equations for natural convection, empirical correlations, and introduction to boiling and condensation heat transfer	10	Basic concepts of heat transfer by forced and natural convection, determination of heat transfer rate over a flat plate. Heat transfer phenomena during phase change of a substance and the corresponding rate equations
4	**Radiation:** Fundamental concepts, Radiation properties and laws of black body radiation, Kirchhoff's law, radiation heat exchange between black and non-black surfaces, radiation shield.	6	Basic concepts of radiation mode of heat transfer, Understanding blackbody radiation and radiation heat exchange between two bodies
5	**Heat Exchanger:** Classification of heat exchanger, recuperative and regenerative heat exchangers, parallel, counter and cross flow heat exchangers, shell and tube heat exchangers, performance of heat	5	Understanding the methodology of designing heat exchangers To determine the heat transfer and performance of heat

	exchangers, effectiveness, Number of Transfer unit and capacity ratio		exchangers
6	**Mass Transfer:** Basic concept, Fick's law of diffusion, Introduction to diffusive and convective mass transfer, different dimensionless numbers and empirical correlations	5	Basic understanding of mass transfer processes and determination of mass transfer rates

Text book

1. Fundamentals of Heat and Mass Transfer-Theodore L. Bergman, Adrienne S. Lavine, Frank P. Incropera, David P. Dewitt, Wiley publication, 8th Edition, 2018

Other References

2. Heat transfer- J.P. Holman Bhattacharya, McGraw Hill, 10th edition, 2011
3. Heat and Mass Transfer: Fundamentals and Applications By YunusCengel and AfshinGhajar ,McGraw Hill, 6th edition, 2019
4. Heat Transfer – A F Mills and V Ganesan, Pearson Education, 2nd edition, 2009

MEC 209 (DC7) - Production Technology

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	MEC209	Production Technology	3	0	0	9

Course Objective

- To provide basic understanding on the technologies involved in Manufacturing processes
- To impart knowledge about the process and applications of metal casing, forming and welding.

Learning Outcomes

Upon successful completion of this course, students will:

- have a broad understanding of the different Processes and their applications.
- be able to select proper process and their parameters and equipment for manufacturing a component.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Metal casting: Principle & review of casting processes, Design of patterns, moulds and cores, types and properties of moulding sand, riser and gating system design, solidification and cooling of casting. Casting defects & remedies and inspection.	10	A complete understanding on casting processes. Students will be able to design pattern, core and gating system.
2	Metal Forming Processes: Elastic & plastic deformation, yield criteria, hot working and cold working, Bulk deformation processes: applications, operations, equipment and load estimation for Bulk deformation processes (forging, rolling, extrusion, drawing).	10	A complete understanding of metal forming process. Students will be able to estimate the required force for different forming processes.
3	Sheet Metal working: applications, operations, equipment and load estimation of Sheet metal processes (shearing, deep drawing, bending), Introduction to Punch and die arrangements.	5	Will understand applications of sheet metal works. Students will be able to design the tools for different sheet metal operations.
4	Joining processes: Broad classification of welding processes, working principle, characteristics and application of important welding processes, Precision welding processes and welding defects. Welding inspection techniques.	10	A complete understanding about different welding process. The students will able to choose the appropriate joining process as per the applications.
5	Working principle, characteristics and application of Brazing, soldering and abrasive bonding.	4	Understanding about the joining process for dissimilar materials.

Text Books:

1. Manufacturing Science : Ghosh and Mallick, East-West Press Private Limited. 2nd Edition, 2010

Reference Books:

2. Materials and Processes in Manufacturing, Degarmo, J. T. Black, Prentice Hall of India Pvt Ltd. 11th Edition, 2017
3. Manufacturing Processes for Engineering Materials, Kalpakjian and Schmid, Prentice Hall. 6th Edition, 2016
4. Fundamentals of modern manufacturing processes, M. P. Groover, Wiley India, 3rd Edition, 2009
5. Machining and Metal Working Handbook, Ronal A Walsh and Denis Cormier McGraw Hill Publication. 3rd Edition, 2005

MEC 210 Heat Transfer and Fluid Machines Lab

1. Determination of Thermal conductivity of metal rod and insulating powder
2. Determination of Thermal conductivity of composite wall
3. Performance study of Pin-fin
4. Determination of Heat transfer coefficient of air under free and forced convection
5. Determination of Stefan Boltzmann constant of a black disc
6. Determination of emissivity of a test surface
7. Performance study of concentric tube heat exchanger
8. Performance study of Pelton Turbine
9. Performance study of Kaplan Turbine
10. Study of Air compressor

MEC 211 Machine Dynamics and Solid Modelling Lab

(Part-I)

(5 experiments+ 1 Project)

1. Holding torque and gear ratio of epicyclic gear train
2. Effect of varying the mass of central sleeve for governors.
3. Gyroscopic effect of rotating disc
4. Static and dynamic balancing of rotors
5. Journal bearing
6. Project

(Part-II)

(5 experiments/assignments+ 1 Project)

7. Basics of 2D and 3D machine drawing in AUTOCAD
8. Draw nut and bolt in 3D and derive front view, top view and side view
9. Draw 3D-isometric view keys, cotters and pins, and derive front view, top view and side view
10. Assembly drawing of bushed pin type flanged coupling
11. Assembly drawing of plummer block
12. Project

3RD YEAR(5TH SEM)COURSE TEMPLATE						
Course Type	**Course Code**	**Name of the Courses**	**L**	**T**	**P**	**Credit Hrs.**
DC8	MEC301	Machine Design	3	0	0	9
DC9	MEC302	Machining and Machine Tools	3	0	0	9
DC10	MEC 303	Advanced Solid Mechanics	3	0	0	9
HSS1/MS1			3	0	0	9
E/SO4			3	0	0	9
DP5	MEC 304	Production Technology Lab	0	0	2	2
DP6	MEC 305	Machine Design Lab	0	0	3	3
						50
Contact Hrs.			**15**	**0**	**5**	**20**

MEC 301 (DC8) - Machine Design

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	MEC301	Machine Design	3	0	0	9

Course Objective

- To develop an ability to apply knowledge of mathematics, science, and engineering to design a system, component, or process to meet desired needs within realistic constraint.
- To develop an ability to use the techniques, skills, and modern engineering tools necessary for engineering practices.

Learning Outcomes

Upon successful completion of this course, students will:

- have a understanding of phases and interactions of the design process.
- be able to make decision with too little information or with an excess of partially contradictory information.
- be able to take into account safety and environmental issues when selecting and/or designing a mechanical components.
- be able to design various mechanical components.
- be able to communicate effectively and work with people of many discipline.
- be able to work professionally in mechanical design area.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Philosophy of engineering Design, Mechanical engineering design, Design process, Design considerations, Factor of safety Codes and Standards. Material selection.	4	Understanding of various design considerations, basic principles of machine design, factor of safety and material selection requirements.
2	Design static loading; Modes of failure, Stress concentration, failure theories, Selection of failure criteria, Fracture mechanics	5	Understanding of static loading for designing machine elements, stress analysis and theories of failure.
3	Design for dynamic loading; Endurance limit and fatigue strength, stress concentration and notch sensitivity, fatigue failure criteria. Surface damage, Wear, contact stresses	7	Understating of dynamic loading, design of machine elements on the basis of strength/ rigidity concepts, stress analysis and failure criteria.
4	Design of Joints: bolted, riveted and welded joints.	4	Designing of bolted, riveted and welded joints and their limitations.
5	Design of Shaft, couplings, springs. brakes and clutches.	8	Ability to design shaft, couplings, springs, brakes and clutches for a particular application.
6	Selection of Rolling contact Bearing, Lubrication and slider bearing, design of journal bearing.	6	Ability to select different types of rolling bearing, from the manufacturers catalogue andabilty to design sliding bearing.
7	Design of gears : Spur gear, helical gear, Bevel gear.	5	Ability to design gears for a particular application.

Text Books:

1. Mechanical Engineering Design, J. E. Shigley, Mischkee& R. Charles

Reference Books:

3. Design of Machine Elements, M. F. Spotts& T. E. Shamp.
4. Machine Design, Robert L. Norton.
5. Machine component Design, R C Juvinall, Kurt M. Marshek
6. Design Data Hand Book, PSG College of Technology.
7. Relevant Indian Standards

MEC 302 (DC9) - Machining and Machine Tools

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	MEC 302	Machining and Machine Tools	3	0	0	9

Course Objective

- To understand the fundamental of machining process and their importance for selection of proper process parameters
- To provide knowledge about different the principle, operation and applications of different machines tools and fixtures
- To understand the principle and applications of various advanced machining processes.

Learning Outcomes

Upon successful completion of this course, students will:

- have understanding of the fundamental of machining process and importance machining process parameters
- be able to manufacture components as per production drawing using suitable machine tools and their process parameters.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Introduction to machining processes, Cutting tools-single and multi-point cutting tools, tool geometry and materials.	8	Understanding about the different types of machining processes and their tools.
2	Mechanics of chip formation, Merchant's force circle diagram. Cutting fluids/lubricants.	8	Understanding of mechanics of metal cutting process. The students will able to estimate optimum machining parameters.
3	Tool wear mechanism, and tool life. Machinability. Economics of metal cutting.	6	This unit will help student in understanding the fundamental of tool life and its effects on productivity.
4	Lathe, Milling, Drilling, Boring and Grinding, machine tool drives, Principles of work holding, design of jigs and fixtures.	8	Students will get complete knowledge about the conventional Machine tools and their accessories.
5	Principles of EDM and WEDM; ECM; USM;AWJ; ECG; Super finishing processes.	9	Students will get basic idea about the non-conventional machining process and their applications.

Text Books:

1. Machining and Machine Tools, A.B. Chattopadhyay, Willey Publishers, 2011

Reference Books:

2. Theory of Metal Cutting, A. Bhattacharya.
3. Fundamentals of Metal Machining and Machine Tools, Winston A. Knight, Geoffrey Boothroyd, CRC Press
4. Principles of Machine Tools, G. C. Sen and A, Bhattacharya, New Central Book Agency
5. Machining and Metal Working Handbook, Ronal A Walsh and Denis Cormier McGraw Hill Publication. 3rd Edition, 2005

MEC 303 (DC10) - Advanced Solid Machines

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	MEC 303	Advanced Solid Machines	3	0	0	9

Course Objective
To solve problems in solid mechanics which cannot be satisfactorily addressed by the approaches of mechanics of materials. Examples of such problems include plane stress and strain problems, semi-inverse problem solution, fracture problems, plasticity, and problems in which some input or system parameters are uncertain.
Learning Outcomes
Students completing this course should be able to: • formulate and understand the differential equations governing the behavior of two dimensional elastic solids, • solve the differential equations governing the bending of beam, • apply concepts of energy conservation to the solution of problems in solid mechanics, • determine whether a solid will exceed the elastic limit and analyze the post-yield behavior

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Continuum concept of stress and strain fields. Generalized Hook's law, equilibrium equation and compatibility conditions. 3-D Mohr's circle representations for stress and strain. Concept of stress function,	12	One would have learnt the continuum concept of "stress" and "strain" in addition to revisiting the concept of a "force" and "displacement".
2	Stresses in a thick cylinder, compound cylinder and a rotating disk.	6	Formulate and understand the differential equations for the stress analysis in a cylinder and disk.
3	Concept and application of energy methods. Unsymmetrical bending of beams, Shear center, shear flow in thin members.	6	Knowledge the concept of energy conversion for solving the solid mechanics problem
4	Failure, yield and fracture, Elements of fracture mechanics.	6	Basic knowledge of failure and fracture analysis of engineering materials
5	Plasticity: yield criteria, hardening rules, flow rules, cyclic loading.	6	Understanding the materials behavior beyond elastic limit.
6	Plastic analysis of beams.	3	Understanding the behavior of beam when plastically deformed.

Text Books:

1. Ugural and Fenster, Advanced Strength and Applied Elasticity. 4th ed. Prentice Hall, 2003.

Reference Books:

1. L.S. Srinath, Advanced Solid Mechanics, Tata McGraw Hill Publication
2. Arthur P. Boresi and Richard J. Schmidt, Advanced Mechanics of Materials, 6th edition, Wiley, 2009.

MS1
E/SO4 Offered by Management Studies Dept

MEC 304 Production Technology Lab

1. Metal cutting tool grinding operation on tool and cutter grinder.
2. Measurement and analysis of cutting forces and temperature in turning operation.
3. Gear manufacturing (with measurement) on milling/gear hobbing/gear shaping machine tool.
4. Sand preparation and testing: specimen preparation for testing permeability, clay content, grain fineness number, moisture content, green compression strength, green shear strength, splitting strength, hardness, etc.;
5. Casting of metals after preparation of mould and demonstration on gravity die casting process.
6. Experiments on welding process: MIG, TIG and demonstration of other advanced welding and brazing processes.
7. Inspection and analysis of welded joints: HAZ, grain structure.
8. Formability tests of sheet metals and product preparation.
9. Mini project work on manufacturing.

MEC 305 Machine design Lab

1. Design of shaft
2. Design of rigid coupling
3. Design of flexible coupling
4. Design of helical spring
5. Design of leaf spring
6. Design of brakes and
7. Design of clutches
8. Design of journal bearing
9. Selection of rolling element bearing
10. Design of spur gear
11. Design of helical gear
12. Design of bevel gear

Text book

1. Mechanical Engineering Design, J. E. Shigley, Mischkee& R. Charles

Reference books

1. Design of Machine Elements, M. F. Spotts& T. E. Shamp.
2. Machine Design, Robert L. Norton.
3. Machine component Design, R C Juvinall, Kurt M. Marshek
4. Design Data Hand Book, PSG College of Technology.
5. Relevant Indian Standards

3RD YEAR(6TH SEM) COURSE TEMPLATE						
Course Type	**Course Code**	**Name of the Courses**	**L**	**T**	**P**	**Credit Hrs.**
DC11	MEC306	Computer Aided Manufacturing	3	0	0	9
DC12~~/DE1~~	MEC 307	IC Engines and Gas Turbines	3	0	0	9
MS2/HSS2			3	0	0	9
OE1			3	0	0	9
OE2			3	0	0	9
DP7	MEC 308	Computer Aided Manufacturing Lab	0	0	2	2
DP8	MEC 309	Heat Power and Refrigeration Lab	0	0	2	2
						49
Contact Hrs.			**15**	**0**	**4**	**19**

MEC 306 (DC11) - Computer Aided Manufacturing

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	MEC306	Computer Aided Manufacturing	3	0	0	9

Course Objective

- To provide detailed understanding of advances in manufacturing particularly in computer numerical control.
- To understand working principle work Numerical control.
- To provide knowledge about in computer control material handling system.

Learning Outcomes

Upon successful completion of this course, students will:

- have a broad understanding of classification of automation system.
- have an understanding about basics of Numerical Control.
- be able to design different types of control systems.
- be able to learn different CNC programming and simulation software.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Introduction to Automation and mechanization, basic elements of an automated system, level of automation	4	Understanding basic difference between automation and mechanization. Also strategies adopted for implementation of automation.
2	Numerical Control of machine tools, different types of controls, point to point, continuous path, digital and analog control, absolute and relative, NC system devices,	6	Learn about classification of CNC system, and their application
3	Computer numerical control (CNC), Direct numerical control (DNC), adaptive control of manufacturing processes, Flexible manufacturing system, Computer Integrated Manufacturing.	10	Understanding of different configuration and level of CNC control, Importance of FMS and CIM system
4	Computer-process interface, NC part programming, APT	10	Learn about computer programming and also simulation of machining process
5	Computer aided material transport and storage system including Industrial robots, AGVs, Introduction to Additive Manufacturing process.	9	Basic knowledge about the different computer controlled material handling system and their control.

Text Books:

1. Computer control of Manufacturing system, Yoramkoren, McGraw Hill Publication.

Reference Books:

2. Machining and Metal Working Handbook, Ronal A Walsh and Denis Cormier McGraw Hill Publication.
3. Machining and CNC Technology, M. Fitzpatrick, McGraw-Hill Publication.

MEC 307 (DC12) - IC Engines and Gas Turbines

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	MEC 307	IC Engines and Gas Turbines	3	0	0	9

Course Objectives

- The course is important for students to understand the basic components, working principles and performance of IC Engines and Gas Turbines.
- The course includes combustion process and related heat transfer in IC engines and gas turbines.
- This course explores applications in automobile industry and gas-operated power plants.

Learning Outcomes

Upon successful completion of this course, students will:

- The introduction to internal combustion engines is based on explaining processes by the application of first principles in thermodynamics, heat transfer, fluid flow etc.
- Through this course, students can gain in depth understanding of the engine components, injection, ignition as well as various stages of combustion inside the spark ignition (S.I) and compression ignition (C.I) engines.
- It also provides some basic knowledge of gas turbines to the students. Besides, students shall gain knowledge about the recent developments in the internal combustion engine technology.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	**Introduction:** Internal and external combustion engines, classification and nomenclature of I. C. Engines, Air standard Otto, diesel and dual combustion cycles, deviation of actual engine cycle from ideal cycle.	5	To understand the classification of I.C Engines, air standard cycles, Air standard cycles and its comparison of actual engine cycle.
2	**Carburetion and fuel Injection:** Mixture requirements for various operating conditions in S.I. Engines; elementary carburetor, single-point and multi-point fuel injection systems; Diesel injection system.	8	To understand the requirement of a carburetor in an engine, working principles, single/multi point fuel injection systems.
3	**Ignition systems:** Types of ignition systems, advancing ignition timing; spark plugs.	5	To understand the different types of ignition systems such as battery/ magneto ignition systems in engines.
4	**Combustion in I.C. Engines:** Stages of combustion in S.I. Engines, factor influencing the ignition lag and flame speed, detonation and its effects on engine performance, influence of engine variables on detonation, pre-ignition, Stages of combustion in C.I. Engines, delay period, variables affecting delay period, knock in C.I. engines, Lubrication and Cooling Systems.	7	To understand various stages of combustion in S.I and C. I engines, detonation and its effect on the engine performance, Different types of lubrication and cooling systems.
5	**Engine Testing and Performance:** Measurement of various engine performance parameters.	3	To understand the various performance parameters in engines and their calculations to assess the engine performance.
6	**Supercharging:** Objectives of supercharging, its advantages and applications; Turbocharging and supercharging of SI and CI Engines; limitations of	5	To understand requirement, objectives and applications of supercharging and turbocharging

	supercharging.		in S.I and C.I engines.
7	**Gas Turbines:** Brayton cycle, open and closed gas turbine plants, Improvements of the basic gas turbine cycle; reheating and regeneration. Applications of gas turbines, requirements of a gas turbine.	6	To understand the basic gas turbine cycle and its improvement, open/closed gas turbine plants, applications of a gas turbine.

Text books

1. Internal Combustion Engines, V. Ganesan, 4th edition, 2012, Tata McGraw Hill Publication
2. Gas turbine theory-H. Cohen, H.I.H. Saravanamuttoo, G.F.Crogers, Paulstraznicky, Andrew nix, pearson publication,7th edition, 2017

Reference books

1. Fundamentals of Internal Combustion Engines, H.N. Gupta, 2nd edition, 2012, PHI publication
2. Internal Combustion Engine Fundamentals: J.B. Heywood, McGrawhill Book Co., 1988
3. Internal Combustion Engines, M.L. Mathur and R.P. Sharma, 2014 edition, Dhanpat Rai Publication

HSS2
OE1
OE2

MEC 308 Computer Aided Manufacturing Lab

1. Demonstration on different types of gauges and measurement instruments.
2. Measurement of surface roughness of a machined part, gear profiles and angle measurements.
3. Accuracy measurements of lathe bed, spindle, carriage, tail stock projections, shaft alignment.
4. Metal cutting tool profile measurement (Single point and multipoint).
5. Disassembling and assembling of machine tool parts.
6. Writing and execution of CNC part programs for turning.
7. Writing and execution of CNC part programs for drilling and milling operations.
8. Programing and practises of flexible manufacturing systems (FMS)
9. Robot control programming and Demonstration.
10. Demonstration on virtual instrumentation.
11. Programming for virtual instrumentation.
12. Measurement of load using load cell, displacement, deflection, strain, temperature etc. using sensors.
13. Demonstration on system devices such as motors, feedback devices, interpolators.

MEC 309 Heat Power and Refrigeration Lab

1. Performance study on VCR Engine
2. Computerized performance test on VCR Engine
3. Morse Test on multi cylinder petrol Engine
4. Performance study of Turbo-charged Diesel Engine
5. Exhaust Gas Analyzer
6. Performance evaluation of a mechanical heat pump when capillary tube is acting as expansion device.
7. Performance evaluation of a mechanical heat pump when thermostatic expansion valve is acting as expansion device.
8. Study of different Psychrometric processes
9. Performance evaluation of summer air-conditioning test rig.
10. Study of cut models of different components of a vapor compression refrigeration unit.
11. Performance test of a vapor absorption test rig.

4TH YEAR(7TH SEM)COURSE TEMPLATE						
Course Type	**Course Code**	**Name of the Courses**	**L**	**T**	**P**	**Credit Hrs.**
DE1			3	0	0	9
DE2			3	0	0	9
DE3			3	0	0	9
OE3			3	0	0	9
OE4			3	0	0	9
UGP*	MES 401	UGP-1 (Zero-Credit) (Compulsory)	0	0	6	6
DC12*	MES 402*	Summer training	0	0	0	3
						45+(9)
Contact Hrs.			**15**	**0**	**6**	**15+6= 21**

DE1
DE2
DE3
OE3
OE4
UGP : MES 401 UGP-1
DC12 : MES 402 Summer training

8TH SEM(4TH YEAR) COURSE TEMPLATE						
CourseType	**Course Code**	**Name of the Courses**	**L**	**T**	**P**	**Credit Hrs.**
DE4			3	0	0	9
DE5			3	0	0	9
OE5			3	0	0	9
OE6			3	0	0	9
DC13*	MES 403*	UGP-2	0	0	6*	6*
						36+6*
Contact Hrs.			**12**	**0**	**6***	**12+6***

DE4
DE5
OE5
OE6
DC13 : MES 403 UGP-2

LIST OF DEPARTMENTAL ELECTIVES (DE)

PROPOSED DEPARTMENTAL ELECTIVE (DE)			
Course No.	**Name**	**Course No.**	**Name**
MED 401	Energy Conversion Equipment	MED 402	Optimization Theory
MEC 500	Theory of Elasticity	MEC 503	Finite Element Method
MEC 507	Incompressible and Compressible flow	MEC 508	Advanced Heat Transfer
MEC 510	Refrigeration and Air-Conditioning		
MED 528	Robotics	MED 530	Theory of Plates and Shells
MED 531	Fracture Mechanics	MED 533	Acoustics and Noise control
MED 534	Automation and Control	MED 535	Vibration Control
MED 543	Solar Energy	MED 553	Laser Processing of Materials
MED 556	Design of Tools, Jigs and Fixtures	MED 557	Micro- Electro-Mechanical Systems (MEMS)
MED 558	Micro Manufacturing	MEO 586	Additive Manufacturing

LIST OF SO/ESO COURSES

SUBJECTS PROPOSED TO OFFER UNDER SO/ESO			
Course No.	**Name**	**Offering Semester**	**Mandatory for Departmental Students**
MEE 201	Engineering Materials	Monsoon	YES
MEE 202	Computer Aided Engineering Design	Winter	NO

LIST OF OPEN ELECTIVES (OE)

PROPOSED OPEN ELECTIVE (OE) COURSES		
Course No.	**Name**	Semester
MEO 306	Mechanical Measurement	Monsoon
MEO 401	Piping System	
MEC 501	Mechanical Vibration	
MEC 516	Unconventional Manufacturing Processes	
MED 529	Composite Materials	Winter
MEO 579	Computational Fluid Dynamics	
MED 544	Advanced Steam Power Plant	

SYLLABI OF DEPARTMENTAL ELECTIVES (DE)

ODD SEMESTER

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	MED401	Energy Conversion Equipment	3	0	0	9

Course Objective
• The purpose of this course is to introduce the undergraduate students with the most important equipments in the thermal engineering related to production of output power in the thermal power plants, and provide proper understanding of its operations.
Learning Outcomes
Upon successful completion of this course, students will: • Effective utilization of available renewable energy resources • To acquire the knowledge of modern energy conversion technologies • Capability to determine thermodynamic efficiency of various energy related processes. • To understand the Gas turbine plant and performance of it.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Vapour Power Cycles: Simple and modified Rankine cycle, Binary vapour cycle.	05	Discuss the energy resources and energy conversion methods available for the production of electric power in India
2	Flow through Nozzle, Velocity and heat drop, mass discharge through a nozzle, critical pressure ratio and its significance, effect of friction and nozzle efficiency, supersaturated flow, design pressure ratio	06	Discuss the effects of area change, the effects of the back pressure on mass flow rate, and the occurrence of chocking and normal shocks.
3	Steam Turbines: Classification, Flow through blades, velocity diagram, power output and efficiency, maximum blade efficiency of single stage impulse turbine, blade friction, compounding of impulse turbine. Reaction Turbine-Flow through impulse reaction blades, degree of reaction, velocity diagram, power output, efficiency and blade height, comparison of impulse and impulse reaction turbines. Losses in steam turbines, stage efficiency, overall efficiency and reheat factor. Governing of steam turbines.	12	Discuss the working principle and basic concepts of the steam turbines, its layout, safety principles and compare it with plants of other types.
4	Steam Condensers: jet and surface condensers., Condenser vacuum, sources of air leakage & its disadvantages, vacuum efficiency and condenser efficiency	06	Select the heat transfer tubes needed for condensers and effects of air leakage in a condenser
5	Gas Turbines: Brayton cycle; Components of a gas turbine plant; open and closed types of gas turbine plants; Optimum pressure ratio; Improvements of the basic gas turbine cycle; multi stage compression with inter-cooling; multi stage expansion with reheating between stages; exhaust gas heat exchanger, Applications of gas turbines; selection of blade materials; gas turbine fuels.	10	Calculate the performance of gas turbines with reheat and regeneration, and discuss the performance of combined cycle power plants.

Text Book:

1. Power plant engineering- PK nag, McGraw Hill, 4th edition, 2014

Other References:

1. Steam turbine theory and practices – W. J kearton, CBS Publication, 7th edition, 2004
2. Gas turbine theory-H. Cohen, H. I. H. Saravanamuttoo, G.F.C Rogers, Paul Straznicky, Andrew nix, Pearson Publication,7th edition, 2017
3. Gas turbine- V Ganesan, McGraw hill,3rd edition,2010
4. Thermodynamics and Heat Engines vol.2- R Yadav, central Publishing house, 6th edition, 2000.

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	MED 402	Optimization Theory	3	0	0	9

Course Objective

- To understand theory of different optimization methods to solve various types of engineering problems.
- To understand physical engineering problem and to construct mathematical formulation towards solving it by selecting proper optimization techniques.
- To understand both computer programming and heuristic approaches to solve optimization problems.

Learning Outcomes

Upon successful completion of this course, students will:

- have a broad understanding formulation of engineering optimization problem.
- have an understanding about single and multivariable engineering problems.
- be able to write MATLAB code for single and multivariable engineering problems.
- be able to understand and write MATLAB code for Nontraditional optimization technique like GA to solve different engineering problems.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Basic Concepts: optimization problem formulation.	4	Understanding the types and basic concept of engineering optimization problem formulation.
2	Single variable optimization algorithms: Exhaustive search method, bounding phase method, Interval halving method, golden search method, Newton Rapshon method, bisection method, secant method. Computer programming to solve the single variable problem	9	This unit discuss about different types of classical single variable optimization algorithms. Student will learn to write MATLAB code for these algorithms also.
3	Multivariable optimization algorithms: Unidirectional search, direct search methods, simplex search and gradient based methods. Computer programming to solve Multivariable optimization algorithm	9	This unit discuss about different types of classical multivariable unconstrained optimization algorithms. Student will learn to write MATLAB code for these algorithms also.
4	Constrained optimization algorithms: Linear programming, nonlinear programming penalty function method, method of multipliers, sensitivity analysis, direct search for constrained minimization. Related computer Programming.	8	Student will learn constrained optimization algorithms and their computer programming.
5	Nontraditional optimization: Introduction to Genetic algorithm: Binary coded GA, Limitation – advantage & disadvantage Real coded GA, Micro GA, Scheduling of GA, computer programming, other evolutionary algorithms.	9	This unit demonstrates basics of Nontraditional optimization techniques. Use of Nontraditional optimization like GA to solve different engineering problem, especially mechanical engineering problems.

Text Books:

1. Deb, K. Optimization for engineering design: algorithms and examples. Prentice Hall of India, New Delhi. 2nd Edition 2012

Reference Books:

1. Rao, S.S. Engineering Optimization: Theory and Practice. Wiley. 3rd Edition, 2014
2. Ravindran, A., Ragsdell, K. M., Reklaitis, G. V. Engineering Optimization: Methods and Applications, Willey, 2nd Edition, 2013
3. Rardin, Ronald L. Optimization in operations research. Prentice Hall.

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	MEC500	Theory of Elasticity	3	0	0	9

Course Objective

- To improve the ability to use the principles of theory of elasticity in engineering problems.
- T provide accurate analysis for the stress, strains and displacements even for structures of complicated geometries and loadings.
- To provide the student with the mathematical and physical principles of Theory of Elasticity using a large gamut of examples.
- To provide the student with various solution strategies while applying them to practical cases.

Learning Outcomes

Upon successful completion of this course, students will:

- Derive the governing equations for 2D and 3D elastic problems.
- Solve these problems with various solution methodologies.
- Apply the theory of elasticity to problems of practical interest.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Introduction of Cartesian tensor analysis, Continuum concept of stress and strain fields, Concept of displacement field, Stress-strain-displacement relationship in polar coordinate system	10	To understand the theory of elasticity including strain/displacement and Hooke's law relationships.
2	Generalized Hook's law, Stress equilibrium equation, Compatibility condition, 3-D Mohr's circle and plan stress & strain Problem, Hydrostatic and deviatoric stress tensor, Lame's elastic constant, energy methods.	10	To analyze the maximum and minimum principal stresses using analytical and graphical (mohr's circle)methods, using classical methods and energy methods
3	Airy's stress function approach ,Cartesian coordinate solutions , Polar coordinate solutions	4	To solve the problems with various solution methodologies in polar and Cartesian coordinates
4	**Torsion**: Torsion of thin walled Tubes, Noncircular Section: Saint Venanat's Method, Membrane Analogy, Torsion of Multiply Connected Sections, Centre of Twist and Flexure Centre	4	To solve torsion problems in bars and thin walled members
5	**Bending of Beams**: Straight beams and Asymmetrical Bending, Shear Centre, Bending of Curved Beams.	5	To solve for stresses and deflections of beams under unsymmetrical loading
6	**Axi-symmetric Problems**: Thick Walled Cylinders Subjected to Internal and External Pressure, Problems of Spherical and Axial Symmetry	6	This unit discuss about the analysis of thick cylinder

Text Books:

2. Advanced Mechanics of Solids, L. S. Srinath, 2nd Ed. TMH, 2003.

Reference Books:

8. Theory of Elasticity, S. P. Timoshenko & J. N. Goodier, 2nd Ed. McGraw-Hill, 1951.
Solid Mechanics, Kazimi, TMH,2001.

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	MEC503	Finite Element Method	3	0	0	9

Course Objective

- To understand a numerical technique to find approximate solutions of partial differential equations.
- Enables the students to virtually test and predict the behavior of mechanical structures in addition to solving complex engineering problems.
- FEM allows for detailed visualization and indicates the distribution of stresses and strains inside the body of a structure.

Learning Outcomes

Upon successful completion of this course, students will able to:

- Know the basic elements, formation of stiffness and force matrices of mechanical problems
- Make virtually model and test & predict the behavior of mechanical structures in addition to solving complex engineering problems.
- Solve complex elasticity and structural analysis problems in Civil, Mechanical and Aerospace engineering.
- Learn the MATLAB based FEM coding

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Introduction: Fundamental concepts and matrix algebra.;steps , applications of FEM.	2	Understanding the Matrix manipulation, basic concept of FEM and apllications.
2	Direct stiffness method: Spring; Truss – coordinate transformation, Shape function in 1D, Governing Differential Equations -strong form and weak form.	6	This unit discuss about the basic steps and formulation of FEM for spring and truss element.
3	Approximation Techniques: Potential energy method, Rayleigh-Ritz method and Galerkin method. 1D problems using the Rayleigh-Ritz Principle.	6	This unit discuss about the different techniques to formulate the FEM problems.
4	Element Properties: Triangular & Rectangular Elements, Lagrange and Serendipity Elements. Isoparametric Formulation, Stiffness Matrix of Isoparametric Elements, Integration: 1D, Two Dimensional	8	Student will learn about the different 2D element.
5	Plate and shell element: Plane stress & plane strain problems, Introduction to Plate Bending Problems. Beam element.	8	Student will learn about the different higher order element – useful for structural analysis
67	Applications of FEM: Finite Elements in Thermal analysis, Dynamic Analysis.	8	This unit discuss about the dynamic eigenvalue problem and thermal analysis.
	FEM programming with MATLAB.	3	Student will learn the MATLAB based FEM coding

Text Book

1. Daryl L. Logan, A first Course of FEM, 5th Edition, Cengage learning, 2012.

Other References

1. T.R .Chandrupatta and A.D.Belegundu, *Introduction to Finite Element in Engineering,* Pearson Education India; 4 edition 2015
2. J.N. Reddy, *An Introduction to the Finite Element Method*, Tata McGraw-Hill edition, 2015.
3. The finite element method, T. J. R. Hughes, PRENTICE-HALL, INC, Englewood Cliffs, New Jersey.

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	MEC 507	Incompressible and Compressible flow	3	0	0	9

Course Objective

1. Fluid dynamics is one of the oldest research area of immense engineering relevance. The primary objective of this advanced course is to motivate the students towards further study and research in this domain.

2. To expand the concepts and understandings of fluid dynamics of the final year undergraduate students who were introduced to elementary Fluid Mechanics in second year.

3. To introduce diverse and advanced topics to the students that will enhance their grasp on the basics of theoretical fluid dynamics, improve their ability to explain fluid flow phenomena through physics supported by mathematical analysis.

Learning Outcomes

1. Students will be comfortable to deal with equations or mathematical expressions written using indicial notations. This will certainly be an added advantage in their higher study of next level.

2. Strong foundation of the viscous, incompressible flow equations and their alternate forms.

3. Understanding of the close coupling between Fluid Mechanics and Thermodynamics.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Generalized curvilinear coordinates, introduction to tensors	3	To express a given algebraic or differential equation in generic form.
2	Reynolds Transport Theorem (RTT), derivation of the continuity and momentum equations, the conservation equations in vector and tensor forms, conservation equations in Cartesian, cylindrical polar and spherical polar coordinates	10	Bridging the particle and point approaches of mechanics, express any conservation equation using vector or tensor notations, express the conservation equations in vector form and also as functions of coordinates.
3	Analytical solutions of Navier-Stokes equations of motion	3	To identify the extremely limited instances of viscous flow where closed form solutions of momentum equations are possible.
4	The concept of boundary layer, Prandtl's boundary layer theory and its limitations, boundary layer equations over a flat plate at zero incidence and similarity solution by Blasius, momentum integral equation, Karman-Pohlhausen method, separation of boundary layer	6	To perform scale analysis and reduce the momentum equations to simplified forms, identify similarity variable and perform similarity solution.
5	Forces on immersed bodies – drag and lift	2	Calculation of global fluid

			loading from distributed fluid forces over a surface, to explain the roles of surface pressure, body shape and separation points in controlling fluid loading.
6	.Transition to turbulence, concepts of turbulence modeling, space and time scales of turbulence, space correlation and cross-correlation, Reynolds form of the continuity and momentum equations	7	Understanding of the applicability and limitations of basic conservation equations to study turbulent flow, to familiarize with the basic approximate equations employed in analyzing turbulence.
7	Compressible Flow, Thermodynamic relations of Perfect gases, Stagnation properties	3	Clear idea of the coupling of compressible flow with the basics of thermodynamics.
8	Isentropic flow with variable area duct and Flow with normal shock waves	5	Ability to distinguish between one-dimensional and quasi-one-dimensional flows. Understanding of normal shock theory.
9	Supersonic wind tunnels, Flow with oblique shock waves, oblique shock relations from normal shock equations, Mach waves	10	Understanding of the source of oblique shocks and thermodynamic relations of oblique shocks.
10	Flow in constant area duct with friction and flow with heat transfer	3	Control volume analysis of one-dimensional Rayleigh-line and Fanno-line flow.

Text Book:

1.F. M. White, Viscous Fluid Flow, McGraw-Hill, New York, 2nd edition, 2012.
2. Philip J. Pritchard and John W. Mitchell, Introduction to Fluid Mechanics, Fox and McDonald's, John Wiley & Sons, 9th edition, 2016.

Reference books:

3. R. L . Panton, Incompressible Flow, John Wiley and Sons, Wiley, 4th edition, 2013.
4. H. Schlichting, Boundary Layer Theory, Springer, 8th revised edition, 2001.
5. W. Yuan, Foundation of Fluid Mechanics, PHI, S.I. unit edition, 1988.
6. V. Babu, Fundamentals of Gas Dynamics, Wiley-Blackwell, Chennai, 2ndedition, 2015.
7. P. H. Oosthuizenand W. E. Carscallen, Compressible Fluid Flow (Engineering Series), McGraw-Hill Science/Engineering/Math, 1st edition, 2003.
8. S. M. Yahya, Fundamentals of Compressible Flow with Aircraft and Rocket Propulsion, New Age International, 2018.

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	MEC508	Advanced Heat Transfer	3	0	0	9

Course Objective
This course is designed to make the student understand the basic principles of heat and mass transfer, and to develop methodologies for solving wide varieties of practical engineering problems
Learning Outcomes
Upon successful completion of this course, students will: • have a broad understanding of advanced topic of heat transfer • Have analytical and mathematical tools to handle complex heat transfer problem • Be able to provide some basic solution to real life heat transfer problems.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	**MODULE I**: Introduction to Conduction, convection and radiation heat transfer, 1-D Steady State Heat Conduction, Heat conduction in non-isotropic materials, Fins with variable cross-section, Moving fins. Conduction shape factor, Multi-dimensional steady state heat conduction, Graphical Method: (The Schmidt Plot).	5	Reviewing the basic heat transfer. Understanding and analysis of extended surface. Applying their knowledge for multidimensional steady state conduction
2	**MODULE II:** Improved lumped models, Duhamel's superposition integral. Transient heat flow in a semi-infinite solid: The similarity method, The integral method.	5	Transient heat conduction and its analysis will be learned. Learning about time dependent boundary condition and solution.
3	**MODULE III :** Heat equation for moving boundary problems, Stefan's solution. Moving Heat Sources.	4	Specific topics discussing about moving boundary problem and phase change will be analyzed.
4	**MODULE IV:** Momentum and Energy Integral Equations, Thermal ad hydrodynamic boundary layer thickness, Heat transfer in a circular pipe in laminar flow when constant heat flux and constant wall temperature to the wall of the pipe, convection correlations for turbulent flow in tubes, Flow over cylinders and spheres, Flow across tube bundles/banks. Heat transfer from a vertical plate using the Integral method.	10	Student will be able to understand convection heat transfer. They will be able to analyze the problem mathematically and relate it to real life examples.
5	**MODULE V:** Free convection in enclosed spaces, Mixed convection, High speed flows.	5	Students will be able to differentiate between forced and free convection. They will also learn to analyze the mixed convection problems.
6	**MODULE VI:** Radiation heat transfer, View factors: Cross string method, unit sphere and inside sphere method, Radiant energy transfer through absorbing, emitting and scattering media, Radiative transfer equation, Enclosure analysis in the presence of an absorbing or emitting gas.	6	Students will be able to analyze the radiation heat transfer. They will also learn about gas radiation.
7	**MODULE VII:** Heat exchangers	4	Students will understand the importance of heat exchanger and its use in process industries.

Text Books:

1. F.Incropera, and D. J. Dewitt, Fundamentals of heat and mass transfer –Wiley & Sons Inc., 7th Edition, 2011.

Reference Books:

9. K. Muralidhar, J. Banerjee., “Conduction and Radiation” 2nd edition, Narosa 2010
10. LatifM. Jiji., “Heat Conduction”, Springer, 3rd Edition, 2009
11. A. Bejan, Convective Heat Transfer, J. Wiley & Sons, 3nd edition, 2004.
12. M. F. Modest, "Radiative Heat Transfer", Academic Press, 3rd edition, 2013.

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	MEC 510	Refrigeration and Air conditioning	3	0	0	9

Course Objective

- To develop the basic understanding of the system, working principles, components, and the methods to improve the performance.
- To provide a detailed knowledge about the common refrigeration and air conditioning system, as well as un-conventional systems.
- To develop the independent thinking about the improvement of the performance and to troubleshoot the system when necessary.

Learning Outcomes

Upon successful completion of this course, students will:

- havethe basic understanding of the system, working principles, components, and the methods to improve the performance.
- be able to thermally design a refrigerator or air conditioner.
- be able to monitor / analyze the performance of a refrigeration and air conditioning system.
- be able to think independently to improve the performance or troubleshoot the system to a limited extent.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Introduction, Natural and Mechanical refrigeration; Application of Refrigeration; Methods of producing low temperature, Units of refrigeration and Coefficient of performance.	3	Ability to distinguish between refrigeration and cooling, Understanding the basics of the refrigeration and air conditioning system, classifications and applications, various methods to achieve low temperature, andevaluation of the systemperformance.
2	Reversed Carnot and Bell Coleman cycles, Aircraft cooling – necessity and different methods, Performance, Merits and Limitations.	4	Understating of basic cycles on which an ideal air refrigeration system works, various methodsassociated with aircraft cooling, and their merits and limitation.
3	Analysis of vapor compression refrigeration cycle and its modification, Effects of operating parameters, Analysis of multi-pressure and multi evaporator systems, Flash chamber, Cascade refrigeration systems.	10	Demonstration ofcommonly used refrigeration cycle, the influence of various design and operating parameters on the system performance, and various methods to improve the performance. To understand the need of multi pressure and multi evaporator systems.
4	Vapor Absorption Refrigeration Systems: Aqua-ammonia, Water-lithium bromide and Electro-lux refrigeration systems	5	To understand the working principle of heat operated refrigeration systems, their merits and limitations.
5	Primary and secondary refrigerants, Classification and desired properties of refrigerants, Important refrigerants, Ozone Depletion Potential (ODP), Global Warming Potential (GWP) and Total Equivalent Warming Index (TEWI) of refrigerants, Future refrigerants.	5	To familiarize the students with the important properties of an ideal refrigerant and make them capable of choosing suitable refrigerant for particular systm.The unit demonstrates the details of present and future refrigerants, and their long-term impact on the environment.
6	Psychrometric properties, relations and chart, Psychrometric processes, Summer and winter air-conditioning systems, requirement of comfort air conditioning, comfort chart.	8	The unit will make the student conversant with various properties related to moist air, psychometric chart, and the basics of various psychrometric processes to achieve different air conditioning requirment
7	Cooling load and heating load calculations, Various air-conditioning systems, their advantages and drawbacks.	4	Learning the details about the thermal design of an air conditioner, various system and their merits and demerits.

Text Books:

1. IntroductionRefrigeration and Air conditioning – R.C Arora, 2012, PHI Publication

Reference Books:

1. Refrigeration and Air Conditioning – W. F Stoecker and J. W. Jones 2nd edition, 2014, Tata McGraw Hill Publication
2. Principles of refrigeration – Ray J. Dossat, Thomas J. Horan, Pearson education, 5th edition, 2001
3. Refrigeration and air conditioning – C.P. Arora, 3rd edition, 2017, Tata McGraw Hill Publication

EVEN SEMESTER

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	MED 528	Robotics	3	0	0	9

Course Objective
• To expose the students in both the aspects of analyses and applications of robotics.
Learning Outcomes
Upon successful completion of this course, students will: • have a broad understanding of classification of robots and robotic manipulators used in automation industry. • have an understanding about basics of robot dynamics and control.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Introduction: Robot definition, application, robot anatomy; robot classifications and specifications, serial robots.	3	Understanding robot classifications and general applications
2	Actuators: Pneumatic, hydraulic and electric actuators, Stepper motors, DC and AC motors, Selection of motors, Robot end-effectors	4	Learning the actuator sizing procedure and different types of end-effectors
3	Robot sensors: Contact and non-contact sensors; position, velocity, acceleration and force sensors; Robot vision and their interfaces.	4	This unit provides an overview of robotic sensors, vision and interfaces
4	Transformations: Grubler-Kutzbach Criterion; DOF of a Robot Manipulator; Pose or Configuration; Denavit-Hartenberg (DH) Parameters; Homogeneous transformation.	4	Understanding the analytical procedure involved in motion transformation from fixed base to the end-effector
5	Robot kinematics: forward and inverse kinematics, link velocity and acceleration analysis: Jacobian matrix; Singularity.	4	This unit demonstrates the kinematic analysis of serial chain robots
6	Statics: Link forces and moments; Recursive formulas; force and moment recursion at different joints, Role of Jacobian; Force ellipsoid.	5	Learning the relationships between the joint torques/forces, and the Cartesian moments and forces at the end-effector
7	Dynamics: Inertial properties, Euler-Lagrange formulation, Generalized coordinates; Kinetic and potential energy; Newton-Euler equations; recursive robot dynamics- forward and inverse.	6	Analyzing forces and moments causing the motion of different parts of serial chain robotic manipulator
8	Control: Transfer function and state-space representation of a robotic joint, performance and stability of feedback control, P, PI, PD and PID control, state-feedback control, joint controllers; Non-linear control; stability and force control.	6	Using linear and nonlinear control techniques when a robot moves slowly
9	Applications: Robots in materials handling, machine loading/unloading and programming for case study.	3	Understanding robotic applications and learning code for real-time controlling of simple robots.

Text Books:

1. S. K. Saha, Introduction to Robotics, McGraw Hill,2nd Edition,2014

Reference Books:

2. John J. Craig, Introduction to Robotics: Mechanics and Control, Prentice Hall
3. Mark W. Spong, Robot Modeling and Control, Wiley
4. K. S. Fu, R. C. Gonzalez, C. S. G. Lee, Robotics: Control, Sensing, Vision and Intelligence McGraw-Hill

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	MED530	Theory of Plates and Shells	3	0	0	9

Course Objective

- To study the behaviour of the plates and shells with different geometry under various types of loads.
- To understand theory and design of plate and thin shell structures of different geometries.
- To understand the basic governing differential equations involved for analysing the plate and shell structure.
- To understand the solution techniques for bending of the plate and shells under various types of loading.

Learning Outcomes

Upon successful completion of this course, students will:

- have a broad understanding formulation of engineering structure under loading.
- have an understanding about different boundary conditions and there uses for the solution of the problem .
- be able to solve inversely the bending problem of plate and shell.

Unit No.	Topics to be Covered	Lecture Hours	Learning outcomes
1	**Introduction to elasticity (pre-requisite of this course)**.	4	Understanding the basic concept of classical elasticity theory
2	**Introduction to Plates:** Classification of Plates, Basic Theory of Plate Bending, Governing Equations of Plates,Boundary Conditions on different Edges, Governing Equations for Deflection of Plate	9	Understand the basic theory, governing equationsand design of plate structures.
3	**Rectangular plates:** Navier's Solution for Simply Supported Rectangular Plates, Levy's Solution for Rectangular Plates, Method of Superposition.	9	Student will learn the solution technique for the bending of a rectangular plate with different boundary conditions.
4	**Circular Plates:** Basic Relation in Polar Coordinates, Symmetrical Bending of Uniformly Loaded Circular Plates, Symmetrical Bending under point loading, Annular plates.	8	Student will learn the bending relationship of a circular plates under various loading condition.
5	**Shells structure:** Introduction, Parametric representation of a surface,Governing Equations of Shells, Boundary Conditions, Governing Equations for bending of shells, Analysis of Shells	9	Understand the basic theory and design of shell structures of different geometries.

Text Books:

1. C. Ugural, *Stresses in Plates and Shells*, 2nd ed., McGraw-Hill, 1999

Reference Books:

4. S. P. Timoshenko and S. Woinowsky-Krieger, *Theory of Plates and Shells*, McGraw Hill Pub
5. Analysis of plates by T.K.Varadan and K.Bhaskar , Narosa Publishing House, 1999

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	MED 531	Fracture Mechanics	3	0	0	9

Upon successful completion of this course, students will:

- have a broad understanding on the fracture behavior of materials.
- have an understanding about different types of the fracture and the their post effect on the material behavior
- be able to solve the fracture mechanics problem.

Unit No.	Topics to be Covered	Lecture Hours	Learning outcomes
1	Overview of Engineering Fracture Mechanics: Types of fracture, Microstructural description of fracture, Mechanisms of Fracture, Review of Theory of Elasticity, Stress concentration factor.	4	Understanding the basic concept of material behaviour and their mechanics
2	Tensor and Index Notation: Einstein summation convention, Free indices, Kronecker delta, Permutation symbol, Tensors of various ranks, Partial derivatives, Governing Eqs in index notation	9	Understand the basic mathematical preliminary required to deal for the analysis of fracture mechanics problem
3	Linear Elastic Fracture Mechanics (LEFM): Asymptotic field, Airy stress function, Stress intensity factors (SIF), K_I, K_{II}, K_{III}, Determination of SIF, Fracture toughness, Irwin's criterion, K-dominance, Small scale yielding, Fracture testing, Structure design by LEFM.	9	Student will learn the concept of linear fracture mechanics and related theories
4	Energy Approach: Energy release rate G, Griffith criterion, Relationship between G and K, J-integral	8	Student will learn the energy concept in fracture mechanics
5	Nonlinear Fracture Mechanics: HRR-singularity field, J-dominance, Small scale yielding, Large scale yielding, Crack initiation and growth.	9	Understand the nonlinear fracture mechanics problem
6	Fracture Resistance of Materials: Fracture criteria, effect of alloying and second phase particles, effect of processing and anisotropy, effect of temperature, closure.		Student will get idea of the effect of inclusion of foreign particles and processing anisotropy on the fracture behaviour

Text Book:

1. D. Broek: Elementary Engineering Fracture Mechanics, Springer; 4th edition (1982)

Reference Book:

1. Prashant Kumar: Elements of Fracture Mechanics, McGraw-Hill (2009), ISBN: 9780070656963
2. T. L. Anderson: Fracture Mechanics: Fundamentals and Applications,CRC Press,2 edition (1994), ISBN-10: 0849342600
3. Richard W. Hertzberg: Deformation and Fracture Mechanics of Engineering Materials, Wiley (1995),ISBN-10: 0471012149

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	MED533	Acoustics and Noise Control	3	0	0	9

Course Objective

- Noise and Harshness has become a major issue in today's society, which calls for a quitter technology.
- This course will be extremely useful engineers and researchers to design quitter machines or machine components.

Learning Outcomes

Upon successful completion of this course, students will:

- Apply the concepts of acoustics to solve practical problems in this field.
- Analyze a noise problem for a possible solution.
- Get exposure to measuring sensors and its utility.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Fundamentals of vibration, Sound and vibration, Acoustics and engineers, basics of acoustics, dB levels, Concept of acoustic impedance etc.	7	Fundamental of acoustics and related terms
2	Type of waves, Characteristic of waves, Mathematical models of sound waves, 3D Wave equation, Types of Microphones and specifications, Octave bands.	8	Mechanism of acoustic wave propagation, basics of measuring sensors
3	Experimental Techniques, Source Modeling, Acoustic Structure Interaction, Sound Radiation from Vibrating Infinite Plate.	8	Different experimental techniques
4	Wavenumber space, K-Space Diagram, Concept of Angular Spectrum, Green's function, Rayleigh Integral, Velocity and far field pressure calculations, Directivity and Sound power calculation.	10	How to use Green's function and Rayleigh Integral techniques to solve near field and far field problems.
5	Acoustics of cavity, Helmholtz resonator, noise control techniques, Noise Control Application, Acoustics of Mufflers etc.	6	How to use acoustics knowledge to design a automobile muffler

Text Books:

1. M. L. Munjal. Noise and Vibration Control, World Scientific Press: Singapore (2014).
2. Lawrence E. Kinsler, Austin R. Frey, Alan B. Coppens and James V. Sanders . Fundamentals of Acoustics, Wiley: New York (1999).

Reference Books:

1. Uno Ingard. Notes on Acoustics, Firewal Media: Delhi (2010).
2. E. G. Williams. Fourier Acoustics: Sound Radiation and Near Field Acoustic Holography, Academic Press: New York (1999).
3. Acoustics of Ducts and Mufflers, 2nd Edition,M. L. Munjal, John Wiley and Sons, ISBN: 978-1-118-44312-5.(2014)

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	MED 534	Automation and control	3	0	0	9

Course Objective

- The course is intended to provide knowledge of any industrial operations involving control of position, velocity, temperature, pressure etc.
- It is desirable that most engineers and scientists are familiar with theory and practice of automatic control.

Learning Outcomes

Upon successful completion of this course, students will:

- have a broad understanding of open-loop and closed-loop control system used in practice.
- be able to compare the performance of different control systems by using both the time response and the frequency response method.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Introduction: Review of Laplace Transform, Close-loop control versus open-loop control, Linear Time Invariant (LTI) systems.	3	Understanding basics of close-loop and open-loop control systems
2	Representation of physical system: Transfer function and impulse response function, modelling in state space, transformation of mathematical models with MATLAB, signal flow graphs, linearization of nonlinear mathematical models	5	To enable students to model dynamic systems and analyze dynamic characteristics
3	Mathematical modeling of control systems: Mechanical, Electrical and Electronic systems, liquid-level systems, pneumatic and hydraulic systems.	5	The students will be introduced the concepts of resistance and capacitance to describe the dynamics of control systems
4	Time response analysis: Transient and Steady-State Response Analyses, 1st order, 2nd order and higher-order systems, Routh's Stability Criterion, Effects of Integral and Derivative Control Actions on System Performance, Steady-State Errors in Unity-Feedback Control Systems,	5	Understanding the basis for performance analysis of control systems by specifying test input signals
5	Control Systems Analysis and Design by the Root-Locus Method: Plotting Root Loci with MATLAB, Root-Locus Plots of Positive Feedback Systems, Lag, Lead and Lag–Lead Compensation	6	Understanding the movement of the closed-loop poles in the s-plane and modification of the dynamics to satisfy the given specifications
6	Frequency-Response Method: Bode Diagrams, Polar Plots, Log-Magnitude-versus-Phase Plots, Nyquist Stability Criterion	7	The students will be able to use the data obtained from measurements on the physical system for control without deriving its mathematical model.
7	PID Controllers: Ziegler–Nichols Rules for Tuning PID Controllers, Design of PID Controllers with Frequency-Response Approach	4	The students will learn different procedures for tuning gain values of PID controllers used in practice
8	Case study by using MATLAB	4	Application of basic control theory in realistic problems and analyses

Text book

1. Automatic Control Engineering by F.H.Raven, 5th ed.,McGrawHill International,1994.

Reference books

1. Modern Control Engineering by K.Ogata, Prentice Hall,2010.
2. Digital Control Systems by B.C.Kuo, Prentice Hall.

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	MED535	Vibration Control	3	0	0	9

Course Objective

- To cross the bridge between the structural dynamics and control communities,
- To providing an overview of the potential of smart materials for sensing & actuating purpose in active vibration control.
- To provide the concept of active and passive control techniques.
- To know the active control materials and it's applications

Learning Outcomes

Upon successful completion of this course, students will able to:

- Know the fundamentals of vibration isolation and reductions.
- Have the concept of active vibration control.
- Have the ability to control the vibration of critical mechanical structure
- Use the active control materials to suppress the vibration.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Review of Basics of Mechanical Vibrations	2	Understanding the fundamentals of Vibrations.
2	Basics of Vibrations for Simple Mechanical Systems, Introduction to Damping in Free and Force Vibrations, Free and Forced Vibrations of Two Degree of Systems, Multi Degree of Freedom Systems	4	Understanding the types of mechanical Vibrations.
3	Basics of Vibrations Control: Reduction at source , Feedback Control System, Shunt Damping	6	Student will learn Introduction of Vibration control
4	Vibration Isolation**,** Vibration Generation Mechanism**,** Design Considerations in Material Selection	**5**	Student will learn how to reduce vibration and selection of materials.
5	Principles of Passive Vibration Control: Basics of Passive Vibration Control. Design of Absorber, Shock Absorber, Isolators with Stiffness and Damping	8	This unit demonstrates Passive techniques of vibration control
6	Principles of Active Vibration Control: Basics of Active Vibration Control,Piezoelectric Material , Piezoelectric Accelerometers	8	This unit demonstrates active vibration control through Piezo-materials
7	Electro-rheological (ER) Fluids , Magneto-rheological (MR) Fluids, Magneto and Electrostrictive Materials, Shape Memory Alloy	6	This unit demonstrates others active vibration control materials

Text Books:

2. Vibration Control of Active Structures - An Introduction by André Preumont (2018), springer

Reference Books:

1. Passive and Active Structural Vibration Control in Civil Engineering, edited by T.T. Soong, M.C. Costantinou, Springer
2. Principles of Vibration Control by A.K. Mallik, East-West Press.
3. Mechanical Vibrations: Active and Passive Control by Tomasz Krysinski and François Malburet

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	MED 543	Solar Energy	3	0	0	9

Course Objective

The course will give a brief overview of renewable energy followed by different solar collection devices. The course will also focus on different types of solar energy collection devices.

Learning Outcomes

Upon successful completion of this course, students will:

- understand the basic requirements of solar energy
- learn the different types of solar collectors
- be able to develop an in-depth understanding of tracking requirement for capturing solar energy

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Need of sources of renewable energy, Introduction to different sources of renewable energy, Solar Energy and Applications	3	Understanding of different sources of energy
2	Basic concepts, Solar constant, Beam and diffused radiation	3	Understanding the terminologies of solar radiation
3	Flat plate and concentrating collectors, Liquid Flat Plate Collector, Flat Plate Solar Air Heater, Concentrating	8	Knowledge of different types of solar collectors
4	Performance analysis of solar collector, Instantaneous collector efficiency	5	Knowledge of mathematical analysis of Solar collector
5	Overall loss coefficient, Collector efficiency factor, Collector heat removal factor	4	Understanding about the different performance factors of the collectors
6	Concentration ratio, Tracking requirements, Thermal energy storages, Solar pond	10	Knowledge of capturing the solar energy by tracking
7	Economic Analysis	4	Knowledge of economics behind the collection of energy
7	Case studies: Performance test on CPC and Flat Plate collector	2	Understanding the collection of solar energy by case studies

Text Book:

1. S.P. Sukhatme, Solar Energy- Principles of Thermal Collection and Storage, TMH, 3rd edition, 2008.

References:

2. John A. Duffie and William A. Beckman, Solar Engineering for Thermal Process, Wiley and Sons, 1st Edition, 2013.

3. H.P. Garg, Solar Energy, 1st Revised Edition, 2000.

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	MED 553	Laser Processing of Materials	3	0	0	9

Course Objective

To train the students for the following:

- How to select a laser source for different operations .
- The laser beam characteristics.
- Process principle of laser cutting, joining, surface treatment, cladding etc.
- Characterization of the surfaces undergo laser operations.

Learning Outcomes

Upon successful completion of this course, students will able to

- Selection of lasers for different operations.
- Understand the underlying physics behind the different laser operations.
- Understand the benefits of using laser over the other processes.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Introduction to industrial lasers: He-Ne, CO2, Excimer, Nd:YAG, Diode, Fiber and Ultra-short pulse lasers and their output beam characteristics; laser beam delivery systems. Laser interaction with the materials.	6	Understanding basics of laser, their classifications and applications.
2	Industrial & scientific applications of laser; Laser cutting, drilling, welding, marking and their process characteristics.	10	Basics of different laser applications, controlling parameters
3	Laser surface modifications: Heat treatment, surface remelting, surface alloying and cladding, surface texturing, LCVD and LPVD.	8	Different surface treatment using lasers and their effects.
4	Ultra-short laser processes; pulse interaction, metallurgical considerations and micro fabrication.	6	This unit demonstrates working of Ultra-short laser processes, and applications
5	Laser additive manufacturing. Laser metal forming: Mechanisms involved including temperature gradient, buckling, upsetting. Laser peening: Laser Shock Processing.	9	Understanding of how the laser can be used different other applications such as for additive manufacturingand metal forming

Text Books:

1.Steen, William M., JyotirmoyMazumder. Laser material processing. Springer science & business media, 2010.

Reference Books:

2.Ion, John. Laser processing of engineering materials: principles, procedure and industrial application. Elsevier, 2005.

3.Duley, Walter W. Laser processing and analysis of materials. Springer Science & Business Media, 2012.

4.Chryssolouris, George. Laser machining: theory and practice. Springer Science & Business Media, 2013.

5.Schaeffer, Ronald. Fundamentals of laser micromachining. CRC press, 2016.

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	MED 556	Design of Tools, Jigs and Fixtures	3	0	0	9

Course Objective
• To provide knowledge about different principle, operation and applications of different machines tools and fixtures.
Learning Outcomes
Upon successful completion of this course, students will: Have good grasp of knowledge of the design, fabrication and use of fixtures.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Introduction: Tool design methods; tool making practices: hand finishing and polishing, screws and dowels, hole location and jig boring practices. Tooling materials tool steel, cast iron, non-metallic tooling material, heat treatment and factor affecting the heat treatment	11	To learn tool making practices
2	Design of cutting tools: Basic Requirement of The Cutting Tools, Metal Cutting Tools and classification. Gauges and gauge design: fixed gauges, gauge tolerance, selection of materials for gauge.	9	To learn how to design cutting tools and gauges.
3	Locating and clamping methods, Classification of jigs, design of drill jigs and milling fixtures, other fixtures: Turning, Grinding, Broaching, Welding and Modular Fixtures.	10	To grasp knowledge about design of jigs and fixture.
4	Design of sheet metal blanking and piercing dies, sheet metal bending, forming and drawing dies, tool design for numerical control machine tools.	12	To have first-hand knowledge about design of blanking and pier

Text Books:

1.Donaldson C, LeCain GH, Goold VC, Ghose J. Tool design. Tata McGraw-Hill Education; 2012

References books:

1. Venkataraman, K. Design of jigs, fixtures and press tools. John Wiley & Sons, 2015.

2. Jones, Ernest James Henry, and Harold Clifford Town. Production engineering: jig and tool design. Newnes, 2013.

3. Reid, D. "Fundamentals of tool design, Society of manufacturing engineers." Publications development department (1991).

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	MED 557	Micro- Electro-Mechanical Systems (MEMS)	3	0	0	9

Course Objective
• To enable students to obtain real life exposure in fabrication and uses of MEMS technology.
Learning Outcomes
The students will acquire knowledge about the significance role, design and development of MEMS.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Introduction, material selection and classification, their characteristic features. Concept of scalability, perception of micron-based dimensions and their real-life significances, challenges of scalability and mass manufacturing related to MEMS, case studies.	15	To acquire the knowledge of significances of MEMS in real life.
2	Surface micromachining processes for MEMS fabrication. Inspection, quality control and microscopic analysis of the micro machined products. MEMS based sensors & actuators: Working Principle, sensitivities. Latest applications of those actuators in cell phones, biomedical instrumentation and aerospace technology, case studies.	12	To grasp the domain knowledge regarding the fabricational role of MEMS.
3	Principles of electro mechanics applied in MEMS, mathematical assessment of the sensitivities and electromechanics features of MEMS, Modelling and design techniques for MEMS based devices, preliminary exposure to software used for modelling.	6	To have pragmatic ideas about roles of working procedures of MEMS.
4	Packaging issues related to MEMS, Reliability assessment and measurement techniques for MEMS, precision, accuracy, uncertainties of MEMS based devices, exposure to distribution fitment for predicting the performance.	6	To attain the role of packaging related to MEMS.

Text books:

1.MEMS, N. P. Mahalik, Tata McGraw-Hill Publications, 2007

2.MOEMS: Micro-Opto-Electro-Mechanical Systems, M. Edward Motamedi, SPIE Publications, 2005

Reference books:

1. MEMS: Introduction and Fundamentals by Mohamed Gad-el-Hak

2. MEMS mechanical sensors by Stephen Beeby

3. Microsensors, MEMS, and smart devices by Julian W. Gardner, V. K. Varadan, Osama O. Awadelkarim

4. MEMS and microsystems: design, manufacture, and nanoscale engineering- Tai-Ran Hsu

6. Micromachining – V.K.Jain, Narosa Publishing house

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	MED 558	Micro Manufacturing	3	0	0	9

Course Objective

To train the students for the following:

- Principles and applications of different micro and macro manufacturing process.
- Selection of relevant process parameters for different micro and macro manufacturing operations.
- Characterization of the macro and micro-machined surfaces.

Learning Outcomes

Upon successful completion of this course, students will able to

- Select a micro and macro manufacturing process for different operations.
- Understand logic behind the different micro and macro manufacturing operations.
- Understand the benefits of using different micro and macro manufacturing process over the other processes.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Introduction and classification of micromachining; Mechanical type micro machining processes: Abrasive jet micromachining (AJMM), Ultrasonic micromachining, abrasive water jet micro machining (AWJMM).	9	Understanding basics of AJMM, USM, AWJMM and their classifications and applications.
2	Magnetorheological finishing (MRF), Magnetorheological abrasive flow finishing (MRAFF), Magnetic float polishing (MFP).	7	Basics of different finishing and polishing applications and their applications.
3	Chemical and electrochemical type advanced machining processes: Electrochemical micromachining (EDMM), electrochemical micro deburring, Chemical and photochemical micro-machining. Abrasive based nano finishing processes: Abrasive flow finishing (AFF), Chemo-mechanical polishing (CMP), and Magnetic abrasive finishing (MAF).	10	Fundamentals of chemical, electrochemical micromachining as well as micro deburring operations and their applications. Also the introduction and applications of AFF, CMP, and MAF.
4	Thermo electric type micro-machining process: Electric discharge micromachining (EDMM), wire EDM, EDDG, ELID, Laser beam micro machining (LBMM), Electron beam micromachining (EBMM).	7	Understanding the basics of electric discharge micromachining, Wire EDM, LBMM, and EBMM operations and their applications.
5	Traditional mechanical micro-machining processes: Micro turning, micro milling, micro drilling.	6	Understanding the basics of micro turning, micro milling, and micro drilling operations and their applications.

Text Books:

1. Introduction to micromachining, VK Jain, Narosa Publisher, New Delhi 2nd edition

Reference books:

2. Micromachining methods, JA Mc Geough, Champan and Hall, London
3. Micro manufacturing processes, VK Jain CRC Press
4. Advanced machining processes, VK Jain, Allied Publisher New Delhi

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	MEO 586	Additive Manufacturing	3	0	0	9

Course Objective

- To provide basic concept of Additive Manufacturing, its classification and applications

Learning Outcomes

Upon successful completion of this course, students will:

- be able to evaluate and select appropriate AM technologies for specific design-manufacturing applications.
- be able to identify, explain, and prioritize some of the important research challenges in Additive Manufacturing

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Introduction to Additive Manufacturing and classification. Applications of additive manufacturing in rapid prototyping, rapid manufacturing, rapid tooling, repairing and coating.	4	Understanding of the applications of Additive Manufacturing
2	Introduction to 3D-printing, Stereolithography apparatus (SLA), Fused deposition modelling (FDM), Laminated Object Manufacturing (LOM))	6	Understanding about the conventional approaches in 3D printing.
3	Selective deposition lamination (SDL), Ultrasonic consolidation, Selective laser sintering (SLS), Laser engineered net shaping (LENS), Electron beam free form fabrication (EBFFF), Electron beam melting (EBM), Plasma transferred arc additive manufacturing (PTAAM), Tungsten inert gas additive manufacturing (TIGAM), Metal inert gas additive manufacturing (MIGAM).	12	A complete understanding about the different processes of Additive Manufacturing; particularly for manufacturing metal parts using 3 printing technologies.
4	Pre-Processing in Additive Manufacturing: Preparation of 3D-CAD model, Reverse engineering and Reconstruction of 3D-CAD model, Part orientation and support generation, STL Conversion, STL error diagnostics, Slicing and Generation of codes for tool path, Surface preparation of materials.	11	Student will able to develop CAD models for 3 printing applications.
5	Post-Processing in Additive Manufacturing: Support material removal, improvement of surface texture, accuracy and aesthetic; property enhancements.	6	Students will able to design support system to fabricate a component through 3 Printing.

Text Books:

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

Reference Books:

2. Chee Kai Chua, Kah Fai Leong, 3D Printing and Additive Manufacturing: Principles and Applications: Fourth Edition of Rapid Prototyping, World Scientific Publishers, 2014
3. Chua C.K., Leong K.F., and Lim C.S., “Rapid prototyping: Principles and applications”, Third Edition, World Scientific Publishers, 2010
4. Gebhardt A., “Rapid prototyping”, Hanser Gardener Publications, 2003
5. Liou L.W. and Liou F.W., “Rapid Prototyping and Engineering applications: A tool box for prototype development”, CRC Press, 2007

SYLLABI OF SO/ESO COURSES

Course Type	Course Code	Name of Course	L	T	P	Credit
E/SO2	MEE 201	Engineering Materials	3	0	0	9

Course Objective

- Gain knowledge in properties and structures of solids.
- Acquire the knowledge about various phase diagrams of both ferrous and non-ferrous metals.
- Attain knowledge in heat treatment of steels, properties of non-ferrous alloys and evaluate the mechanical properties of different metals.
- Impart the knowledge about the failure mechanism of ductile and brittle materials.

Learning Outcomes

Upon successful completion of this course, students will:

- have a broad understanding of classification of various kind of materials
- have an understanding about structural analysis and the various properties of the materials.
- be able to design for new materials and their properties.
- be able to understand the material failure mechanism under thermal and cyclic loading.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Classification and selection of engineering materials; Bonds in solids, Electron theory of metals, Crystal Geometry	5	Understanding the basic concept of material section and the theories.
2	Structure and Defects in crystals and methods of their determination, Electron theory of Metals, Diffusion in Solids	5	Structural analysis and various defect in engineering materials
3	Mechanical properties of materials and their assessment methods, Alloy Systems, Phase diagrams of common Engineering alloy systems, TTT Curves Heat Treatment Processes	10	Knowledge on the mechanical properties of the material and the possible techniques to improve the properties.
4	Heat Treatment Processes, Strengthening Mechanisms of Materials, Basics of Thermal, Optical, Electrical and Magnetic Properties of Materials	10	Knowledge of physical properties of the materials and strengthening mechanism
5	Concepts of Creep, Fatigue, Fracture and Corrosion, Introduction to Semiconductors, Superconductivity.	5	Knowledge on the behavior of the material at high temperature and cyclic loading
6	Ceramics, Composites, Shape Memory Alloys, Met glasses, and Nanostructure Materials.	4	Idea on the synthesis and the properties of recent smart/high specific strength materials

Text Book

1. Materials Science and Engineering, William D Callister Jr, John Wiley & Sons, Inc, 7th Edition.

Reference Books

1. Physical Metallurgy Principles, T. E. Reed-Hill & R Abbaschian, Thomson.
2. Elements of Materials science & Engineering, L. H. Van Vlack. Addison Wesley Pub. Company.
3. Mechanical Metallurgy, G.E. Dieter, McGraw-Hill, London.
4. Materials Science and Engineering, V. Raghvan, Prentice Hall of India.

Course Type	Course Code	Name of Course	L	T	P	Credit
E/SO2	MEE 202	Computer Aided Engineering Design	3	0	0	9

Course Objective

To impart knowledge dealing with computation aspects of engineering drawing and geometric modeling.
This course is essential for design automation. It is the first step in all engineering analysis

Learning Outcomes

Upon successful completion of this course, students will:

- get basic knowledge of different transformations which will be very useful in robotic and mechatronics
- get mathematic details of the projections used in mechanical Engineering for visualization
- learn the concepts of parametric curves and surface modeling
- learn the basic techniques of representation of solids.
- learn the basic of object oriented programming and OpenGL

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1.	Overview of computer graphics: Introduction to CAD and Geometric Modeling, advantages of CAD, computer graphics software.	2	Students will know the use of Computer Aided Design in engineering and other applications.
2.	2-D Transformations: Transformations of points and straight lines, midpoint transformation, transformation of parallel lines and intersecting lines, rotation, reflection, scaling, combined transformations, solid body transformations, translations and homogeneous coordinates, rotation about an arbitrary point, reflection through an arbitrary line, projection.	6	Basic knowledge of transformed geometry in 2D and 2D homogeneous coordinate system will be the output of this module.
3.	3-D Transformations: 3-D scaling, shearing, rotation, reflection and translation, rotation about an arbitrary axis in space, reflection through an arbitrary plane, affine and perspective geometry, orthographic and axonometric projections, techniques for generating perspective views, vanishing points, stereographic projection, reconstruction of 3-D images.	6	3D transformation will be applied to any model efficiently after completion of this module. Different projection used in engineering graphics will be learned after completion of this module.
4.	Plane curves: Introduction to geometrical modeling, representation of parametric curves, composite curves, rational curves, interpolation, intersection of curves	6	Basic knowledge of parametric curves can be used in Path/ trajectory planning for road, rail and well-paths after completion of this module
5.	Surface description and generation: Surfaces of revolution, sweep surfaces, quadratic surfaces, mapping parametric surfaces, Bilinear surface, ruled and developable surfaces, linear Coons surface, Coons bicubic surface, Bezier and B-spline surfaces, Gaussian curvature and surface fairness.	7	At end of this module students will be able to model different parametric surfaces.
6.	Solid Modeling and Programming: Introduction to solid modeling, feature based design,	4	At end of this module students will able to model different objects use in mechanical engineering.
7.	Introduction of object oriented programming, and introduction to OpenGL...	2	At end of this module students will able to know the basic concepts of computer graphics and object oriented programming

Text Books:

2. Mathematical Elements of Computer Graphics, D. F. Roger and J. A. Adam, McGraw Hill Pub. 2017

Reference Books:

1. Geometric Modelling, M. E. Mortenson, Industrial Press In., New York. 2017
2. Introduction to Solid Modeling, M. Mantyla, Computer Science Press,1988.

SYLLABI OF OPEN ELECTIVES (OE)

Course Type	Course Code	Name of Course	L	T	P	Credit
OE	MEO 306	Mechanical Measurement	3	0	0	9

Course Objective
• To provide knowledge of various measuring instruments, highly accurate and precise instruments.
Learning Outcomes
Upon successful completion of this course, students will: Learn use of measuring instruments, errors and sources of errors,

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1.	Introduction to measurement, definition, purpose and structure of measurement systems, linear and angular measurements, Errors in measuring instruments, sources of errors, types of errors and quantification of different types of errors in measurement; principle of calibration.	08	Introduction to measuring systems.
2.	Static and dynamic performance characteristics of measuring instruments, Limits, fits and tolerances; comparators. Interferometry, form and surface finish measurement.	09	Behavior of measuring instruments under different measuring conditions.
3.	Alignment and testing methods for machine tools; tolerance analysis in manufacturing and assembly.	5	Able to perform testing of machine tool alignment.
4.	Introduction to sensors, transducer and actuator, sensing elements: working principles of resistive, capacitive, inductive, thermoelectric, piezoelectric, piezoresistive, hall effect sensors, optical sensors and encoders, charge coupled devices.	10	Knowledge about different electronic sensing elements.
5.	Principle of measurement of pressure, strain, force, temperature. Introduction to virtual instrumentation.	08	Knowledge about measurements of different mechanical parameters.

Text Books

1. Experimental Methods for Engineers, J. P Hollman, Tata McGraw-Hill Education, 8E,2011.

Reference Books:

1. Bentley John, P. Principle of Measurement system, Pearson education, 2005.
2. Measurement and Instrumentation in Engineering: Principles and Basic Laboratory Experiments, Francis L. S. Tse, Ivan E. Morse, Marcel Dekker Inc, New York.
3. Mechanical Measurement, Beckwith Thomas G, Narosa Publishing House .
4. Measurement systems, Application design, E.O. Doeblein, McGraw Hill.
5. Instrumentation, Measurement and Analysis (2/e), Nakra& Chowdhury.

Course Type	Course Code	Name of Course	L	T	P	Credit
OE	MEO 401	Piping System	3	0	0	9

Course Objective
• To provide various piping system design, development skills and knowledge of current trends of plant layout • To provide relevant piping design and layout knowledge to the Mechanical, civil and chemical engineers.
Learning Outcomes
Upon successful completion of this course, students will: • have a broad understanding of application of various piping system. • have an understanding about different components of piping system. • be able to design a piping system and its layout. • have a broad understanding about different piping material.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
6.	Introduction to piping engineering and role of piping engineer in various fields, various piping system	2	Introduction to piping system in various engineering field
7.	Flow Hydraulics and Pipe Network Analysis: Basic principle of pipe flow, noncircular conduits, economic pipe diameter, various fittings, Non-Newtonian fluids, pumps and compressors. Pipe network problems: Hardy cross analysis	10	Knowledge about the pipe flow hydraulics and pipe network analysis
8.	Piping fundamentals: pipe size, pipe wall thickness, Codes and Standards, piping elements: fittings	5	Knowledge about Piping fundamentals and codes and standards
9.	Valves: Isolation, regulation, non-return, special purpose valves, terms used for valve specifications	5	Knowledge about different pipe fittings
10.	Basic Equipment and Piping Layout: Plans and isometrics, Equipment layout and unit plot plan drawing	5	Knowledge about piping layout and its drawing
11.	Pipe Materials: Ferrous pipe, Non-ferrous pipe, Fabrication of Steel Pipe, Fabrication of Pipe fitting and components, Mechanical Properties, Procurement Specifications	4	Knowledge about piping materials
12.	Internal Pressure: Pressure design of Piping, Pressure design of Plant Piping, Yield and Burst Pressure, Pressure design of Plastic pipe, Pressure rating, Pressure stress in fitting, High pressure design, Pipe specification, valve specification	5	Knowledge about internal pressure design of piping.
13.	External Pressure: Buckling pressure, Flexibility and Fatigure: layout for flexibility	3	Knowledge about external pressure and fatigue failure of pipeline

Text Books:

2. George A. Antaki "Piping and Pipeline engineering: Design construction, maintenance, integrity and repair"- Marcel Dekker Inc., USA, 2003

Reference Books:

3. P. K. Swamee and A. K. Sharma DESIGN OF WATER SUPPLY PIPE NETWORKS, Wiley Interscience, 2008

4. J. Paul Tullis "Hydraulics of Pipelines: pumps, valves, cavitations, Transients", John Wiley & Sons, 1989

Course Type	Course Code	Name of Course	L	T	P	Credit
OE	MEC501	Mechanical Vibration	3	0	0	9

Course Objective

The primary objective of this course is to impart necessary fundamental knowledge to a student so that he/she can confidently cater to the needs of industry or R & D organizations. This course would empower students to build and solve mathematical models of vibrating systems. The emphasis is on linear systems subjected to sinusoidal or periodic excitations in general.

Learning Outcomes

Upon successful completion of this course, students will be able to:

- Apply the concepts of vibration to solve practical problems in this field.
- Analyze a vibration problem for a possible solution.
- Get exposure to measuring sensors and its utility.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Free vibration of SDF system with and without damping, concept of phase plane, logarithmic decrement, quality factor.	05	Basics of vibration
2	Response of single degree of freedom system to periodic and non-periodic excitation, rotating unbalance, whirling of rotating shafts	06	How a vibrating system respond to imposed external excitation
3	Vibration isolation, support motion, absorption and isolation, Measuring instruments.	06	Methods to isolate something from vibrating platform, exposure to measuring instruments
4	Transient analysis and impulse response, arbitrary excitation, Laplace Transform formulation, response spectrum.	04	Response of a single DOF system due to arbitrary excitation
5	Multi degree of freedom system, normal mode vibration, co-ordinate coupling, modal analysis, orthogonal properties, modal matrix, Lagrange's equation.	06	Free and forced response of a multi-degree of freedom system
6	Multi degree of freedom system – exact analysis and numerical methods, classical methods like Rayleigh, Dunkerley, Rayleigh-Ritz, Holzer etc.	05	Exposure to various numerical method to tackle vibration problem
7	Vibration in continuous system like sting, shaft, bar, beam and membrane. Fourier analysis of signals, Presentation of the results of frequency analysis.	07	Free vibration analysis of continuous systems, frequency domain analysis

Text Book:

1. Theory of vibrations with applications – W. T. Thomson, M.D. Dahleh, C Padmanabhan, Pearson, 5th Edition. (2008)

Other References:

1. Vibration: Fundamentals and practices,Clarence W.de Silva; CRC press,2nd Ed.2006.
2. Vibration and noise for engineers – K. Pujara; Dhanpat Rai and Co,2013.
3. Vibrations, Waves and Acoustics – D Chattopadhyay and P C Rakshit; Books and Allied(P) Ltd,2019.

Course Type	Course Code	Name of Course	L	T	P	Credit
OE	MEC 516	Unconventional Manufacturing Processes	3	0	0	9

Course Objective

To provide detailed understanding of advanced manufacturing processes. The prospect of future research will also discuss in the course which will encourage the students to carryout research in the advance area,

Learning Outcomes

Upon successful completion of this course, students will:

- Broad understanding of machining using different energy sources.
- Students will be able to think about the possibility of combining different process to develop more efficient machining process
- It will help the students to select the best process among various alternative.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Introduction and classification, Theory of machining by Abrasive Jet, Abrasive water Jet, Abrasive flow; Ultrasonic machining.	8	Understanding of mechanical based unconventional processes (UMP). It will develop the ability of select the process for particular application.
2	Electrochemical Machining and grinding, polishing, sharpening, honing and turning. Chemical Machining. Electrochemical Discharge machining and Grinding; Electro-stream and Shaped Tube Electrolytic Machining.	14	Understanding of electrical and chemical based unconventional processes (UMP). The students will learn the principle of hybrid process and their applications.
3	Thermal energy methods of material processing (machining/welding/heat treatment) by Electro-discharge, Laser and Electron beam, Plasma arc and Ion beam.	12	Understanding of thermal based unconventional processes (UMP). The students will learn the importance of high pulse energy source.
4	Unconventional metal forming processes: principle, working and applications, High Energy Rate Forming and Electroforming, Physical Vapour and Chemical Vapour Deposition and Plasma Spraying.	6	The students will understand the use of controlled explosive and spark energy in deformation process. The students will also learn about thin coating techniques.

Text book:

1. Fundamentals of Machining Processes (Conventional and Nonconventional Processes), Hassan Abdel-Gawad El-Hofy, CRC press, 3rd Edition, 2018

Reference books:

1. Non-traditional manufacturing processes , Gary F. Benedict, CRC press, 2015
2. Fundamentals of modern manufacturing processes, M. P. Groover.
3. Unconventional Machining, P K Mishra
4. Unconventional Machining, V K Jain
5. Unconventional Machining, Pandey and Shah

Course Type	Course Code	Name of Course	L	T	P	Credit
OE	MED529	Composite materials	3	0	0	9

Course Objective

- To solve mechanics of composite materials problems using classical methods and Numerical method (FEM)
- To do research and present on an advanced material topic.

Learning Outcomes

Upon successful completion of this course, students will be able to:

- Explain the mechanical behavior of layered composites compared to isotropic materials.
- Apply constitutive equations of composite materials and understand mechanical behavior at micro and macro levels.
- Determine stresses and strains relation in composites materials.
- Develope MATLAB based FEM codes for analysis of Laminated composite

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Introduction to composites: Processing of FRP Composites	5	Describe the types of composite and its manufacturing process
2	Micromechanical Analysis of Composite Strength and Stiffness	6	To determine the materials properties of FRP
3	Elastic Properties of Unidirectional Lamina,	7	Derive the properties of a single layer of FRP
4	Analysis of Laminated Composites	8	Find the elastic stiffnesses of laminate based on the elastic moduli of individual laminas and the stacking sequence
5	Analysis of Laminated Plate & FEM	9	Formulation of structural laminated plate with different boundary condition, descriptions of shear deformation theories, numerical modelling through FEM
6	Hygro-thermal Effects on Laminates	3	Develop relationships of hygrothermal loads applied to a laminate
7	Failure Theories and Strength of Unidirectional Lamina	3	Establish the failure criteria for laminates based on failure of individual lamina in a laminate
8	Design of Composite structure & Example	2	Designing of laminated structures and Introduce other mechanical design issues in laminated composites

Text Books:

1. Mechanics of composite materials and structures, M. Mukhopadhyay. Universities Press, 2012

Reference Books:

1. Engineering mechanics of composite materials, I. M. Daniel & O. Ishai, oxford university press, 2006.
2. Principles of composite material mechanics, R. F. Gibson, 2nd edn. CRC Press, 2007.
3. Mechanics of composite materials, Rr. M. Jones, 2nd edn. Taylor & Francis, 1999.

Course Type	Course Code	Name of Course	L	T	P	Credit
OE	MEO 579	Computational Fluid Dynamics	3	0	0	9

Course Objective

The course will give a brief overview of N-S equations followed by its applications for solving flow and heat transfer problems. . The course will also focus on different discretization techniques like, FDM and FVM.

Learning Outcomes

Upon successful completion of this course, students will:

- understand the basic requirements of CFD
- learn the different types of Discretization methods
- be able to develop an in-depth understanding of new methods for solving the PDE equations

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Review of governing equations for conservation of mass, momentum and energy in primitive variable form	3	Understanding of different flow equations
2	Mathematical behaviour of the conservation equations, equilibrium and marching problems	2	Understanding the mathematical behaviours of the equations
3	The finite difference method (FDM) and the variational methods, discretization, comparison of finite difference method, finite volume method (FVM) and finite element method (FEM)	6	Knowledge of different types of discretization methods
4	Implicit, explicit and semi-implicit schemes, alternate direction implicit method	6	Knowledge of different solution methods of unsteady equations
5	Convergence, stability analysis of a numerical scheme	4	Understanding about the different terms using in CFD
6	Solution of linear matrix equation system and programming	6	Knowledge of linear alagebraic equations
7	Application of FDM in one- and two-dimensional steady and unsteady heat conduction and computer programming, artificial viscosity, upwinding SIMPLE Algorithm	4	Understanding the FDM for solving 2-D Heat conduction and convection problems

8	Stream function-vorticity formulation for solving flow and heat transfer problems	5	Understanding this formulation for solving the flow problems having no pressure gradient teram.
9	Implementation of SIMPLE algorithm in two-dimensions, Introduction to commercial package ANSYS-FLUENT.	3	Understanding the ANSYS FLUENT Software for solving the flow and heat transfer problem.

Text Book:

1. John D. Anderson, Computational Fluid Dynamics The basics with applications, McGraw-Hill Education, 1st Edition, 2017.
2. K. Muralidhar and T. R. Sundararajan, Computational Fluid Flow and Heat Transfer, Narosa Publishing House, 2nd Revised Edition, 2003.

References:

1. Richard H. Pletcher, John C. Tannehill and Dale A. Anderson, Computational Fluid Mechanics and Heat Transfer, CRC Press, 3rd Edition, 2012,
2. S. V. Patankar, Numerical Heat Transfer and Fluid Flow, CRC Press, 1st Edition, 1980.

Course Type	Course Code	Name of Course	L	T	P	Credit
OE	MED 544	Advanced Steam Power Plant	3	0	0	9

Course Objective

- Coal-based power generation is still a fundamental part of energy supply throughout the world. Reliability, security of supply, low fuel costs, and competitive cost of electricity make a good case for coal-fired steam power plants.
- This course has been designed to make the students conversant with various methods to improve the thermal efficiency of the steam power plant, utilization of waste heat, efficient ofutilization of fuel etc.

Learning Outcomes

Upon successful completion of this course, students will:

- Describe and analyze different types of sources and mathematical expressions related to thermodynamics and various terms and factors involved with power plant operation.
- Analyze the working and layout of steam power plants and the different systems comprising the plant and discuss about its economic and safety impacts.
- Describe the working principle and basic components of the nuclear power plant and the economic and safety principles involved with it.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1.	Introduction: Energy sources and scenario, Different power plants and their comparison	03	Students will acquire knowledge trends in the different Power sources and current trends in different Power energy conversion technologies.
2.	Thermal Power Plant: Rankine cycle, Reheat, Regenerative cycles, Supercritical cycles, Coupled and combined cycle, Cogeneration plants	08	Describe different types of steam cycles and it's efficiencies in a steam power plant and analyze basic working principles of the combined cycles.
3.	Analysis of Coal Combustion: Properties and analysis of coal, combustion of coal, stoichiometric and actual air-fuel ratios, heating value, exhaust gas analysis.	06	Appreciate the importance of coal and coal preparation for the Indian and global economies and understand the construction and operation of crushers and screens used for coal preparation.
4.	Analysis and sizing of various Heat Exchangers in Steam Power Plant: Steam generator, superheater, economizer, feed water heater, air preheater condenser, and cooling tower.	10	Describe basic information about boiler components to improve the performance of the thermal power plant.
5.	Exergy analysis of various components and overall cycle of a power plant to determine irreversibilities, energy and exergy efficiencies.	04	Demonstrate understanding of key concepts related to exergy analysis, including the exergy reference environment, the dead state, exergy transfer, and exergy destruction.
6.	Direct conversion of heat into electricity: Magneto-hydrodynamic, thermionic and thermo-electric power generation.	04	Discusstheworkingprincipleandbasiccomponentsofthehydroelectricplantsandtheeconomicprinciplesandsafetyprecautionsinvolvedwithit
7.	Power plant economics: Various factor, Determination of cost of power generation and unit price, Depreciation cost, Energy	04	Analyzethe cost of thedifferentsystemscomprisingtheplant during power generations

	audit.		anddiscussaboutitseconomics

Text book:

1. P.K.Nag, Power Plant Engineering, Tata McGraw Hill, 4th Edition, 2014.

References:

1. Ramnath, Elanchezhian, and Saravanakumar: Power Plant Engineering, I. K. International, 1st Revised Edition, 2007.
2. Louis Allen Harding: Steam power plant engineering, John Wiley and sons, 1st Edition, 1932.
3. P.K Das, and A.K Das: An Introduction to Thermal Power Plant Engineering and Operation: For Power Plant Professionals, Notion Press, 1st Edition, 2018.
4. R.W. Haywood, *Analysis of Engineering Cycles*, Pergamon Press, 1st Revised Edition, 1975.
5. A.W. Culp, *Principles of Energy Conversion*, McGraw Hill, 2nd Revised Edition, 1991.
6. M.M. Elwakil, *Power Plant Technology*, McGraw Hill, 1st Edition, 2002.
7. T.D. Eastop and A.McConkey, *Applied Thermodynamics*, ELBS, 1st Edition,1986.