B. TECH DEGREE IN MECHANICAL ENGINEERING
(2019 SCHEME)

REVISED SCHEME OF EXAMINATIONS AND SYLLABUS
(3-8 SEMESTER)

B.TECH DEGREE COURSE IN MECHANICAL ENGINEERING

Scheme of Examinations (2019 admissions)

SEMESTER III

Code No.	Subject	L Hours/ Week	T Hours/ Week	P/D Hours/ Week	C	Marks		Total
						CA	SEE	
19-200-0301	*Linear Algebra & Transform Techniques	3	1	0	3	40	60	100
19-205-0302	Electrical Technology	3	1	0	3	40	60	100
19-205-0303	Mechanics of Solids	3	1	0	3	40	60	100
19-205-0304	Fluid Mechanics	3	1	0	3	40	60	100
19-205-0305	Metallurgy & Materials Science	3	1	0	3	40	60	100
19-205-0306	Machine Drawing	3	1	0	3	40	60	100
19-205-0307	Strength of Materials Lab	0	0	3	1	25	25	50
19-205-0308	Fluid Mechanics Lab	0	0	3	1	25	25	50
	TOTAL	**18**	**6**	**6**	**20**			

* Common for CE/CS/EC/EE/IT/ME/SE

CA – Continuous Assessment**,** SEE – Semester End Examination

SEMESTER IV

Code No.	Subject	L Hours/ Week	T Hours/ Week	P/D Hours/ Week	C	Marks		Total
						CA	SEE	
19-200-0401	*Complex Variables and Partial Differential Equations	3	1	0	3	40	60	100
19-205-0402	Metrology & Instrumentation	3	1	0	3	40	60	100
19-205-0403	Mechatronics	3	1	0	3	40	60	100
19-205-0404	Applied Thermodynamics	3	1	0	3	40	60	100
19-205-0405	Hydraulic Machinery	3	1	0	3	40	60	100
19-205-0406	Manufacturing Processes	3	1	0	3	40	60	100
19-200-0407	*Universal Human Values	3	0	0	3	50		50
19-205-0408	Metrology Lab	0	0	3	1	25	25	50
19-205-0409	Hydraulic Machinery Lab	0	0	3	1	25	25	50
	TOTAL	**21**	**6**	**6**	**23**			

* Common for CE/CS/EC/EE/IT/ME/SE

SEMESTER V

Code No.	Subject	L Hours/ Week	T Hours/ Week	P/D Hours/ Week	C	Marks		Total
						CA	SEE	
19-200-0501	*Numerical and Statistical Methods	3	1	0	3	40	60	100
19-205-0502	Mechanics of Machinery	3	1	0	3	40	60	100
19-205-0503	Machining Science & Machine Tools	3	1	0	3	40	60	100
19-205-0504	Thermal Engineering	3	1	0	3	40	60	100
19-205-0505	Power Plant Engineering	3	1	0	3	40	60	100
19-205-05**	Professional Elective – I	3	1	0	3	40	60	100
19-205-0510	Computational Methods Lab	0	0	3	1	25	25	50
19-205-0511	Machine Shop	0	0	3	1	25	25	50
	TOTAL	**18**	**6**	**6**	**20**			

* Common for CE/CS/EC/EE/IT/ME/SE
A student should opt for atleast one industry based elective during the B.Tech Programme.

19-205-0506 to 0509: PROFESSIONAL ELECTIVE – I
19-205-0506(IE): Industrial Management
19-205-0507: Computational Methods for Engineers
19-205-0508: : Smart Materials
19-205-0509: Principles of Turbomachinery

SEMESTER VI

Code No.	Subject	L Hours/ Week	T Hours/ Week	P/D Hours/ Week	C	Marks		Total
						CA	SEE	
19-205-0601	Dynamics of Machinery	3	1	0	3	40	60	100
19-205-0602	Machine Design – I	3	1	0	3	40	60	100
19-205-0603	Operations Management	3	1	0	3	40	60	100
19-205-0604	Heat and Mass Transfer	3	1	0	3	40	60	100
19-205-0605	CAD/CAM	3	1	0	3	40	60	100
19-205-06**	Professional Elective – II	3	1	0	3	40	60	100
19-205-0610	CAD/CAM Lab	0	0	3	1	25	25	50
19-205-0611	Heat and Mass Transfer Lab	0	0	3	1	25	25	50
	TOTAL	**18**	**6**	**6**	**20**			

19-205-0606 to 0609: PROFESSIONAL ELECTIVE – II
19-205-0606(IE): Additive Manufaturing
19-205-0607: Energy Conservation and Environment Protection
19-205-0608: Advanced Mechanics of Solids
19-205-0609: Fundamentals of Combustion & Pollution

SEMESTER VII

Code No.	Subject	L Hours/ Week	T Hours/ Week	P/D Hours/ Week	C	Marks		Total
						CA	SEE	
19-205-0701	Refrigeration & Air Conditioning	3	1	0	3	40	60	100
19-205-0702	Vibration & Noise Control	3	1	0	3	40	60	100
19-205-0703	Machine Design – II	3	1	0	3	40	60	100
19-205-07**	Professional Elective - III	3	1	0	3	40	60	100
19-205-07**	Open Elective - I	3	0	0	3	40	60	100
19-205-0712	Thermal Engineering Lab	0	0	3	1	25	25	50
19-205-0713	Automation Lab	0	0	3	1	25	25	50
19-205-0714	Entrepreneurship Development	0	0	2	1	50	-	50
19-205-0715	Project Phase I	0	0	3	1	50	-	50
19-205-0716	Industrial Internship***	0	0	-	1	50	-	50
	TOTAL	**15**	**4**	**11**	**20**			

**** A student should opt for atleast one open elective offered by a Division other than their branch of study in the 7th or 8th semester.**

***** Industrial internship of a minimum duration of two weeks must be completed after the 4th semester and before the commencement of 7th semester classes. The evaluation of internship shall be conducted along with Project Phase I.**

19-205-0704 to 0707: PROFESSIONAL ELECTIVE – III
19-205-0704(IE): Robotics & Artificial Intelligence
19-205-0705: Supply Chain Management
19-205-0706: Automobile Engineering
19-205-0707: Computational Fluid Dynamics

19-205-0708 to 0711: OPEN ELECTIVE – I
19-205-0708: Quality Engineering and Management
19-205-0709: HRD and Organisational Behaviour
19-205-0710: Computational Statistics for Engineers
19-205-0711: Finite Element Method

SEMESTER VIII

Code No.	Subject	L Hours/ Week	T Hours/ Week	P/D Hours/ Week	C	Marks		Total
						CA	SEE	
19-205-0801	Compressible Fluid Flow	3	1	0	3	40	60	100
19-205-08**	Professional Elective - IV	3	1	0	3	40	60	100
19-205-08**	Professional Elective - V	3	1	0	3	40	60	100
19-205-08**	Open Elective - II	3	0	0	3	40	60	100
19-205-0815	Seminar			3	1	50	-	50
19-205-0816	Project Phase - II			12	6	200	-	200
19-205-0817	Comprehensive Viva Voce			0	1	-	50	50
	TOTAL	**12**	**3**	**15**	**20**			

19-205-0802 to 0805: PROFESSIONAL ELECTIVE – IV
19-205-0802: Materials Management
19-205-0803: Hydraulic and Pneumatic drives
19-205-0804: :Aerospace Engineering
19-205-0805: Cryogenic Engineering

19-205-0806 to 0809: PROFESSIONAL ELECTIVE - V
19-205-0806: Production Technology
19-205-0807: Mechanical Behaviour of Materials
19-205-0808: Theory of Plates and Shells
19-205-0809: Propulsion Engineering

19-205-0810 to 0813: **OPEN ELECTIVE – II**
19-205-0810: Operations Research
19-205-0811: Nano Technology and Surface Engineering
19-205-0812: Mechanics of Composite Materials
19-205-0813: Engineering Economics, Estimation and Costing
19-200 - 0814: Constitutional Law

Evaluation Pattern for Theory and Practical courses

1. Theory courses

Type of Questions for Semester End Examination (SEE)

PART - A (8 x 4 = 32 marks)
Question No. I (a) to (h) – Eight short answer questions of 4 marks each with two questions from each of the four modules.

PART - B (4 x 10 = 40 marks)
Question nos. II, III with sub sections (a), (b) ---- 10 marks each with option to answer either II or III from Module I.
Question nos. IV, V with sub sections (a), (b) ---- 10 marks each with option toanswer either IV or V from Module II.
Question nos. VI, VII with sub sections (a), (b) ---- 10 marks each with option to answer either VI or VII from Module III.
Question nos. VIII, IX with sub sections (a), (b) ---- 10 marks each with option to answer either VIII or IX from Module IV.

The maximum marks that can be awarded for the Semester End Examination (SEE) will be only 60, even though the questions are for 72 marks.

Note: *The evaluation pattern for 19-205-0306 Machine Drawing is different and indicated at the end of its detailed syllabus.*

2. Practical courses

50% marks is earmarked for Continuous Evaluation, and 50% marks for Semester End Examination. The Semester End Examination to be conducted by a minimum of two examiners – one, not below the rank of an Associate Professor. A candidate shall secure a minimum of 50% marks in the aggregate and 40% minimum in the Semester End Examination for a pass.

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19-200-0301:LINEAR ALGEBRA AND TRANSFORM TECHNIQUES
(Common for all branches)

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

1. Solve linear system of equations and to determine Eigen values and vectors of a matrix.
2. Understand the concept of vector space and sub space.
3. Determine Fourier series expansion of functions and transform.
4. Solve linear differential equation and integral equation using Laplace transform.

Module I
Linear Algebra 1: Rank of a matrix, solution of linear system of equations- existence, uniqueness, general form - Eigen values and Eigen vectors- properties of Eigen values - Diagonalization of a matrix - Cayley Hamilton theorem (without proof) Verification-Finding inverse and power of a matrix using it-Quadratic form-orthogonal reduction of quadratic form to Canonical form.

Module II
Linear Algebra 2: Vector space-subspace-Linear dependence and independence-Spanning of a subspace- Basis and Dimension. Inner product- Inner product spaces - Orthogonal and Orthonormal basis –Gram- Schmidt Orthogonalization process. Linear Transformation.

Module III
Fourier Analysis: Periodic function, Fourier series, Functions of arbitrary period, Even and odd functions, Half Range Expansion, Harmonic analysis, Complex Fourier Series, Fourier Integrals, Fourier Cosine and Sine Transform, Fourier Transform.

Module IV
Laplace Transforms: Gamma functions and Beta function-Definition and properties, Laplace transforms. Inverse Laplace Transform, Shifting theorem, Transform of Derivative and Integrals, Solution of differential equation and integral equation using Laplace transform, Convolution, Unit step function, Second Shifting theorem, Laplace transform of periodic function.

References:
1. Erwin Kreyzig, Advanced Engineering Mathematics, 10th Edition, John Wiley & Sons, (2010).
2. Grewal, B. S., Higher Engineering Mathematics, 43rd Edition, Khanna Publishers, (2013).
3. Hsiung,C. Y. and Mao G.Y., Linear Algebra, World Scientific Publishing Co. Inc., (1999).
4. Hoffman K. and Kunze, R., Linear Algebra, Prentice Hall, New Delhi, (1971).
5. Venkataraman M. K., Linear Algebra, The National Publishing Co., (1999).

19-205-0302:ELECTRICAL TECHNOLOGY

Course Outcomes:
On completion of this course the student will be able to:
1. Study the different types, constructional details, operational principles, and performance characteristics of DC motors and DC generators.
2. Understand the construction and working of transformers, transformer losses, current transformer, and potential transformers.
3. Understand the constructional details, operational principles, and performance characteristics of induction motors and alternators.
4. Learn about the generation, transmission, and distribution of electrical energy.

Module I
DC machines:Basic principle of operation of DC Generator,construction, emf equation, types of generators, armature reaction and commutation, characteristics, losses and efficiency .
DC Motor: working principle, Concepts of motoring and generating action, Torque equation, Types of motors, characteristics, starting, speed control, losses and efficiency ,brake test, Swinburne's test, applications.

Module II
Transformers: Working principles and elementary theory of an ideal transformer, Constructional features of singlephase transformer, emf equation, turns ratio, vector diagram, equivalent circuit, impedence transformation, transformer losses, flux leakage, efficiency, open circuit and short circuit test, load test. Auto transformer – working principle and saving copper, basic idea of current transformer and potential transformer, distribution and power transformer, applications, standard rating, IS specifications.

Module III
AC Machines: Alternator- rotating field, speed and frequency, effect of distribution of winding, coil span,characteristics, emf equation, losses and efficiency, regulation (emf method only), applications, synchronous motor-principles of operation, over excited and under excited, starting, applications, synchronous capacitor.
Induction Motor: Induction motor, principles of operation, constructional features of squirrel cage and slip ringmotors, torque-slip characteristics, starting, speed control, losses and efficiency.

Module IV
Generation, transmission & distribution of electrical energy: Different methods of power generation-thermal,hydro-electric, nuclear, diesel, gas turbine stations(general idea only), electrical equipment in power stations, concept of bus bar, load dispatching, methods of transmission, transmission lines, overhead lines and insulators, corona and skin effect of DC & AC distribution, substation (elementary idea only).

References

1. Hughes, K, Electrical Technology, English Language Book Society, (1996).
2. Cotton, H., Advanced Electrical Technology, CBS Publishers and Distributors, New Delhi, (1984).
3. Nagrath, I. J, Kothari D.P, Electrical Machines, Tata McGraw Hill Publishing Co. Limited, (1997).
4. Bimbra, F. S., Electrical Machines, 7th Edition, Khanna publishers, (2007).
5. Gupta B.R and Vandana Singhal, Fundamentals of Electric machines, D. K Publishers, (2000).
6. Vincent Del Toro, Electrical Machines & Power systems, Prentice Hall, (1998).
7. Chapman, S. J, Electric Machines & Power systems, McGraw Hill, (1999).

19-205-0303:MECHANICS OF SOLIDS

Course Outcomes:

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

1. Understand and apply the concept of stress and strain to analyse and design structural members and machine parts under axial, torsional, and flexural loads
2. Model and analyse the behaviour of structural and machine components subjected to various loading and support conditions based on principles of equilibrium and material constitutional relationships.
3. Determine the deflections and deformations of loaded flexural members.
4. Design simple bars, beams, and circular shafts for allowable stresses and loads

Module I

Tension, Compression, and Shear: Normal stress and strain, stress-strain diagrams, elasticity and plasticity, linear elasticity and Hooke's law, shear stress and strain, allowable stresses.

Axially loaded members: Deflections of axially loaded members, statically indeterminate structures, temperature and pre-strain effects, strain energy.

Analysis of stress and strain: Plane stress, plane strain, principal stresses and maximum shear stresses, Mohr's circle for plane stress, spherical & cylindrical pressure vessels.

Module II

Torsion : Torsion of circular bars, pure shear, relation between modulus of elasticity and modulus of rigidity, power transmission, strain energy in torsion.

Shear force and Bending moment: Types of beams, shear force and bending moment, relation ship among load, shear force, and bending moment, shear force and bending moment diagrams.

Module III

Stresses in beams: Normal strains in beams, normal stresses in beams, cross sectional shapes of beams, shear stresses in beams, beams with axial loads, Combined axial, bending, and torsional loads.

Theories of failure: Various theories of failure and their applications to ductile and brittle materials.

Module IV

Deflections of beams: Differential equations of the deflection curve, deflections by integration, Macaulay's method, moment area method, deflections of non prismatic beams, deflections of statically indeterminate beams-propped cantilevers and fixed beams.

Columns: Buckling and stability, Euler's equations for columns with different support conditions.

References:

1. Gere and Timoshenko, Mechanics of Materials, 2nd Edition, CBS Publisher, (2004).
2. Popov, E.P, Introduction to mechanics of solids, Pearson Education, (1998).
3. Beer &Johnston, Mechanics of Solids, 3rd Edition, Mc Graw Hill, (2002).
4. Shames & Pittaresi, Introduction to Solid Mechanics, 3rd Edition, PHI, (2009).
5. Mott, Applied strength of materials, 5th Edition, PHI, (2009).
6. Carl, T.F., Ross, Strength of Materials & Structures, 4th Edition, Elsevier, (1999).

19-205-0304:FLUID MECHANICS

Course Outcomes:

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

1. Understand the basics of fluid kinematics, manometry, forces on submerged bodies, fluid dynamics, and continuity equations
2. Explore the applications of Bernoulli's equation, Laminar and Turbulent flows, one dimensional flow through pipe
3. Understand the basics of two dimensional flow, vorticity, vortex tube, velocity potential, stream function, and concept of formation of Rankine half body, Rankine oval, Doublet, Magnus effect etc.
4. Apply the concepts of boundary layer, Prandtl's boundary layer equations, Blasius solution, Karman's momentum integral equations, skin friction drag in flows.

Module I

Preliminaries, Concept of continuum, Properties of fluids – density – pressure – viscosity - surface tension - capillarity - vapour pressure, Fluid statics, Basic equations of fluid statics, Variation of pressure in a fluid, - Manometry - Forces on surfaces and bodies in fluids, Floatation - stability of bodies in fluid - metacentric height and its measurement, Fluids in rigid body motion, Fluid kinematics -Eulerian and Lagrangian description - local and material rates - deformation of a fluid element -strain rate-velocity relations, Graphical description of flow – streamlines - path lines - streak lines - stream tube, Fluid dynamics - concept of the control volume -Reynolds transport equation and its use to formulate fluid mechanics problems, Integral and differential forms of the continuity - momentum and energy equations, Illustrative examples.

Module II

One dimensional flow through pipes, Non viscous equation for the flow through a stream tube and along a stream line – Euler's equation – Bernoulli's equation, - Energy equation, Applications of the one dimensional equations - velocity and flow measuring devices and quasi steady problems, Laminar and turbulent flow through pipes - Hagen- Poiseuille equation - Darcy-Weisbach equation - pipe friction -Moody's chart - minor losses in pipes.

Module III

Two dimensional incompressible inviscid flows – Vorticity - Vortex tube - Irrotational flow - Velocity potential, Stream function - relation between stream function and potential function in ideal flows -Equation of a streamline - governing equations, Fundamental flow patterns. Combination of basic patterns - Rankine half body - Rankine oval - Doublet and flow over a cylinder, Karman vortex street and Strouhal number, Reynolds number and Froude number, Magnus effect and the calculation of lift and drag on bodies.

Module IV

Plane viscous flow past bodies, The boundary layer - Prandtl's boundary layer equations, Boundary layer equations, Naviers -Stokes equations, Couette flow, Poiseuille flow, Boundary layer separation, Methods to control boundary layer, Order of magnitude analysis, skin friction drag.

References:

1. Shames, I.H., Mechanics of fluids, Mc Graw Hill Book Co., (1962).
2. Frank M. White, Fluid Mechanics, 7th Edition, Tata Mc Graw Hill, New Delhi, (2008).
3. Cengel Y. A., & Cimbala J. M., Fluid Mechanics-Fundamentals and Applications, Tata McGraw Hill, (2006).
4. Gupta V., & Gupta S. K., Fluid Mechanics and its applications, 1st Edition, New Age International, (1984).
5. Som S. K., and Biswas G., Fluid Mechanics and Fluid Machines, 2nd Edition., Tata McGraw Hill, (2004).
6. Cohen and Kundu, Fluid Mechanics, 6th Edition, Elsevier, (2015).
7. Babu, V., Fundamentals of Incompressible flow, 1st Edition, CRC Press, (2010).
8. Massey, Fluid Mechanics, English Language Book Society, (2006).

19-205-0305:METALLURGY AND MATERIAL SCIENCE

Course Outcomes:

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

1. Study the crystal structure, crystal systems, crystallographic planes, crystal imperfections, solidification, and diffusion
2. Understand the phase rule, phase diagrams, solid solutions, examples of binary solid solutions
3. Learn about different heat treatment processes for steel and applications of ferrous and nonferrous alloys
4. Understand different failure mechanisms

Module I

Crystallography : crystal structure, space lattice, crystal systems, miller indices of crystal planes and directions, atomic density of crystallographic planes and lines, atomic packing factor, coordination number, inter planar spacing.

Solidification of metals : homogenous and heterogeneous nucleation, crystal growth, grains and grain boundaries, equi-axed and columnar grains, dendritic pattern, polymorphism.

Crystal imperfections : point defect, line defect, edge dislocation, screw dislocation, interaction between dislocation, planar defects, stacking faults, grain boundary, twist and twin boundaries, volume defects.

Diffusion : mechanism of diffusion in crystals, types of diffusion, factors affecting diffusion, Fick's law of diffusion,metallurgical application of diffusion.

Module II

Phase: Equilibrium between phases, Gibb's phase rule, solid solution, interstitial, substitutional, ordered and disordered types, Hume – Rothery rules, equilibrium phase diagrams of binary alloys complete solid solubility, partial solid solubility, no solid solubility,: eutectic, peritectic and eutectoid reactions, Cu- Ni, Cd-Bi, Pb-Sn, Ag-Pt, and Fe-C systems as examples.

Heat treatment of steel: Definition and aims of heat treatment, T T T diagram, isothermal and continuous cooling, annealing, normalizing, hardening, tempering, austempering, martempering, hardenability of steels, jomini test, surface treatments – case hardening, carburising, cyaniding, nitriding, flame hardening, induction hardening, metal coating- hot dipping, electro plating, metal cladding, impregnation, metal spraying.

Module III

Deformation of metals : Elastic, anelastic and visco elastic behaviour, plastic deformation, mechanism of slip, slip planes and slip directions, mechanism of twinning, strengthening mechanisms, work hardening, grain boundary hardening, precipitation hardening, cold working, hot working, recovery, recrystalisation and grain growth.

Failure of metals : creep, mechanism of creep, creep curves, creep resistant materials, fracture, brittle fracture, Griffith's theory, ductile fracture, ductile-brittle transition, protection against fracture, fatigue.

Module IV

Applications of ferrous and non ferrous alloys steel - low, medium, high carbon steels, Stainless steels ferritic, austenitic, martensitic, duplex steels, tool steels cast iron, gray, white, ductile cast irons, copper and its alloys, aluminium and its alloys, magnesium and alloys, titanium and its alloys, refractories - super alloys, ceramics, composite and glasses, shape memory alloys, Nano materials, bio materials, Optical fibers.

References:

1. Van Vlack, L.W., Elements of material science and Engineering, 6th Edition, Prentice Hall, (1989).
2. Reed Hill, Physical metallurgy principles, 2nd Edition, Affiliated East-West Press, New Delhi, (2008).
3. William D Callyster, Material Science & Engg, Wiley , 9/e (2014).
4. Raghavan, V., Material science and engineering, 5th Edition, Prentice Hall, (2007).
5. Narula, Material Science, 1st Edition, Tata McGraw Hill, (2001).
6. Agarwal, B.K., Introduction to engineering materials, 1st Edition, McGraw Hill Education, (2007).

19-205-0306: MACHINE DRAWING

Course Outcomes:

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

1. Convert a pictorial view in to orthographic view
2. Draw the different views of threaded nuts and bolts
3. Draw the orthographic views of cotter joints, pipe joints, couplings and bearings
4. Draw the assembly drawing of machine parts

Module I

Introduction to Machine Drawing: Conversion of pictorial views to orthographic views.

Screwed fastenings: Screw thread forms, V and Square threads, Conventional representation of threads, Hexagonal headed bolt and nut, Square headed bolt, Nut locking arrangements, Foundation bolts- ray bolt and Lewis foundation bolt.

Cotter and Pin joints: Socket and Spigot joints, Gib and Cotter joint for rectangular rods, Sleeve and Cotter joints, Knuckle joint.

Module II

Pipe joints : Coupler joints, Nipple joints, Union, Socket and Spigot joints, Integral flanged joints and Hydraulic joints.

Couplings: Parallel and Tapered sunk keys, Saddle keys, Feather keys and Pin keys, Muff coupling, Protected type flange coupling, Pin type flexible coupling.

Bearings : Solid journal bearings, Bushed bearings, Plummer block, Foot step bearing, Thrust bearings.

Module III

Assembly of machine parts: Machine Vice, Tail-Stock of Lathe Steam Engine parts: Stuffing box, Cross head.

I.C. engine: Piston and Connecting rod.

Valves: Steam stop valve, Spring loaded safety valve, Lever safety valve, Ramsbottom safety valve.

References:

1. Bhatt, N.D., Elementary engineering drawing, 30th Edition, Charotar publishing house, (1990).
2. Parkinson, First year engineering drawing, Pitman, London, (1958).
3. Gill, P.S., Machine drawing, 18th Edition, Kataria & Sons, (2013).
4. John, K.C., Text Book of Machine Drawing, 1st Edition, PHI, (2009).
5. Basudeb Bhattacharyya, Machine drawing, Oxford University Press, (2011).

Note: Duration of the Semester End Examination is 4 hours

Pattern of Questions for Semester End Examination

Question Nos. I, II with sub sections (a), (b) if required ---- (15 marks each with options to answer either I or II) from Module I.

Question Nos. III, IV with sub sections (a), (b) if required ---- (20 marks each with options to answer either III or IV) from Module II.

Question Nos. V, VI with sub sections (a), (b) if required ---- (25 marks each with options to answer either V or VI) from Module III.

19-205-0307:STRENGTH OF MATERIALS LAB

Course Outcomes:
On completion of this course the student will be able to:
1. Design the required experiments.
2. Conduct different experiments on the specimens to find out the material properties using the theoretical knowledge
3. Tabulate the data and use necessary theoretical knowledge to find out the results
4. Interpret the results.

Experiments

1. Shear test on M.S.Rod.
2. Vicker's pyramid hardness test.
3. Brinnel Hardness test.
4. Tension test on M.S.Rod.
5. Impact test.
6. Spring test.
7. Bonding test on R.S.J. Beam.
8. Rockwell hardness test.
9. Compression test on concrete cubes and cylinders (300 T machine)
10. Preparation of cubes and cylinders.
11. Testing of cubes and cylinders.
12. Torsion test.

19-205-0308: FLUID MECHANICS LAB

Course Outcomes:
On completion of this course the student will be able to:
1. Design the required experiments
2. Conduct different fluid flow experiments using the theoretical knowledge.
3. Tabulate the data and use necessary theoretical knowledge to find out the results.
4. Interpret the results.

Experiments

1. Study of pipe fittings and plumbing tools
2. Experiment on notches
3. Pipe friction apparatus
4. Determination of minor losses
5. Metacentric height
6. Venturimeter
7. Orificemeter
8. Flow through orifice
9. Heleshaw experiment
10. Reynolds experiment
11. Free & forced vortex apparatus
12. Verification of Bernoullis equation

19-200-0401:COMPLEX VARIABLES AND PARTIAL DIFFERENTIAL EQUATIONS
(Common to all branches)

Course Outcomes:
On completion of this course the student will be able to:
1. Transform a region to another region using conformal mapping
2. Evaluate real integrals using residue theorem
3. Form and solve partial differential equation
4. Determine solution of partial differential equation for vibrating string and heat conduction

Module I
Analytic function- Cauchy-Riemann equation (Cartesian and polar)-Harmonic function-construction of analytic function given real or imaginary parts- Conformal mapping of standard elementary function and bilinear transformation.

Module II
Cauchy's integral theorem, Cauchy's integral formula and for derivatives-Taylor's and Laurent's expansion (without proof) - Singularities-Residues-Cauchy's Residues theorem- Contour integration involving unit circle.

Module III
Formation of partial differential equation eliminating arbitrary constants and function—Solution of first order equation-four standard types- Lagrange's equation—Linear homogeneous partial differential equation with constant coefficient.

Module IV
One dimensional wave equation, Alembert's solution and one dimensional heat flow equation—solution by the method of separation of variables- application of Fourier series solution. Solution of Laplace's equation over a rectangular region by the method of separation of variables.

References:
1. Erwin Kreyzig, Advanced Engineering Mathematics, 10th Edition, John Wiley & Sons, (2010).
2. Grewal, B.S., Higher Engineering Mathematics, 43rd Edition, Khanna Publishers, (2013).

19-205-0402:METROLOGY & INSTRUMENTATION

Course Outcomes:

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

1. Understand the concepts of measurements, limits, fits and tolerance.
2. Learn about measurement techniques of angles, tapers, and surface finish
3. Learn about applications of measuring instruments
4. Understand the measurement techniques for strain, force, torque, temperature, air pollution and nuclear radiation.

Module I

General measurements concepts: precision and accuracy, Methods for estimating accuracy and precision, measuring errors.

General principle of measurements: line and end measurements, standards; linear measurements, basic units, and quantities for displacement, mass, time, temperature & optics; Limits, Fits & Tolerance: systems of limits and fits, Hole basis and shaft basis system of representation ; tolerances for linear dimensions, calculation of tolerance grade, representaion.

Gauges*:* classification, types of gauges, gauge maker's tolerances, wear allowance, gauges, materials.

Module II

Measurement of angles & tapers: sine bars, angle gauges: auto collimator, clinometer & spirit level; taper gauges, bevel protractors.

Measurement of surface finish: surface structure, integrity, texture, roughens, waviness, lay, RMS & CLA values, roughness values produced by machining processes.

Optical measuring instruments: interferometry, optical flats, optimeters, and optical projectors, tool maker's microscope, limitations.

Module III

Applications of measuring instruments-functional elements of an instrument-instrument as transducer-generalized measuring instrument-generalized mathematical model of measuring systems-zero order, first order and second order instruments-classification of instruments- input output configurations-methods of correction for spurious inputs - static calibration and determination of bias systematic error and random error-static and dynamic characteristics, potentiometer transducer as a zero order instrument-analysis of its loading error- mercury in glass thermometer as a first order instrument-step, ramp, frequency response-seismic instrument as a second order instrument.

Module IV

Measurement of strain : strain gauge classification –un bonded and bonded strain gauges-gauge factor-strain rosettes-temperature compensation-calibration. Measurement of force : multiple lever system for weighing- load cells-temperature sensitivity calibration- ballistic weighing- hydraulic and pneumatic load cells. Measurement of Torque: water break-Heenan and Froude hydraulic dynamometer-beam and strain gauge transmission dynamometer. Measurement of Temperature : pressure thermometer-RTDs-compensation for lead resistance thermocouples- five laws of thermocouples and their applications-series and parallel connected thermocouples-pyrometry-optical pyrometer-infrared pyrometry-total radiation pyrometers.

Air pollution measurements : gas chromatography-ORSAT's apparatus. Nuclear instrumentation: Gieger Muller Counter-ionization chamber-scintillation counter.

Acoustical measurements : basic acoustical parameters-sound pressure-sound pressure levelpower- intensity-power level-microphones-sound.

References:

1. Doebelin E. O., Measurement systems: Application & Design, 3rd Edition, McGraw Hill, (1983).
2. Beckwith, Marangoni, & Lienhard, Mechanical Measurements, 6th Edition, Prentice Hall, (2006).
3. Mahajan, M., A textbook of metrology, Dhapat Rai and Co., (2011).

19-205-0403:MECHATRONICS

Course Outcomes:

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

1. Understand the basics of sensors and transducers and different mechatronics systems
2. Model and analyse first and second order systems for their time and frequency domain responses
3. Analyse a system for its stability
4. Design mechatronics system for simple applications
5. Use software tools for modeling and simulation of mechatronic systems.

Module I

Introduction to Mechatronics – Scope - Mechatronics and Engineering Design, Sensors and transducers – classification - thermal, electrical, optical, acoustic, pneumatic, magnetic and piezo electric sensors.

Actuation Systems: Pneumatic and hydraulic systems – Direction control valves, Pressure control valves, servo and proportional control valves, cylinders, rotary actuators, Mechanical actuation systems: kinematic chains, cams, gears, ratchet and pawl, belt and chain drives, bearings.

Electrical actuation systems: Mechanical switches (relays), Solid-state switches, Solenoids, DC motors, PWM and speed control, AC motors, Stepper motors, DC and AC servo motors, tacho generators, synchros.

Module II

Open loop and closed loop control systems - continuous and discrete processes - servo mechanism – principles - components – error detectors – potentiometers - types.

System modelling - mathematical models -mechanical, electrical, fluid and thermal system building blocks – system models, Electrical and mechanical analogous systems, Transfer function, block diagram reduction, signal flow graph, state-space representation, dynamic response of systems - first and second order systems, time constant, rise time, peak time, peak overshoot, settling time.

Closed loop controllers - proportional, derivative and integral controls - PID controller – digital controllers - controller tuning - adaptive control of machine tools.

Module III

Stability analysis: Concepts of stability, characteristic equations, stability analysis, determination of stability by Routh-Hurwitz criterion, Root locus, frequency response using Bode plot and stability from Bode plot, Nyquist criteria.

Module IV

Stages in designing mechatronic systems - traditional and mechatronic design - possible design solutions, digital logic circuits, microprocessors and Micro controllers – architecture - programmable logic controllers, Ladder diagram.

Automatic control and real time systems, robot position and proximity sensing - tactile sensing, Man-machine interface.

Case studies of mechatronic systems - pick and place robot - automatic car park system - engine management system.

References:

1. Rolf Isermann, Mechatronic Systems: Fundamentals, Springer, (2005).
2. Bolton, W., Mechatronics, Pearson Education Limited, (2015).
3. Singh & Joshi, Mechatronics, PHI, (2006).
4. David G. Alciatore, Michael B. Histand, Introduction to Mechatronics and Measurement System, Tata McGraw Hill, (2003).
5. Onwubolu, Mechatronics: Principles and Applications, 1st Edition, Elsevier, (2006).
6. Dorf & Bishop, Modern Control Systems, 11th Edition, Pearson Education, (2008).
7. Ogata K, Modern Control Engineering, 4th Edition, Prentice Hall Inc., (2002).
8. Kuo, B.C., Automatic Control Systems, 8th Edition, Wiley, (2002).

19-205-0404:APPLIED THERMODYNAMICS

Course Outcomes:

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

1. Learn first and second law of thermodynamics and the application of these laws for various thermodynamic processes.
2. Apply the knowledge of thermodynamic laws to various engineering systems.
3. Analyse the performance of steam generators with additional accessories used for enhancing the performance.
4. Understand the various types of nozzles and its performance at various back pressure conditions and also for different flow conditions.
5. Calculate the mole and mass fractions of various mixtures and also various specific properties of the mixtures.

Module I

First and second law of thermodynamics, Carnot theorem, Thermodynamic temperature scale, Internal Energy and entropy, Claussius inequality, entropy charge in various thermodynamic processes of ideal gases, Application of first and second law of thermodynamics for steady flow processes, reversibility, irreversibility & Availability, Tds equations, (Helmoholtz, Gibbs function & Maxwell relations) Claussius clapeyron equations.

Module II

Pure substance – PV, PT and TS systems – PVT surface – Properties of steam – steam table and Mollier diagram – Analysis of vapour process – thermodynamic analysis of steam power cycles – Rankine, reheat, and regenerative – binary vapour cycles – modern steam generators – performance calculations of boilers.

Module III

Steam nozzles – mass flow rate – throat pressure for maximum discharge – throat area – effect of friction – super saturated flow – effect of back pressure.

Steam turbines – types and classification– velocity diagram – force on blades, workdone by blades, blade or diagram efficiency- effect of friction on blades.

Module IV

Ideal, perfect and real gases, Properties of Mixtures of Gases and Gas and vapours: Dalton's law of Partial Pressure, Amagat's law of Partial volume, Volumetric and Gravimetric analysis of Gas mixtures, Gibb's Dalton Law, Mean value of Gas constant, Equivalent Molecular weight, Density, Specific volume, specific heat and Molar heat capacity of gas mixture, Advanced Problem on Adiabatic mixing.

References:

1. Spalding D.B. & Cole, E.H., Engineering Thermodynamics, Edward Arnold, London, (1967).
2. Holman, J. P., Thermodynamics, 4th Edition, McGraw Hill Inc., (1987).
3. Nag, P. K., Engineering Thermodynamics, 4th Edition, Tata McGraw Hill, (2008).
4. Bacon, Engineering Thermodynamics, Newnes- Butterworth, (1972).
5. Van Wylen, G. J., Borgnakke, C., & Sonntag R. E., Fundamentals of Thermodynamics, 6th Edition, John Wiley & Sons, (2003).

19-205-0405:HYDRAULIC MACHINERY

Course Outcomes:

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

1. Understand dimensional analysis and principles of similitude
2. Apply the momentum principles to impinging jets and analyse its performance.
3. Learn the working of various hydraulic turbines and their performance characteristics
4. Understand the working of roto-dynamic pumps and positive displacement pumps
5. Study the principle of working of hydraulic devices

Module I

Dimensional Analysis & Similitude : Rayleigh's method, Buckingham's Pi theorem, nondimensional parameters in fluid mechanics and machinery – principles of similitude – geometric, kinematic and dynamic similarities – model studies. Physical meaning of important dimensional groups of fluid mechanics and their practical use.

Dynamic action of fluid : Momentum equation applied to a control volume, impact of jets, flow of an incompressible fluid over fixed and moving vanes, work done and efficiency.

Module II

Hydraulic turbines: Impulse and Reaction turbines, Pelton wheel, Francis turbine and Kaplan turbine, theirconstructional features, Velocity triangles, Performance characteristics – non dimensional parameters for comparative study of turbine study of turbine performance, Specific speed, Unit speed, Unit power, theory of draft tubes, speed regulation of turbines, Cavitation, Selection of type and speed of turbines.

Module III

Pumping machinery: general features of positive displacement and rotodynamic pumps, centrifugal pumps, classification, principle of working, velocity diagrams, work done, efficiency, minimum speed, specific speed, losses in pumps, circulatory flow, multistage pumps, propeller pumps, priming, Cavitation and its significance.

Reciprocating pumps: Working, single acting and double acting pumps, Slip, Acceleration head, effect of friction,use of air vessels, Indicator diagrams, efficiencies, pump characteristics.

Module IV

Hydraulic Press, Hydraulic Ram, Hydraulic Intensifier, Hydraulic lift, Hydraulic Accumulator, Hydraulic Crane, Hydraulic Coupling, Hydraulic Torque Converter, Surge tank, Vane pump, gear pump, Working principles of axial and radial pumps, Application to hydraulic devices, Fluid transients, Free and Forced vortex apparatus.

References:

1. Shepherd, D.G., Principles of turbo machinery, MacMillan & Co. Ltd., (1957).
2. Agarwal, Fluid mechanics & Machinery, Tata McGraw Hill, (2001).
3. R K Bansal, Fluid mechanics, Luxmi Pulications, (2008).
4. Vallentine, Applied hydrodynamics, Newnes- Butterworths, London, (1969).
5. Herbert Addison, A treatise on applied hydraulics, 5th Edition, Chapman & Hall, (1972).
6. Stepanof, A. J., Centrifugal and axial flow pumps, Wiley, New York, (1957).

19-205-0406: MANUFACTURING PROCESSES

Course Outcomes:

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

1. Learn about the sand casting process.
2. Understand the special casting process and casting defects.
3. Learn about different metal forming processes.
4. Understand different metal joining processes and their characteristics.

Module I

Foundry: foundry materials, moulding and core sand, binders, additives, sand preparation, pattern and pattern making, pattern allowances and their calculations, mould and core making, types of cores, buoyancy force calculation on cores, chaplets, mould assembly, melting furnaces, pouring and fettling, solodification of pure metals and alloys, calculation of solidification time, grain growth.

Module II

Casting processes: sand casting, shell moulding, investment casting, slush casting, gravity and pressure die casting, cetrifugal casting, casting design, gateway system design, riser design – (Caine's method, Modulus method, shrinkage volume consideration method, simple problems), casting defects, inspection and testing (destructive and non-destructive), casting alloys, economics of casting.

Module III

Yield criteria of metals (Von Mises, Tresca), isotropic hardening, kinematic hardening, plastic stress-strain relationship, metal forming operations, principle, process and equipments for punching, drawing, extrusion, rolling and forging, load calculation for punching, drawing, extrusion, rolling and forging, punch size and die size calculation for blanking and puncing operations

Module IV

Metal joining: Classification, Welding heat sources, Arc welding machines, Arc production characteristics, metal transfer, welding electrode, optimum voltage, current, and arc length calculation, duty cycle and current relations, design of weld bead(no. of electrodes, welding speed, number of passes, welding time) , Gas welding (TIG, MIG), Resistance welding, Thermit welding, Ultrasonic welding, Electron beam welding, Laser beam welding, Forge welding, Friction welding, Diffusion welding, Explosion welding, Gas and arc cutting, Welding metallurgy, Weldability of ferrous and non ferrous metals, design of weldments, joint design, residual stresses and distortion, tesing of welded joints, brazing and soldering.

References:

1. Campbell J. S., Principles of Manufacturing materials and Processes, McGraw Hill, (1961).
2. Heine R. W., Loper C. R. and Rosenthal, P. C., Principles of Metal Castings , McGraw Hill, (1967).
3. Rowe G. W., Elements of metal working theory , Edward Arnold, London, (1979).
4. Little R. L., Welding and welding technology, Tata McGraw Hill , (1996).
5. Patte H. E., Technological Advances in welding and other joining processes, Battelle Press, (1982).
6. Rao, P.N., Manufacturing Technology, 3rd Edition, Tata McGraw Hill, (2008).

19-200-0407 UNIVERSAL HUMAN VALUES
(Common to all the branches)

Course Outcomes: On completion of the course, a student will be able to:

1. More aware of themselves and their surroundings (family, society, nature).
2. More responsible in life in handling problems with sustainable solutions
3. Keep human relationships and human nature in mind.
4. Having better critical ability and would also become sensitive to their commitment towards what they have understood (human values, human relationship and human society).
5. Apply what they have learnt to their real life.

Module 1: Course Introduction - Need, Basic Guidelines, Content and Process for Value Education

Purpose and motivation for the course, recapitulation from Universal HumanValues-I
Self-Exploration–what is it? - Its content and process; 'Natural Acceptance' and experiential Validation- as the process forself-exploration
Continuous Happiness and Prosperity- A look at basic HumanAspirations
Right understanding, Relationship and Physical Facility- the basic requirements for fulfilment of aspirations of every human being with their correctpriority
Understanding Happiness and Prosperity correctly- A critical appraisal of the currentscenario
Method to fulfil the above human aspirations: understanding and living in harmony at variouslevels.

Include practice sessions to discuss natural acceptance in human being as the innate acceptance for living with responsibility (living in relationship, harmony and co-existence) rather than as arbitrariness in choice based on liking-disliking

Module 2: Understanding Harmony in the Human Being - Harmony in Myself!

Understanding human being as a co-existence of the sentient 'I' and the material'Body'
Understanding the needs of Self ('I') and 'Body' - happiness and physicalfacility
Understanding the Body as an instrument of 'I' (I being the doer, seer andenjoyer)
Understanding the characteristics and activities of 'I' and harmony in'I'
Understanding the harmony of I with the Body: Sanyam and Health; correct appraisal of Physical needs, meaning of Prosperity indetail
Programs to ensure Sanyam andHealth.

Include practice sessions to discuss the role others have played in making material goods available to me. Identifying from one's own life. Differentiate between prosperity and accumulation. Discuss program for ensuring health vs dealing with disease

Module 3: Understanding Harmony in the Family and Society- Harmony in Human-Human Relationship

Understanding values in human-human relationship; meaning of Justice (nine universal values in relationships) and program for its fulfilment to ensure mutual happiness; Trust and Respect as the foundational values ofrelationship
Understanding the meaning of Trust; Difference between intention andcompetence
Understanding the meaning of Respect, Difference between respect and differentiation; the other salient values in relationship
Understanding the harmony in the society (society being an extension of family): Resolution, Prosperity, fearlessness (trust) and co-existence as comprehensive HumanGoals

Visualizing a universal harmonious order in society- Undivided Society, Universal Order- from family to worldfamily.

Include practice sessions to reflect on relationships in family, hostel and institute as extended family, real life examples, teacher-student relationship, goal of education etc. Gratitude as a universal value in relationships. Discuss with scenarios. Elicit examples from students' lives

Module 4: Understanding Harmony in the Nature and Existence - Whole existence as Coexistence

Understanding the harmony in theNature
Interconnectedness and mutual fulfilment among the four orders of nature- recyclability and selfregulation innature
Understanding Existence as Co-existence of mutually interacting units in all-pervasivespace
Holistic perception of harmony at all levels ofexistence.

Include practice sessions to discuss human being as cause of imbalance in nature (film "Home" can be used), pollution, depletion of resources and role of technology etc.

Module 5: Implications of the above Holistic Understanding of Harmony on Professional Ethics

Natural acceptance of humanvalues, Definitiveness of Ethical HumanConduct
Basis for Humanistic Education, Humanistic Constitution and Humanistic UniversalOrder
Competence in professional ethics: a. Ability to utilize the professional competence for augmenting universal human order b. Ability to identify the scope and characteristics of people friendly and eco-friendly production systems, c. Ability to identify and develop appropriate technologies and management patterns for above productionsystems.
Case studies of typical holistic technologies, management models and productionsystems
Strategy for transition from the present state to Universal Human Order: a. At the level of individual: as socially and ecologically responsible engineers, technologists and managers b. At the level of society: as mutually enriching institutions andorganizations
Sum up.

Include practice exercises and case studies to discuss the conduct as an engineer or scientist etc.

TextBook -Human Values and Professional Ethics (2nd revised edition) by R R Gaur, R Asthana, G P Bagaria, Excel Books,New Delhi, 2019

ReferenceBooks

1. JeevanVidya: EkParichaya, A Nagaraj, JeevanVidyaPrakashan, Amarkantak,1999.
2. Human Values, A.N. Tripathi, New Age Intl. Publishers, New Delhi,2004

19-205-0408:METROLOGY LAB

Course Outcomes:

On completion of this course the student will be able to:
1. Design the required experiments
2. Conduct different measurement techniques with the available theoretical knowledge
3. Tabulate the data and use necessary theoretical knowledge to find out the results
4. Interpret the results

Experiments

1. Use of vernier caliper, micrometer, depth gauge and height gauge – source of error in measurement ideas on range, precision and accuracy
2. Slip gauges and their use in linear measurements.
3. Ideas on tolerance allowance, limits, fits.
4. Dial gauges – their use in the measurement of small linear displacements, parallelism and concentricity.
5. Measurements using tool maker's microscope – tool angles and tool wear.
6. Measurement of surface roughness – surface roughness parameters – surface finish evaluation using perth-O-meter/ Talysurf
7. Standards for screw threads – Screw thread measurements using Universal Measuring
8. Microscope/Measuring Projector.
9. Use of measuring Projector to evaluate form error.
10. Microstructure studies using Metallurgical Microscope.
11. Lathe tool dynamometer – study and use of measurement of cutting forces in turning.
12. Milling forces – Milling parameters – measurement of milling forces in slab milling operations.
13. Measurement of drilling thrust and torque using drill toll dynamometer.
14. Study of grinding wheel and grinding parameters – experiments in grinding.
15. Non-destructive tests.

19-205-0409:HYDRAULIC MACHINERY LAB

Course Outcomes:

On completion of this course the student will be able to:
1. Design the required experiments.
2. Conduct different performance tests on hydraullic machinery using the theoretical knowledge
3. Tabulate the data and use necessary theoretical knowledge to find out the results
4. Interpret the results.

Experiments

1. Pelton Wheel
2. Francis Turbine
3. Kaplan Turbine
4. Centrifugal Pump
5. Variable Speed Centrifugal Pump
6. Reciprocating Pump
7. Plunger Pump
8. Gear Pump
9. Impact of Jets
10. Hydraulic Ram
11. Subsonic Wind Tunnel
12. Study of cut models of pumps and turbines

19-200-0501:NUMERICAL AND STATISTICAL METHODS

(Common to all branches)

Course Outcomes:
On completion of this course the student will be able to:
1. Solve algebraic and transcendental equations by numerical methods
2. Perform numerical differentiation and integration
3. Find the mean and variance of a probability distribution including the binomial distribution.
4. Use statistical tests in testing hypotheses on data

Module1
Numerical solution of algebraic and transcendental equation by - Regula-Falsi method, Newton Raphson's method. Gauss Seidal iteration method to solve a system of equations and convergence (without proof) Newton's forward and backward interpolation formula. Lagrange interpolation, Newton's divided difference and central differences.

Module II
Numerical differentiation at the tabulated points with forward, backward and central diffrences. Numerical integration with trapezoidal rule, Simpson's 1/3 rule, Simpson's 3/8 rule. Taylor series method. Euler method, Modified Euler method, Runge–Kutta method of second and fourth order for solving 1st order ordinary differential equation.

Module III
Random variable (discrete and continuous) Expectation-mean and variance of probability distribution. Binomial, Poisson and Normal distribution and Fitting of this Distribution to the given data. Curve fitting-fitting of straight line, parabola, exponential.

Module IV
Population and Sample-Sampling Distribution (of mean and variance) Testing of Hypothesis-level of significance, Z-test statistic, Chi square test for variance, for goodness of fit and F-test.

References:

1. Erwin Kreyzig, Advanced Engineering Mathematics, 10th Edition, John Wiley & Sons, (2010).
2. Grewal, B.S., Higher Engineering Mathematics, 43rd Edition, Khanna Publishers, (2013).
3. Kandaswamy, P., Thilagavathy, K., & Gunavathy, K., Numerical methods, S. Chand & Co., (2007).
4. Richard A. Johnson, Irwin Miller & Freund, J. E., Probabilty and statistics for Engineers, 8th Edition, Pearson, (2010).

19-205-0502:MECHANICS OF MACHINERY

Course Outcomes:

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

1. Understand the principles of kinematic pairs, chains and their classification, DOF, inversions, equivalent chains and planar mechanisms.
2. Analyze the planar mechanisms for position, velocity, and acceleration.
3. Synthesize planar four bar and slider crank mechanisms for specified kinematic conditions.
4. Evaluate gear tooth geometry and select appropriate gears for the required applications.
5. Design cams and followers for specified motion profiles.

Module I

Introduction : Machines and mechanisms, lower and higher pairs, kinematic chains, kinematic inversions of four bar, slider crank and double slider crank chains, equivalent linkages, Lower pairs - Pantograph, Paucellier mechanism, Thomson indicator mechanism, Watt mechanism, Geneva mechanism, Steering mechanism, Hooke's joint.

Kinematic analysis of plane mechanisms: General case of plane motion, Arnold Kennedy's theorem, velocity analysis using instantaneous center method, velocity and acceleration diagrams, Coriolis component of acceleration.

Module II

Spur gear: gear terminology, conjugate gears, involute arc of motion, generation of gear teeth profiles, interference, cycloidal and involute gear characteristics, law of gearing, length of path of contact, length of arc of contact, contact ratio, interchangeable gears, standard and non-standard tooth profiles, description of various types of gears like helical, bevel, worm.

Gear Trains: Analysis of simple, compound, reverted and epicyclic gears, solution of epicyclic gear train problems, gear train in differentials.

Module III

Cams: Classification of cams and followers, geometry of radial cams, displacement diagrams, follower motion, uniform velocity, simple harmonic, uniform acceleration and retardation, cycloidal, parabolic, graphical layout of cam profiles, displacement, velocity, acceleration and jerk relations, pressure angle, analysis of tangent cam, convex sided cams with roller follower and flat faced followers.

Friction: Laws of friction, Limiting angle of friction, Flat pivot bearing, Flat collar bearing, Conical pivot bearing, Efficiency of inclined plane, Screw friction, Screw Jack, Torque required to lift and lower the load by screw jack, Efficiency of a screw jack.

Module IV

Friction clutches – Single disc clutch, Multiple disc clutch, Cone clutch, Centrifugal clutch.

Dynamometer – Types of dynamometer, Prony brake dynamometer, Rope brake dynamometer, Belt transmission dynamometer, Torsion dynamometer

Introduction to synthesis: synthesis of slider crank mechanism, crank and rocker mechanism. Optimum transmission angle, synthesis of four bar links, three and four position synthesis. Overlay method, Coupler curve synthesis, Freudenstein's equations for Four bar and Slider crank mechanism.

References:

1. Rattan, Theory of Machines, 3rd Edition, Tata McGraw Hill, (2009).
2. Ghosh & Mallick, Theory of Machanisms and Mechines, Affiliated East- West Press, (1988).
3. Myszka, Machines & Mechanisms, 4th Edition, Pearson Education, (2012).
4. Thomas Bevan, Theory of Machines, Pearson Education, (1944).
5. Uicker, Pennock & Shigley, Theory of Machines and Mechanisms, 4th Ed., OxfordUniversity Press, (2010).
6. Ashok G. Ambekar, Mechanism & Machine Theory, PHI, (2007).
7. Norton, Kinematics & Dynamics of Machinery, McGraw Hill, (2008).

8. Waldron & Kinzel, Kinematics, Dynamics and Design of Machinery, Wiley, (2004).

19-205-0503: MACHINING SCIENCE & MACHINE TOOLS

Course Outcomes:

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

1. Study the geometry of single point & multipoint cutting tools and mechanics of chip formation.
2. Get the concept of the mechanics of metal cutting.
3. Understand the principle of working, specification, different types and different operations performed in lathe, drilling and shaping machines.
4. Learn the principle of working, specification, different types, and different operations performed in milling and grinding machines.

Module I

Mechanics of chip formation, orthogonal and oblique cutting, velocity relationship, Merchant's analysis of cutting forces, cutting power estimation, Tool nomenclatures, Cutting tool materials, inserts, Effect of cutting variables on forces, Tool failure analysis, Theories and measurement of tool wear, Thermal aspects of machining, Tool life and economics of machining.

Module II

Basic concepts of machine tools: Tool – work motions, machine tools for various processes, Kinematics of machine tools and gear boxes, feed and speed mechanism, machine tool drives, machine tool dynamics, Hydraulic control of machine tools (basics), Testing of machine tools for positioning accuracy and repeatability.

Module III

Engine lathes, specification, types, work holders, tool holders, taper turning, thread turning, Turret and capstan lathes, automatic lathes, Shaping, slotting and planning machines, Drilling machines, Twist drill geometry, Boring machines, Fine boring and Jig boring macines, machining time calculations.

Module IV

Milling machines, features of horizontal, vertical and universal machines, Milling cutter geometry, Types of cutters, indexing methods, Grinding machines, classification, abrasives, specification and selection of grinding wheels, Jigs and fixtures, basic principles of location and clamping, Types and mechanics of locating and clamping elements, Design of jigs and fixtures.

References:

1. Pandey, P. C., & Shan, H. S., Modern Machining Processes, Tata McGraw Hill, (1980).
2. Ghosh & Mallick, Manufacturing Science, Affiliated East- West Press, (1985).
3. Richard R. Kibbe, Roland O. Meyer, Machine tool practices, 9th Edition, Prentice Hall, (2009).
4. Rao, P. N., Manufacturing Technology, Volume: 2, Tata Mc Graw Hill, (1992).
5. Donaldson, Lecain, & Goold, Tool Design, Tata Mc Graw Hill, (1987).
6. Esposito, A., Fluid Power with applications, 7^{th} Ed., Pearson Education, (2008)

19-205-0504:THERMAL ENGINEERING

Course Outcomes:

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

1. Understand fuels, calorimetry, and basics of combustion of fuels
2, Determine the Air-Fuel ratio and analyse adiabatic flame temperature by applying thermodynamic laws to combustion.
3. Study the air standard cycles used in various thermal equipments, its thermodynamic analysis, actual working of Internal Combustion Engines and its performance analysis.
4. Understand various systems in Internal Combustion Engines components and alternate potential engines and their working.
5. Study the different phases of combustion in Internal Combustion (IC) engines and also to understand the occurrence of combustion related phenomenon in IC engines.

Module I

Fuels and combustion – Solid, liquid and gaseous fuels – calorific value – calorimeter – combustion equation – Air – Fuel ratio gravimetric & volumetric analysis – excess air Enthalpy and Internal Energy of Combustion – application of first law of thermodynamics to chemical reaction (combustion), adiabatic flame temperature – application of second law of thermodynamics to chemical reaction.

Module II

Air standard cycles, Otto, Diesel, Dual, Brayton, Stirling cycles. Actual cycles of four stroke and two stroke IC Engines, valve timing diagram – Engine testing – Performance and characteristics of constant speed and variable speed engines – heat balance test – Morse test – retardation test – effect of dissociation – variable specific heads and heat losses – scavenging – objectives – effects and methods – Efficiencies (thermal, mechanical and volumetric efficiencies)

Module III

Systems and components of IC Engines – fuel systems – Ignition systems – Cooling – starting – lubrication – governing of IC engines – super charging of SI and CI Engines – turbo charging – exhaust emissions of IC engines – alternate Potential Engines – free piston engines – Wankel Engine and Stratified charged engine automotive transmission system and its components.

Module IV

Combustion in IC engines – flame propagation normal and abnormal combustion detonation – Pre ignition – after burning – HUCR – fuel rating – additives in petrol – combustion chambers of SI engines – combustion in CI engines-– phase of normal combustion diesel knock – effect of engine variables on diesel knock – cetane number – additives in diesel – combustion chambers of CI engines.

References:

1. Cengel and Boles, Thermodynamics: An Engineering Approach, 7th Edition, McGraw Hill, (2010).
2. Maleev, V. L., Internal Combustion Engines, 2nd Edition, McGraw Hill, (1945).
3. Bacon, Engineering Thermodynamics, Butterworth & Co., (1989).
4. Rogowsky, Elements of Internal Combustion Engine, McGraw Hill, (1953).
5. Gill, Smith & Ziurys, Fundamentals of Internal Combustion Engines, Oxford, (1959).
6. Judge, Modern Petrol Engine, Chapman & Hall, (1955).
7. Eastop, T. D., Mcconkey A., Applied Thermodynamics for Engineering Technologists, Prentice Hall, (1996).

19-205-0505:POWER PLANT ENGINEERING

Course Outcomes:

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

1. Get a general understanding of the scale and scope of hydroelectric power stations and also grasp the basics of diesel engine and gas turbine power plants.
2. Comprehend the complexity of the steam power plant after getting to know about the working of its different components and elements.
3. Understand the basic principle of the working of nuclear power plant and the various types of nuclear reactors with its safety aspects, especially with respect to the current scenario of national and international debates on the same.
4. Equip with the knowledge of the basics of various non-conventional energy producing methods.

Module I

Power plant economics – base load and peak load power plants -estimation of load – load curve – load factor – diversity factor – capacity factor – use factor – selection of units – number and size – scheduling operation – cost of energy – depreciation and replacement – economics of plant selection. Hydroelectric power plants – general layout – types of dams – penstock, draft tubes, surge tanks - power house equipments – site selection

Module II

Diesel engine power plant – Layout – Components of a diesel power plant – starting methods – Gas turbine – open and closed cycles – thermodynamics cycles – regeneration – reheating – intercooling – efficiency and performance of gas turbines. combustion chambers of gas turbines – cylindrical – annular and industrial type combustion chamber design– combustion efficiency – advantages and disadvantages Gas Turbine power plants – classification – elements of a Gas Turbine power plant

Module III

Steam power plants - General layout – fuel handling systems – types of furnaces – stokers – burning systems – types of firing : stokers, pulverized coal burners and fluidized bed combustion - power plant boilers, mountings and accessories - dust and ash handling systems – draft and chimney calculations – condensers – cooling systems - Environmental aspects of thermal power systems Nuclear power plants - Fundamentals of nuclear fission – nuclear power plants – reactors – classification – components layout of simple plant – nuclear power safety and waste disposal.

Module IV

Non conventional energy sources – solar radiation and its measurement – Solar energy collectors – Applications of solar energy - Wind energy conversion – site selection – wind energy collectors – Energy from biomass - ocean energy possibilities and future scope – Ocean Thermal electric conversion (OTEC) – Tidal energy - geothermal energy- Magneto Hydro Dynamic (MHD) power – Fuel cells - thermo electric power - thermionic generation.

References:

1. Wakil, E. I., Power Plant Technology, McGraw Hill, (1985).
2. Nag, P. K., Power Plant Engineering, 3rd Edition, Tata McGraw Hill, (2007).
3. Morse, Power Plant Engineering, Van Nostrand Co., (1953).
4. Lee J. F., Power Station Engineering and Economy, Tata McGraw Hill, (1960).
5. Robert L. Loftness, Nuclear Power Plants, Van Nostrand, (1964).
6. Verma Mahesh, Power Plant Engineering, Metropolitan Book Co., (1976).
7. Rai G. D., Non Conventional Energy Sources, Khanna Publishers, (2004).
8. Cohen & Rogers, Gas Turbine Theory, 6th Edition, Prentice Hall, (2008).

19-205-0506(IE) :INDUSTRIAL MANAGEMENT

Course Outcomes:

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

1. Understand the concept of management, organization, personnel management and apply these concepts in an industrial environment.
2. Get the concept of industrial relations and use it in real life.
3. Understand the concept of financial management, project management and economics to use in an industrial situation.
4. Study the concept of marketing management and basics of IPR.

Module I

Management (basic concepts): Definition, characteristics, nature and purpose; System approach to the management process; Levels of management, Managerial skills, Functions of Managers-ethics and social responsibility; Scientific management – contributions of Gilbreth and Gantt; Organization – definition, elements, process of organization, principles of organization, formal and informal organization, organization structure; Forms of business organization - concepts, types of ownership.

Module II

Human resource management – Definition, Objectives, Characteristics and Functions of HRM; Organization of HRM, Recruitment and Selection, Selection process, Techniques and Instruments; Training - need assessment, Levels and methods; Job evaluation and Merit rating, Performance appraisal-methods, Labour turnover-reasons, Exit interview, Workers participation in management, Wages and Incentives; Industrial safety, Accidents – causes and effects on industrial performance, Industrial pollution, Waste control and disposal.

Module III

Financial management: Basic functions, capital – classifications, sources of funds; Financial accounting– Double entry system, debit and credit concepts, journals, ledgers, trial balance, preparation of trading account, profit and loss account, balance sheet (simple numerical). Financial ratios, budgets and budgetary controls, overheads, standard costing, marginal costing;

Project Management-Project characteristics and project identification, Sources of project ideas, Project feasibility -methods.

Economics: principles, problem of scarcity, demand, supply, utility, time value of money, inflation and deflation, consumer – demand curve;

Module IV

Marketing management: Functions and objectives, 4P's of marketing, E-marketing and Traditional marketing, Green marketing and Services Marketing, Marketing environment and information, Branding strategy, Market segmentation, Distribution channel management, Consumer and industrial markets, Consumer behaviour, Product pricing methods, Sales promotion and Advertisement, Marketing research – objectives and methods.

IPR – general introduction, Patent, Trademark, Copyright, Eligibility for patent, Procedure for filing patent application, Rights of patent owner and duration, Ownership of patent and commercialization.

References:

1. Bethel L. L., & Atwater, F. S., Industrial Organisation and Management, 5th Edn., McGraw Hill, (1971).
2. Koontz &Donnel, Principles of Industrial Management, (1959).
3. Prasanna Chandra, Financial Management, 8th Edition, TMH, (2011).
4. Pandey, I. M., Financial Management, 11th Edition, Vikas Publishing House, (2015).
5. Reddin& Ryan, Hand Book of MBO, Tata McGraw Hill, (1988).
6. Fabrycky W. J., Operation Management, Tata McGraw Hill, (1987).
7. Goyal V.K and Ruchi Goyal, Financial Accounting, 4th Edn.,PHI, (2012)
8. Batliboi J. R., Advanced Accounting, Standard Accountancy Publications, 24th Edition, (1969)

19-205-0507:COMPUTATIONAL METHODS FOR ENGINEERS

Course Outcomes:

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

1. Apply computational methods in Engineering and Technology using CAS (Computer Algebra Systems)
2. Understand errors and their propagation and the measures to control errors in the application of computational methods
3. Apply numerical methods to solve linear algebra problems
4. Apply numerical methods for interpolation, differentiation, integration, and integral transforms
5. Understand ordinary and partial differential equations and apply finite difference (FDM) method to solve them
6. Understand calculus of variations and Finite Element Method (FEM). Apply FEM to solve Ordinary Differential Equations (ODE)

Module I

Approximations: Accuracy and precision, definitions of round off and truncation errors, error propagation.

Introduction to CAS programs like Matlab/Mathematica/Maple/Python and their application to solve numerical examples of the topics covered.

Algebraic equations: Formulation and solution of linear algebraic equations, Gauss elimination, LU decomposition, iteration methods (Gauss – Siedel), convergence criteria, Eigen values and Eigen vectors.

Module II

Interpolation methods: Newton's divided difference, interpolation polynomials, Lagrange interpolation polynomials. Numerical Differentiation: High accuracy differentiation formulae, extrapolation, derivatives of unequally spaced data. Numerical Integration: Trapezoidal, Simpson's 1/3 rule – Romberg's method – Two point and three point Gaussian quadrature formulae – Evaluation of double integrals by Trapezoidal and Simpson's 1/3 rules.

Module III

Differential equations: Initial and boundary value problems. Numerical solutions differential equations: Formation of difference equations, types of difference equations and their solutions. Laplace and Poisson's equations. Iterative methods for solutions of parabolic, elliptic and hyperbolic types of Partial Differential Equations.

Module IV

Finite Element theory: Introduction to finite element theory, generalization of finite element concept. Finite element modelling, weighted residual and potential energy approaches, Shape functions, natural co-ordinates system, element and global stiffness matrices, sssembly of global stiffness matrix and load vector. Solution of 1D problems.

References

1. Steven C Chapra, Applied Numerical Method with Matlab for Engineers and Scientists, McGraw-Hill, (2017).
2. Schilling R.J and Harris S. L, Applied Numerical Methods for Engineering using Matlab and C, Brooks/Cole Publishing Co., (2003).
3. S. S. Sastry, Introduction to Numerical Methods, Prentice-Hall, (1999).
4. Fon Sneddon, Introduction to Integral Transforms, McGraw Hill, (2016).
5. R. Forsythe, Calculus of Variation, CambridgeUniversity Press, (1927).
6. David V Hutton, Fundamentals of Finite Element Analysis, McGraw- Hill, (2003).
7. Gerald and Wheatley, Applied Numerical Analysis, Pearson Education, (1998).

19-205-0508:SMART MATERIALS

Course Outcomes:

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

1. Understand characteristics of smart materials.
2. Appreciate the use of smart materials in the field of sensors and actuators.
3. Analyse smart composite laminates using stress strain relationship.
4. Analyse the dynamics of smart laminated composites structure.

Module I

Introduction to Smart Materials: Principles of Piezoelectricty, PerovskytePiezoceramic Materials, Single Crystals vs Polycrystalline Systems, Piezoelectric Polymers, Principles of Magnetostriction, Rare earth Magnetostrictive materials, Giant Magnetostriction and Magneto-resistance Effect, Introduction to Electro-active Materials, Electronic Materials, Electro-active Polymers, Ionic Polymer Matrix Composite (IPMC), Shape Memory Effect, Shape Memory Alloys, Shape Memory Polymers, Electro-rheological Fluids, Magneto Rhelological Fluids

Module II

High-band width, low strain smart sensors: Piezeoelctric Strain Sensors, In-plane and Out-of Plane Sensing, Shear Sensing, Accelerometers, Effect of Electrode Pattern, Active Fibre Sensing, Magnetostrictive Sensing, Villari Effect, Matteuci Effect and Nagoka-Honda Effect, Magnetic Delay Line Sensing, Application of Smart Sensors for Structural Health Monitoring (SHM), System Identification using Smart Sensors

Module III

Smart actuators: Modelling Piezoelectric Actuators, Amplified Piezo Actuation – Internal and External Amplifications, Magnetostrictive Actuation, Joule Effect, Wiedemann Effect, Magnetovolume Effect, Magnetostrictive Mini Actuators, IPMC and Polymeric Actuators, Shape Memory Actuators, Active Vibration Control, Active Shape Control, Passive Vibration Control, Hybrid Vibration Control

Module IV

Smart composites: Review of Composite Materials, Micro and Macro-mechanics, Modelling Laminated Composites based on Classical Laminated Plate Theory, Effect of Shear Deformation, Dynamics of Smart Composite Beam, Governing Equation of Motion,

Self-Sensing Piezoelectric Transducers, Energy Harvesting Materials, Autophagous Materials, Self Healing Polymers, Intelligent System Design, Emergent System Design.

References:

(1) Brian Culshaw, Smart Structures and Materials, Artech House, 2000
(2) Gauenzi, P., Smart Structures, Wiley, 2009
(3) Cady, W. G., Piezoelectricity, Dover Publication

19-205-0509: PRINCIPLES OF TURBOMACHINERY

Course Outcomes:

1. To understand the types of turbo machines
2. To study the working principle of various turbo machines.
3. To enhance the theoretical knowledge
4. To design energy efficient turbo machines.

MODULE: 1

Introduction to turbo-machines, definition and classification, principles of operation, fundamental laws, Euler work, enthalpy and relative velocity, efficiency of turbines and compressors, polytrophic efficiency, flow unsteadiness.

MODULE: 2

Two dimensional cascades: cascade nomenclature, lift and drag, circulation and lift, losses and efficiency, compressor and turbine cascade performance, nominal deflection, fluiddeviation

MODULE: 3

Axial flow turbines: velocity diagram, multistage turbines, stage losses and efficiency, stage reaction, diffusion within blade rows, efficiencies and characteristics, turbine blade cooling.

MODULE: 4

Axial flow compressors: velocity diagram, stage loss and efficiency, mean line calculation, off-design performance, multistage compressor performance, stall and surge phenomena.

Three-dimensional flows in axial turbines: theory of radial equilibrium, indirect and direct problems, compressible flow through a fixed blade row, constant specific mass flow, free vortex turbine stage.

Radial flow turbines: types of inward flow radial turbines, thermodynamics, design point efficiency, Mach number relations, loss coefficient, optimum efficiency, specific speed, clearance andwindage
losses.

References:

1.S. L. Dixon, Cesare A. Hall, Fluid Mechanics and Thermodynamics of Turbo machinery, Butterworth Heinemann, 7th Ed., 2013.

2 H. I. H. Saravanamuttoo, G F C Rogers, H Cohen, P.V Straznicky, Gas Turbine Theory, Pearson Prentice Hall, 6th Ed.,2009.

3V. Ganesan, Gas Turbines, Tata McGraw Hill, 3rd Ed.,2010.

4P. Hill, C. Peterson, Mechanics and Thermodynamics of Propulsion, Pearson, 2nd Ed.,2010.

5S. M. Yahya: Turbines, Compressors and Fans, Tata McGraw-Hill, 4th Ed.,2011.

6V. Kadambi and Manohar Prasad, Turbomachinery, New Academic Science, 3rd Ed.,2012.

7. G. F Wislicenus, Fluid Mechanics of Turbomachinery, Dover Publications

19-205-0510: COMPUTATIONAL METHODS LAB

Course Outcomes:

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

1. Identify the required computational method
2. Write different programs using the theoretical knowledge
3. Obtain the results by running the program
4. Interpret the results.

Review of fundamentals of C programming, Pointers-pointer declaration-pointers and one dimensional arrays-pointers and functions, Data files- opening and closing a data file-creating a data file- processing a data file. C-graphics- drawing lines, rectangles, circles and ellipse

Numerical Techniques: Preparation of computer programs for solution of polynomial and transcendental equations: bisection method, regula falsi method, successive iteration- Newton Raphson method. Solution of system linear algebraic equations : Gauss elimination- matrix inversion, Gauss Jordan method, Gauss-Seidel method.

Numerical integration : trapezoidal rule- Simpson's 1/3 rule- Gauss quadrature formulae

Numerical solution of ordinary differential equations : Taylor series method- Runge- kutta method

Numerical solution of boundary value problems.

References:

1. Chapra and Canale, Numerical methods for engineers, 6th Edition, McGraw Hill, (2012).
2. Froberg, Introduction to numerical analysis, 2nd Edition, Addison- Wesley, (1969).
3. Kandaswamy, Numerical Methods, S Chand & Co., (2006).
4. Hildebrand, Introduction to Numerical Analysis, Tata McGraw Hill, (1982).

19-205-0511:MACHINE SHOP

Course Outcomes:

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

1. Design the required experiments.
2. Prepare the required specimen to perform the experiments.
3. Perform different machining operations using the theoretical knowledge.
4. Measure the dimensions.

Introduction to Machine Tools : Types of Machine tools, Spindle drive – work holding devices tool holders – tool movement – selection of speeds. Feed and depth of cut – use of cutting coolants – principle of thread cutting – V-thread and Square thread – thread standards – cutting tool types – grinding of tools – selection of cutting speeds.

Practical : Exercises on Lathe: cylindrical turning, Taper Turning, Facing, Shoulder turning and curve turning – thread cutting, internal thread

Exercises on Milling Machine: Face milling, End Milling, Gear cutting Exercises on Drilling and Boring Machines

Exercises on Shaping and Slotting Machines Exercises on Grinding Machines

References:

1. HMT, Production technology, Tata Mc Graw Hill, (2001).
2. Wilson F. W., ASTME, Tool Engineer's hand book, Mc Graw Hill, (1959).
3. Boguslavsky, B. L., Automatic and semi- automatic lathes, Peace publications, (1963).
4. ASTME, Fundamentals of tool design, Prentice Hall, (1987).

19-205-0601:DYNAMICS OF MACHINERY

Course Outcomes:
On completion of the course the student would be able to:
1. Recall the concepts of free body diagrams, principles of statics and dynamics
2. Use graphical and analytic methods to do force analysis of planar mechanisms.
3. Apply these concepts in different machine elements for the evaluation of forces and moments
4. Analyze the dynamics of different mechanisms and machine elements and determine the various forces and torques

Module I
Force analysis of plane motion mechanism: Static force analysis, analysis of four bar chain, slider crank mechanism, static force analysis with friction. Dynamic force analysis: D'Alembert's principle, inertia forces, dynamic force analysis of four bar and slider crank mechanism, Shaking forces, gear force analysis of spur, helical and bevel gears, Dynamics of reciprocating engines, equivalent masses, inertia force in single engine, bearing loads in single cylinder engine.

Module II
Flywheels: Inertia torque-turning moment diagrams for multi-cylinder engines, steam engines, coefficient of fluctuation of speed and energy, flywheel mass calculation.
Gyroscopes: motion of a rigid body in 3 dimension, Gyrodynamics, gyroscope and gyroscopic couple, Gyroscopiceffects on ships, aircrafts and automobiles.
Brakes – Types of brakes, Block brake, Band brake, Band and Block brake, Internal expanding brake, Condition of self locking, Power transmitted and Heat generated.

Module III
Balancing: Static and dynamic balancing, balancing of several masses in a plane, balancing of rotating masses inseveral planes, balancing of several masses in several planes. Condition of complete balancing of an engine, reciprocating and rotating parts, Multi-cylinder inline engines, Radial and V-engines, Balancing machines and principles of working.

Module IV
Belt, Rope and Chain drives: Types of belt drives, Velocity ratio, Slip, Creep, Length of belt, Power transmitted,Ratio of tensions, Angle of contact, Centrifugal tension, Maximum tension, Initial tension, V belt drive, Ratio of Tensions in V belt and Rope drives, Kinematics of chain drive, Classifications of chains, Chain length.
Governors – Watt governor, Porter governor, Proell governor, Hartnell governor, Sensitiveness, Hunting,Isochronism, Effort of governor, Controlling force.

References:

1. Rattan, S. S., Theory of Machines, Tata McGraw Hill, (2009).
2. Ghosh & Mallick, Theory of Machines and Mechanisms, Prentice Hall India, (2004).
3. David H. Myszka, Machines & Mechanisms: Applied Kinematic Analysis, 4th Ed., Pearson Education, (2012).
4. Thomas Bevan, Theory of Machines, 3rd Edition, Pearson Education, (2009).
5. Sharma & Purohit, Theory of Mechanism & Machines, PHI, (2006).
6. Uicker, Pennock, & Shigley, Theory of Machines and Mechanics, OxfordUniversity Press, (2006).
7. Ashok G. Ambekar, Mechanism & Machine Theory, PHI Learning, (2009).
8. Norton, Kinematics and Dynamics of Machinery, McGraw Hill, (2009).

19-205-0602:MACHINE DESIGN - I

Course Outcomes:

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

1. Understand the customers' need, formulate the problem and draw the design specifications.
2. Understand component behavior subjected to loads and identify the failure criteria.
3. Apply the concepts of stress analysis, theories of failure and material science to analyze, design and/or select commonly used machine components.
4. Analyze the stresses and strains induced in a machine element.
5. Design a machine components using theories of failure.

Module I

Introduction to design: Steps in design process, design factors, practical considerations in design, selection ofmaterials, strength of mechanical elements, theories of failure, impact load, shock load, fatigue loading, effects of surface, size, temperature and stress concentration, consideration of creep and thermal stress in design.

Module II

Detachable joints: design of screws, standards, thread stresses, preloading of bolts, fatigue and shock load,eccentric loading. Power screws, mechanism of power screws, thread stresses, efficiency of power screws, types of keys, stresses in keys, design of socket and spigot joint, Gib and cotter, knuckle joints, design of rigid couplings and flexible couplings.

Module III

Riveted joint: Stresses in riveted joint, design of riveted joints with central and eccentric loads, boiler and tankjoints, structural joints.

Springs: stresses in helical springs, deflection of helical compression and tension springs, springs subjected tofatigue loading, concentric and helical torsion spring, critical frequency of springs, leaf springs, design of automotive leaf springs.

Module IV

Welded joints: types of welded joints, stresses, design of welded joints subjected to axial, torsional and bending loads, welds subjected to fluctuating loads.

Power shafts: stresses in shafts, design of static loads, combined stresses, reversed bending and steady loads, design of shafts based on deflection and strength, critical speed of shafts.

Data Book

1. Mahadevan K. and Balaveera Reddy, Design data hand book, 4th Edn., CBS Publishers, (2013).
2. P.S.G. TECH, Design Data Hand Book, DPV Printers, (1993).
3. Linghaigh K., & Narayana Iyengar, B. R., Design Data Book, Vol. I & II, McGraw Hill, (1994).

References:

1. Joseph Edward Shigley, Mechanical engineering design, Tata Mc Graw Hill, (2004).
2. Bhandari, Design of machine elements, 3rd edition, Tata Mc Graw Hill, (2010).
3. Spotts, M. F., Design of machine elements, eighth edition, Prentice Hall, (2003).
4. Sadhu Singh, Mechanical Machine Design-I , S.K.Kataria & Sons, (2011).
5. Pandya & Shah, Machine Design, 17th edition, Charotar Publishing House Pvt. Limited, (2009).
6. Jain, R. K ., Machine Design, Khanna Publishers, (1978).
7. Robert C., Juvinall, Kurt M. Marshek, Machine component design, 5th Ed., Wiley India, (2013).
8. Sharma & Purehit, Design of machine elements, PHI, (2002).

19-205-0603:OPERATIONS MANAGEMENT

Course Outcomes:

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

1. Understand different network techniques and forecasting methods
2. Learn production planning and control as well as inventory control techniques.
3. Study the concepts of aggregate planning and scheduling
4. Get the basic knowledge of plant location and lay out and material handling

Module I

Operations Management-Charecteristics and functions, Production process- nature and importance of production function, relationship with other business activities; Network techniques - Basic concept of network construction, critical path, slack and float, CPM-crashing, PERT- multi-time estimate;

Forecasting - Importanace in operations management, methods of forecasting - time series, moving average, exponential smoothening.

Module II

Production planning and control: Scopes, objectives and functions of production planning and control; Product Design- Process and Functions, guiding principles, consumption cycle, product life cycle, factors affecting product design, simplification, standardization, specialisation, inter-changeability; Inventory control: Structure of inventory problems, relevant costs, basic EOQ models, stores ledger, materials requisition sheet, materials return note, material transfer note, bin cards, just in time and lean management.

Module III

Aggregate Planning: Role and need of aggregate planning, graphical and reaction rate methods of aggregate planning; Scheduling - Definition and scheduling decisions, Gantt charts, indexing methods, critical ratio method of loading & scheduling; Sequencing : Basic concepts and importance of sequencing, one machine n jobs, 2 machine n jobs, m machines - n jobs problems.

Module IV

Plant Location: Factors influencing location,significance of sites in urban,semi-urban and rural areas. Plant Layout: Types, need for layout, layout design process- factors, determination of equipment and employee requirement, production rate determination, space determination, block plan, systematic layout planning.

Material handling: The principles of materials handling, classification of equipments and its selection factors.

Maintenance & replacement: Different types of maintenance,merits and demerits, operational and economic aspects. Replacement of equipments, methods, concept of depreciation.

References:

1. James L. Riggs, Economic decision models for engineers and managers, 4th Ed., McGraw Hill, (1996).
2. Wiest & Levy, A management guide to PERT and CPM, 2nd edition, Prentice Hall, (1977).
3. Starr & Miller, Inventory control: Theory & Practice, Prentice HallIndia, (1962).
4. Sammuel Eilon, Production planning and control, Universal book corporation, Bombay, (1991).
5. Francis & White, Facility layout and location, 2nd edition, Prentice hall Inc., (1992).
6. Miller & Blood, Modern maintenance management, American Management Association, (1963).

19-205-0604:HEAT AND MASS TRANSFER

Course Outcomes:

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

1. Understand the basic modes of heat transfer
2. Get an insight on conduction, convection and radiation heat transfers
3. Apply the knowledge of heat transfer through various geometries for optimizing the thickness of insulation.
4. Understand the unsteady heat conduction and its applications.
5. Get a concept on multiphase flow, diffusion and convective mass trnasfer
6. Attain information of parallel and counterflow heat exchangers and their design aspects

Module I

Introduction to heat transfer – basic modes of heat transfer – conduction heat transfer –Fourier law of heat conduction– temperature dependence of thermal conductivity- general heat conduction equation in cartesian, cylindrical and spherical coordinates – boundary conditions – one-dimensional steady state conduction- critical insulation thickness -one-dimensional steady state conduction with heat generation - extended surface – two dimensional steady state heat conduction – conduction shape factor – unsteady state heat conduction in one dimension – lumped heat capacity system – semi-infinite solids with sudden change in surface temperature – Introduction to numerical methods in conduction.

Module II

Convective heat transfer – Newton's law of cooling – Prandtl number – laminar forced convection heat transfer from flat plates – fully developed laminar flow in pipes – turbulent forced convection – Reynolds' analogy – natural convection – natural convection heat transfer from vertical plates and horizontal tubes – condensation and boiling – film and drop wise condensation – film boiling and pool boiling – introduction to multiphase flow and heat transfer. Diffusion and convective mass transfer-Ficks law of diffusion.

Module III

Radiative transfer – electromagnetic radiation spectrum – thermal radiation –radiation properties- black body, gray body – monochromatic and total emissive power – Planck's law – Stefan-Boltzman law – Wien's displacement law – Kirchhoffs identity – shape factor- reciprocity relation – heat exchange between non black bodies; surface and shape resistances- electrical network analogy- heat transfer between parallel surafces – radiation shields.

Module IV

Heat Exchangers: Type of heat exchangers- overall heat transfer coefficient -fouling factors -Logarithmic mean temperature difference (LMTD)- derivation of LMTD for parallel flow and counter flow heat exchangers-LMTD correction factor- effectiveness, NTU method of heat exchanger analysis- effectiveness derivation for parallel flow and counter flow heat exchangers. Design of parallel flow-counterflow-shell and tube multipass heat exchangers-condensers.

References:

1. Cengel, Heat Transfer, 3rd edition, Tata Mc Graw Hill, (2007).
2. Holman J. P., Heat Transfer, 10th edition, McGraw Hill International Students Edition, (2009).
3. Incorpera F. P. & De Witt, D. P., Fundamentals of Heat and Mass Transfer, 7th Ed., Wiley, (2011).
4. Kreith F., Heat Transfer, International Text Book Company, (1958).
5. Gebhart B., Heat Transfer, 2nd edition, McGraw Hill, (1971).
6. Rajput, R. K., Heat and Mass Transfer, S Chand, (2007).
7. Venkanna, Fundamentals of HMT, Prentice Hall, (2011).

Data Book:

1. C. P. Kothandaraman, Heat & Mass Transfer Data Book, 8th edition, New Age International, (2014).
2. Domkundwar, Heat & Mass Transfer Data Book, 3rd edition, Dhanpat Rai, (2006).

Approved data book is to be specified in the question paper.

19-205-0605:CAD/CAM

Course Outcomes:

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

1. Understand the basics of modelling and automation
2. Study the basics of computer numerical control
3. Study the design features of CNC machines
4. Understand the basic concepts of robotics

Module I

Fundamentals of CAD: Role of computers in design, Transformation of Geometry, 3D Transformations, Mathematics of Projection, geometric modelling- wireframe and solid, modelling, engineering analysis-FEM, design review and evaluation, , design data base, softwares used in CAD, data exchange between CAD and CAM. Fundamentals of CAM: Definition of automation, levels of automation, high volume discrete parts production, Detroit type of automation, transfer machines, analysis of automated flow lines, assembly machines, flow line balancing, line balancing.

Module II

Computer Numerical Control: basic theory of numerical control, advantages of NC, open and closed loop system, information flow and control theory, classification of CNC machine tools, position control and continuous path control,resolution, accuracy and repeatability, numerical problems based on Basic Length Unit (BLU), principles of displacement measurement, digital linear and rotary displacement transducer, analog displacement measuring system. CNC part programming: Manual programming, work piece modelling and computer aided part programming, G and M function, canned cycles, CAPP languages, structure and use of major CAPP languages, programming in APT. Design features of CNC machines: Special design features to match machine tools to numerical control system CNC tooling: ATC, APC, features of CNC systems for lathes and machining centre. Testing of NC machine tools, static and dynamic errors.

Module III

Basic concepts of Robotics: Introduction, basic structure of Robots, resolution, accuracy, and repeatability. Classification and structure of Robotic systems: PTP and CP systems, control loops of robotic systems, types of robots Drives and Control systems: hydraulic systems, DC servo motors, control approaches of Robots. Applications of Robots: handling, loading and unloading, welding, spray painting, assembly, machining. Programming: manual teaching, lead – through teaching, programming languages, Sensors and Intelligent Robots: introduction to Robotic sensors, vision systems, range detectors, force and torque sensors

Module IV

Advanced concepts in automation: Evolution of manufacturing Systems, direct numerical control, CAE, CIM, FMS, – basic concepts of AI and expert systems for manufacturing automation,

Introduction to Rapid Prototyping, Need of RP, Basic principles of RP, Process chain in RP in Integrated CAD/CAM environment, Classification of RP technologies, Brief introduction to different process technologies in RP, Advantages of RP.

References:

1. Groover & Zimmers, CAD/CAM, 5th edition, PHI, (2008).
2. Radhakrishnan, P., Subramanyam, S., CAD/CAM/CIM, New Age International
3. Mikell P. Groover, Automation, Production Systems and Computer Aided Manufacturing, Prentice Hall, (2008).
4. Kundra T. K., Rao P. N. and Tiwari N. K., CNC Machine Tools and Computer aided Manufacturing, Tata McGraw- Hill Education, (1988).
5. Zeid, CAD/CAM theory & Practice, Tata McGraw-Hill Education, (2009).
6. Jha, B. K., CNC Programming made easy, Vikas Publishing House, (2003).
7. James G Keramas, Robot Technology Fundamental, Vikas Thomson Learning, (1998).
8. Rapid prototyping-Priciples and Applications, Chua C.K etal.,World Scientific Publishing (2010).

19-205-0606(IE):ADDITIVE MANUFACTURING

T **Course Outcomes:**

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

1. Understand the concept of AM
2. Study various AM technologiesthe basics of computer numerical control
3. Study the modeling of AM processes
4. Study the application of various feilds

Module 1

Introduction to Additive Manufacturing (AM)

General overview Introduction to reverse engineering, Traditional manufacturing vis AM, Computer aided design (CAD) and manufacturing (CAM) and AM, Different AM processes and relevant process physics AM process chain Application level: Direct processes – Rapid Prototyping, Rapid Tooling. Rapid Manufacturing; Indirect Processes - Indirect Prototyping. Indirect Tooling, Indirect Manufacturing

Module 2

Materials science for AM

Discussion on different materials used. Use of multiple materials, multifunctional and graded materials in AM. Role of solidification rate Evolution of non-equilibrium structure, Structure property relationship Grain structure and microstructure,

Module 3

AM technologies, Powder-based AM processes involving sintering and melting (selective laser sintering, shaping, electron beam melting. involvement). Printing processes (droplet based 3D Solid-based AM processes - extrusion based fused deposition modeling object Stereolithography Micro- and nano-additive. Process Selection, planning, control for AM

selection of AM technologies using decision methods, Additive manufacturing process plan, strategies and post processing. Monitoring and control of defects, transformation

Module 4

Mathematical models for AM

Transport phenomena models: models for temperature, fluid flow and composition, buoyancy driven tension driven free surface flow pool Case studies: Numerical Modeling of AM process, Powder bed melting based process, Droplet based printing process, Residual stress, part fabrication time, cost, optimal orientation and optimal Defect in AM and role of transport Simulations (choice of parameter, Model validation)

References:

I. Ian Gibson, David W. Rosen, Brent Stucker, Additive manufacturing technologies: rapid prototyping to direct digital manufacturing Springer, (2010)

2. Andreas Gebhardt, Understanding additive manufacturing: rapid prototyping, rapid tooling, rapid manufacturing, Hanser Publishers, (2011)

3. J.D. Majumdar and I. Manna, Laser-assisted fabrication of materials, Springer Series in Material Science, e-ISBN: 978-3-642- 28359-8.

4. L. Lu, J. Fuh and Y.-S. Wong, Laser-induced materials and processes for rapid prototyping, Kluwer Academic Press,(200I).

5. Zhiqiang Fan and Frank Liou, Numerical modeling of the additive manufacturing (AM) processes of titanium alloy, lnTech, (2012)

6. C.K. Chua, K.F. Leong and C.S. Lim, Rapid prototyping: principles and applications, 3rd Edition, World Scientific, (2010)

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19-205-0607:ENERGY CONSERVATION & ENVIRONMENT PROTECTION

Course Outcomes:

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

1. Understand the overview of World Energy Scenario and energy economics
2. Study the Importance of energy management and energy auditing
3. Learn about the renewable energy sources
4. Understand the Environmental Impacts of energy use

Module I

Overview of World Energy Scenario. Fossil Fuel Reserves - Estimates, Country Energy Balance Construction - Examples Trends in energy use patterns, Energy Economics - Simple Payback Period, IRR, NPV, Life Cycle Costing.

Module II

Importance of energy management. Energy auditing: methodology, analysis of past trends plant data), Steam Systems: Boiler -efficiency testing, excess air control, Steam distribution & use - steam traps , condensate recovery , flash steam utilisation. Thermal Insulation. Energy conservation in Pumps, Fans (flow control), Compressed Air Systems, Refrigeration & air conditioning systems. Waste heat recovery.

Module III

Cogeneration - concept, options (steam/gas turbines/diesel engine based), selection criteria. Heat exchanger networking- concept of pinch, target setting, composite curves. Renewable energy sources- overview of solar, wind, tidal, geothermal , nuclear energy sources.

Module IV

Environmental Impacts of energy use - Air Pollution - SOx, NOx, CO, particulates Solid and Water Pollution, Formation of pollutants, sources of emissions. Exhaust emission test, procedures, standards and legislation; environmental audits; Emission factors and Global Warming, CO2 Emissions, Impacts. Water pollution

References:

1. Nebojsa Nakicenovic, Arnulf Grubler and Alan McDonald, Global energy perspectives, Cambridge University Press, (1998).
2. Fowler, J. M., Energy and the environment,. 2nd Ed., McGraw Hill, New York, (1984).
3. Witte, L. C., Schmidt P. S. and Brown, D. R., Industrial Energy Management and Utilisation, Hemisphere Publ, Washington, (1988).
4. Industrial Energy Conservation Manuals, MIT Press, Mass, (1982).
5. Stoecker, W.F., Design of Thermal Systems McGraw-Hill , (1989)
6. Sukhatme, S. P., Nayak, J. K., SolarEnergy: Principles of Thermal Collection and Storage,Third Edition, Tata Mc Graw Hill, (2008).
7. Arcadio P. Sincero & Gregoria A. Sincero, Environmental Engineering: A Design Approach, Prentice Hall, (1995).
8. Shenoy, U. V., Heat Exchanger Network Synthesis: Process Optimization by Energy and Resource Analysis, Gulf Publishing Company, Houston, (1995).

19-205-0608:ADVANCED MECHANICS OF SOLIDS

Course Outcomes:
On completion of this course the student will be able to:
1. Transform a stress/strain tensor in a given direction and evaluate the principal stresses and strains.
2. Formulate the differential equations of equilbrium, boundary conditions and compatibilty conditions in cartesian and polar co-ordinates.
3. Apply these pinciples to 2D, 2D axi-symmetric, and 3D problems and evaluate stresses and strains.
4. Analyse problems of bending of un-symmetrical sections and torsion of non-circular sections.

Module I
2D problems in Cartesian co-ordinates - Stress & strain at a point, components of stress & strain, Hooks law plane stress & plane strain, measurement of surface strains, construction of Mohr circle for stress & strain , strain rosettes, differential equations of equilibrium, boundary conditions, compatibility equations, stress function. Solution by polynomials, St.Venant's principle, bending of a cantilever loaded at the end.

Module II
2D problems in polar co-ordinates - General equations in polar co-ordinates. Stress distribution symmetrical about an axis pure bending of curved bars. Strain components in polar coordinates, displacement for symmetrical stress distribution, rotating disks, thick cylinders, pure bending of curved bars.

Module III
Analysis of stress & strain in 3D - Principal stresses, stress ellipsoid, stress invariants, maximum shearing stress, homogenous deformation. Strain at a point, rotation, differential equations of equilibrium, compatibility. Equations of equilibrium in terms of displacements Stretching of a prismatic bar by its own weight
Energy methods: principle of virtual work, reciprocal theorems, strain energy methods, Castigliano's theorems.

Module IV
Unsymmetric bending, shear flow, shear centre.
Torsion of noncircular straight bars, elliptic cross sections. Membrane analogy, Torsion of thin tubes, open and closed sections.

References :

1. Timoshenko & Goedier, Theory of Elasticity, 3rd Edition, McGraw Hill, (1970).
2. Solecki & Conant, Advanced Mechanics of Materials, OxfordUniversity Press, (2003).
3. Srinath, L.S., Advanced Mechanics of Solids, Tata McGraw Hill, (2009).
4. Kazimi, S. M. A., Solid Mechanics, Tata McGraw Hill, (2001).
5. Boresi & Schmidt, Advanced mechanics of materials, 6th Edition, Wiley, (2002).
6. Bhaskar K. & Varadan, T. K., Theory of Isotropic/Orthotropic elasticity: An introductory primer, Ane Books, (2009).

19-205-0609:FUNDAMENTALS OF COMBUSTION AND POLLUTION

Course Outcomes:

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

1. Study the thermodynamics of combustion and formation of conservation equations.
2. Understand the reaction kinetics and laws of transport phenomenon.
3. Get exposure to premixed and diffusion flames and their stabilization characteristics.
4. Learn about the constituents of emission and instrumentation to measure pollutants.

Module I

Introductory concepts: Review of thermodynamics, Thermodynamics of combustion, Stoichiometry of combustion, heats of reaction and formation, Mass transfer definitions: Fick's law. Equations of conservation of species mass, momentum, and energy; multi-component diffusion equation adiabatic flame temperature.

Module II

Chemistry of Combustion: Basic Reaction Kinetics, Elementary reactions, Chain reactions, Multistep reactions, simplification of reaction mechanism, Global kinetics.

Physics of Combustion: Fundamental laws of transport phenomena, Conservations Equations, Transport in Turbulent Flow.

Module III

Premixed Flames: One dimensional combustion wave, Laminar premixed flame, Burning velocity measurement methods, Effects of chemical and physical variables on Burning velocity, Flame extinction, Ignition, Flame stabilizations, Turbulent Premixed flame.

Diffusion Flames: Gaseous Jet diffusion flame, Liquid fuel combustion, fuel atomization, Characteristics of spray Combustion, Solid fuel combustion.

Module IV

Combustion generated pollutants: Constituents and types of emission, mechanisms of hydrocarbon and particulate emissions, and theories of soot and NOx formation, industrial furnace emissions. Quantification of emission, emission control methods, modelling of emissions. Emission standards. Instrumentation to measure pollutants.

References

1. Stephen R Turns, An Introduction to Combustion, Mc-Graw Hill, 2nd Edn., (2006).
2. Mukunda, H. S., Understanding Combustion, University Press, 2nd Edn., (2009).
3. Kanury A Murty, Introduction to Combustion Phenomena, Gordon and Breach, (1975).
4. Kenneth K Kuo, Principles of Combustion, John Wiley and Sons, (1986).
5. Forman A Williams, Combustion Theory - The Fundamentals Benjamin and Cummings publishing, 2nd Ed., (1985).
6. Irvin Glassman and Yetter, R. A., Combustion, Academic press, 4th Ed., (2008).
7. Law, C. K., Combustion Physics, Cambridge University Press, (2006).
8. Strehlow R. A., Fundamentals of Combustion, McGraw Hill Book Company, (1984).

19-205-0610:CAD/CAM LAB

Course Outcomes:
On completion of this course the student will be able to:
1. Get famliarised with using modelling software packages.
2. Get exposed with analysis using software packages.
3. Get famliarised with working on CNC machines
4. Get exposed with the operation of robotic arm.

Practicals:

1. Use of CAD/CAM software packages
2. Use of project management software packages
3. Maintenance of PC and peripherals
4. Operation of CNC milling machine and CNC Lathe
5. Manual part programming exercises (editing and simulation)
6. Part programming using APT or APT like languages
7. Operation of Robots
8. Programming of Robots
9. Operation Coordinate Measuring Machine.

19-205-0611:HEAT AND MASS TRANSFER LAB

Course Outcomes:
On completion of this course the student will be able to:
1. Design the required experiments
2. Conduct different heat transfer experiments using the theoretical knowledge
3. Tabulate the data and use necessary theoretical knowledge to find out the results
4. Interpret the results.

Introduction to fundamentals of heat transfer - condensation and boiling heat exchanges experimental techniques in thermal sciences

Practicals:

1. Performance studies on a shell and tube heat exchanger
2. Performance studies on parallel and counter flow arrangements in a concentric pipe heat exchanger
3. Emissivity measurement of a radiating surface
4. Measurement of solar radiation
5. Thermal conductivity of a metal rod
6. Measurement of unsteady state conduction heat transfer
7. Experimental study on forced convection heat transfer
8. Experimental study of dropwise and flimwise condensation
9. Experiments on boiling heat transfer
10. Measurement of critical heat flux.

19-205-0701:REFRIGERATION AND AIR CONDITIONING

Course Outcomes:

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

1. Understand the basics of different refrigeration cycles.
2. Study the vapour compression and vapour absorption refrigeration cycles- both theoretical and practical cycles, properties of refrigerants, and selection criteria for refrigerants.
3. Understand the different components of refrigeration systems.
4. Get knowledge of psychrometry, air-conditioning systems and will be able to do the cooling load calculation

Module I

Principles of refrigeration-unit of refrigeration - capacity - Coefficient of Performance - refrigeration systems: Carnot refrigeration cycle - Steam jet refrigeration - Thermoelectric refrigeration - vortex tube - pulse tube - air refrigeration cycle boot strap & boot strap evaporating cooling - thermodynamic analysis of Bell- Coleman cycle.

Module II

Vapour compression system - theoretical and practical cycles - simple and multi pressure systems - thermodynamic analysis - vapour absorption system - principle of operation of aqua - ammonia and lithium bromide - water systems - Electrolux system - comparison between vapour compression and absorption systems - refrigerants - thermodynamic, physical and chemical properties of refrigerants, environment friendly refrigerants and its properties, selection criteria of refrigerants.

Module III

System components - compressors - reciprocating compressors - single and multistage compressors - rotary compressors – centrifugal and axial flow compressors - screw type and vane type compressors - hermetic, semi hermetic and open compressors - condensers - water cooled and air cooled condensers - evaporative condensers - expansion devices - capillary tube - thermostatic expansion valve - float valves - evaporators - natural convection and forced convection coils - flooded evaporators - direct expansion coils.

Module IV

Psychrometry - Psychrometric properties and processes - determination of air entering conditioned space - air conditioning systems – Summer and Winter air conditioning systems - central and unitary systems - human comfort - comfort chart and limitations - effective temperature - factors governing effective temperature.

Cooling Load Calculation - various heat sources - design of air conditioning systems: duct design - air distribution systems - heating systems.

Note: Refrigeration Data Books are permitted for examination

1. Domkundwar A. V., & Domkundwar, V. M., Refrigeration and Air conditioning Data Book, Dhanpat Rai & Co., Delhi, (2013).

References:

1. Roy J. Dossat, Thomas J. Horan, Principles of Refrigeration, 5th edition, Prentice Hall, (2001).
2. Stoecker W. F. and Jones J. W., Refrigeration and Air Conditioning, 2nd Ed., Tata McGraw Hill, (1982).
3. Jordan R. C. and Priester G. B., Refrigeration and Air Conditioning, 2nd Ed., Prentice Hall, (1969).
4. Arora, C. P., Refrigeration and Air Conditioning, Tata McGraw Hill, (2001).
5. Norman Harris, Modern Air Conditioning Practice, McGraw Hill, (1974).

6. Arora, R. C., Refrigeration and Air Conditioning, Prentice Hall, (2010).

19-205-0702:VIBRATION AND NOISE CONTROL

Course Outcomes:

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

1. Model a given physical system using spring, mass, and damping elements.
2. Formulate the governing diffeential equations of single dof, multi dof, and continuous systems.
3. Solve the governing equations and interpret the results.
4. Understand the effects of noise and the control measures adopted.

Module I

Introduction to mechanical vibrations: Free vibrations, Response of single degree of freedom system, Viscous damping, Under damped, Critically damped and Over damped vibrations, Forced vibrations, Transmissibility, Vibration isolation, Support excited motion, Rotating Unbalance, Coulomb damping.

Module II

Multi degree freedom systems: two degree of freedom and three degree of freedom spring mass systems, Matrix formulation, Eigen value problems, Mode shapes, Coordinate Coupling, Lagrange's equations. Torsional vibratory systems, Torsionally equivalent shaft, Two rotor system, Three rotor system, Geared system, Location of Nodes, Frequency of torsional vibration. Measurement of vibration - Accelerometer and Seismometer.

Module III

Transverse vibration of shafts, Whirling speed of shafts, Approximate methods to analyse vibratory system: Rayleigh's energy method, Dunkerleys method.

Vibration of continuous systems: exact methods, boundary value problem, Eigen value problem, Axial vibration of rods, Transverse vibration of beams.

Module IV

Noise, Sound level meter scales, Octave bands, Psychophysical indices, Overall sound pressure level, Sound intensity level, Sound power level, Noise and loss of hearing, Normal hearing and hearing loss, Temporary hearing loss from continuous noise, Permanent haring loss from continuous noise, Physiological effects of noise, Specific effects of noise, Noise exposure limits, Continuous and intermittent noise, Impulse noise, Annoyance of noise, Jet noise, Noise control; control at the source, control at the receiver, control along the path, Cylindrical and spherical acoustic waves.

References:

1. Rao, S. S., Mechanical Vibrations, 5th edition, Prentice Hall, (2010).
2. Mark S. Sanders, Ernest J. Mc Cormick, Human Factors in engineering and design, Mc Graw Hill, (1993).
3. Thomson, W. T., Theory of Vibrations with applications, 3rd Edn., CBS Publishers, (2002).
4. Benson H. Tongue, Principles of Vibration, OxfordUniversity Press, (2002).
5. Shabana, A. A., Theory of Vibration: An Introduction, Springer International Edition, (1974).
6. Rossing T. D. & Fletcher, N. H., Principles of Vibration & Sound, 10th Edn., Springer, (1995).
7. Nag, D., Mechanical Vibrations, Wiley India Pvt. Ltd., (2011).

19-205-0703:MACHINE DESIGN - II

Course Outcomes:

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

1. Understand the customers need, formulate the problem and draw the design specifications.
2. Understand component behavior subjected to loads and identify the failure criteria.
3. Apply the concepts of stress analysis, theories of failure and material science to analyze, design and/or select commonly used machine components.
4. Analyze the stresses and strains induced in a machine element.
5. Design a machine components using theories of failure.
6. Get basic knowledge of the preparation of working drawings by including the manufacturing details like tolerance, surface finish etc.

Module I

Design of Clutches : Friction clutches, uniform wear and uniform pressure assumptions, centrifugal clutches. Brakes : Design of internal expansion elements, assumptions, design of external contraction elements, band type brakes.

Belt and chain drives : flat belts, V-Belts, roller chain.

Module II

Design of Gears : Spur, helical, bevel and worm gears-tooth loads, design stresses, basic tooth stresses, stress concentration, overload factor, velocity factor, bending strength of gear teeth, Buckingham equation for dynamic load, surface durability, surface strength, heat dissipation, gear material, design for strength and wear, gear box design (description only).

Module III

Bearings and lubrication: types of lubrication, viscosity, journal bearing with perfect lubrication, hydrodynamic theory, design factors, bearing load, bearing dimensions, journal bearing design. Ball and roller bearings- bearing life, static and dynamic capacity, selection of bearings with axial and radial loads, bearing materials used. Thrust bearings, lubrication, wear of metal, adhesive wear, abrasive wear, corrosion wear, fatigue and impact wear, measurement of friction and wear.

Module IV

Product design for manufacturing : general design recommendations for rolled sections, forgings, screw machine parts, turned parts, machined round holes, parts produced on milling machines, welded parts, castings etc., Modification of design for manufacturing easiness for typical products – preparation of working drawings for manufacture of parts with complete specifications including manufacturing details like tolerance, surface finish.

Data books allowed for Examination:

1. Mahadevan K. and Balaveera Reddy, Design data hand book, 4th Edn., CBS Publishers, (2013).
2. P.S.G.TECH, Design Data Hand Book, DPV Printers, (1993).
3. Linghaigh K.and Narayana Iyengar, B.R., Design Data Book, Vol. I & II, Mc. Graw Hill, (1994).

References:

1. Shigley, J.E., Mechanical engineering design, 5th edition, McGraw Hill, (2009).
2. James G. Bralia, Handbook of product design for manufacturing, 2nd Edn., McGraw Hill, (1998).
3. Bhandari, V. B., Design of machine elements, third edition, Tata Mc Graw Hill, (2010).
4. Doughtie, V. L., Design of machine members, McGraw Hill, (1964).
5. Siegel, Maleev, Machine design of machines, International and Hartman text book Co, (2007).
6. Donald J. Myatt, Machine design, McGraw Hill, (1962).
7. Sadhu Singh, Mechanical Machine Design-I, S. K. Kataria & Sons, (2011).
8. Pandya & Shah, Machine Design, 17th edition, Charotar Publishing House Pvt. Limited, (2009).

19-205-0704(IE):ROBOTICS AND ARTIFICIAL INTELLIGENCE

Course Outcomes:

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

1. Understand the concept of intelligent machines.
2. Analyse the direct and inverse kinematics of robots.
3. Analyse differential motion and workspace of robots.
4. Study the dynamics and trajectory planning of robots.

Module I

Direct & Inverse Kinematics:Introduction -Co-ordinate frames, Rotations, Homogeneous Coordinates, Link coordinates, D-H Representation, Arm equation -Two axis, three axis, four axis, five axis and six axis robots. Inverse Kinematic problem, General properties of solutions, Tool configuration, Inverse Kinematics of Two axis Three axis, Four axis and Five axis robots.

Module II

Workspace Analysis: Workspace analysis of Four axis, Five axis and Six axis robots, Perspective transformation, structured illumination, Camera calibration, Work envelope of Four and Five axis robots, Workspace fixtures.

Differential Motion and Statics: The tool Configuration jacobian matrix for three axis and, four axis robots, joint space singularities, resolved motion rate control, manipulator jacobian for three and four axis joint space singularities, induced joint torques and forces.

Module III

Dynamic Analysis and Forces:Introduction, Langrangian mechanics, Effects of moments of Inertia, Dynamic equation for two axis planar articulated robot.

Trajectory Planning: Trajectory planning, Pick and place operations, Continuous path motion, Interpolated motion, Straight line motion.

Module IV

Self Driving Cars:Introduction to Modern Robots, Intelligent Machines, Autonomous Driving, Perception for self driving cars, Deep learning for Self Driving cars, Decision planning and Control: Mtion planning, Feedback control, PID control.

Reinforcement Learning for Autonomous driving: Q Learning, Actor critic methods, Reinforcement Learning for Behavioral Decision, Planning and Control.

References:

1. Robert J. Schilling, Fundamentals of Robotics Analysis and Control, PHI Learning, (2009).
2. Niku S B, Introduction to Robotics, Analysis, Systems, Applications, Prentice Hall, (2001).
3. John J Craig, Introduction to Robotics, Pearson, (2009).
4. Deb S R and Deb S, Robotics Technology and Flexible Automation‖, Tata McGraw Hill Education Pvt. Ltd, (2010).
5.Shaoshan Liu, Creating Autonomous Vehicle systems, Morgan and Claypool Publishers (2018).
6. Saha S K, Introduction to Robotics, Tata McGraw Hill Education Pvt. Ltd, (2010).

19-205-0705:SUPPLY CHAIN MANAGEMENT

Course Outcomes:

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

1. Define a supply chain and understand its different structures and its importance to the success of a firm.
2. Understand the concept of strategic fit between the SC strategy and the competitive strategy of the firm and how to achieve it.
3. Identify the main drivers of supply chain (SC) performance and measure them using precise metrics.
4. Assess the importance of distribution networks and the different options available for their design.
5. Develop a methodological framework for network design and facility location and use optimization models and techniques for facility location and capacity allocation.
6. Use safety inventory to deal with demand uncertainty in the supply chain.
7. Understand the importance of transportation in the SC, and identify the different modes of transportation and the role played by infrastructure and policies.

Module I

Introduction and a strategic view of supply chains, Evolution of Supply Chain Management (SCM), Importance of the supply chain, Decision phases in a supply chain, Process views of supply chain, Enablers of supply chain performance, Supply chain performance in India – challenges in maintaining supply chain in India, Supply chain strategy and performance measures– competitive and supply chain strategies – customer service and cost trade –offs, Achieving strategic fit, Supply chain performance measures – enhancing supply chain performance.

Module II

Supply chain drivers – framework for structuring drivers, Introduction to inventory management – types of inventory – inventory related costs, Managing inventories in a supply chain – single stage inventory control, Inventory control policies – periodic review and continuous review – deterministic and probabilistic models – managing cycle stock, safety stock and seasonal stock.

Module III

Drivers of transportation decisions – modes of transportation– choices and comparison of their performance measures, Devising a strategy for transportation – distribution network design options for a transportation network – cross docking practices, Network design and operation decisions – role of network design in the supply chain – factors influencing network design decisions – framework for network design decisions.

Module IV

Models for facility location and capacity allocation – network optimization models – capacitated plant location models – gravity location models – network operations model, Strategic role of units in the network, Innovations in supply chains– supply chain integration – internal and external, Bullwhip effect – quantifying the bullwhip effect, Remedial strategies for coping with the bullwhip effect.

References

1. Shah, J., Supply Chain Management –Text and Cases, Pearson Education, (2009).
2. Chopra, S., and Meindel, P., Supply Chain Management: Strategy, Planning, and Operation, Pearson Prentice Hall, (2007).

3. Levi, D.S., Kaminsky, P., Levi, E.S., and Shankar, R., Designing and Managing the Supply Chain: Concepts, Strategies, and Case Studies, Tata McGraw Hill, (2008).
4. Chase, R.B., Shankar, R., Jacobs, F.R., and Aquilano, N.J., Operation and Supply Chain Management, Tata McGraw Hill, (2010).
5. Shapiro, J.F., Modeling the Supply Chain, Thomson Learning, (2007).
6. Vollmann, T.E., Berry, W.L., Whybark, D.C., and Jacobs, F.R., Manufacturing Planning and Control for Supply Chain Management, Tata Mc Graw Hill, (2006).

19-205-0706:AUTOMOBILE ENGINEERING

Course Outcomes:

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

1. compare the working of various types of automobiles
2. learn the functions and working of different engine components
3. appreciate the use of alternate fuels.
4. Understand the latest technology used in the field of automobile

Module I

Automotive engine classification, S.I. & C.I. engines, combustion chamber types, engine balancing, multi cylinder arrangements. Multi axle vehicles

Automobile engine parts: Cylinder block, cylinder head, crank case, oil pan, cylinder liners, piston, arrangements to control piston slap, piston rings, connecting rod, crank shaft, valves, materials used, valves lay out, valve and port timing diagrams, valves actuating mechanism, Variable Valve Timing, Method used to effect variable Valve Timing, Electromagnetic Valves, Cam less engine actuation, wheel balancing, engine tuning, energy balance sheet, cooling curves.

Module II

Fuel supply system:Simple carburetor, constant choke, constant vacuum carburetor, types of carburetor, mixture strength requirements, fuel pumps for petrol engines, petrol injections, diesel fuel pump and fuel injector for diesel engines, Multi-Point Fuel Injection systems, Common Rail Direct Injection systems, Alternate fuels,CNG, advantages, Characteristics of CNG with relation to conventional fuels.

Ignition System:Battery ignition system, comparisons between battery ignition and magnetic ignition system, ignition advance methods, electronic ignition.

Cooling System:Necessity, Properties of coolants, methods of cooling, Liquid cooled system, Thermosyphon system, Pressure cooling system.

Lubrication System:Objectives, properties of lubricants, systems of engine lubrication, Mist lubrication system, Wet sump and dry sump lubrication, Crank case ventilation.

Module III

Gear box:sliding mesh gear box, constant mesh gear box, synchromesh gear box, epicyclic gear box, overdrive, torque converter, automatic transmission an overview, AMT and CVT vehicles.

Universal coupling, propeller shaft, final drive, Steering mechanisms, wheel suspension.

Factors for wheel alignment:camber, caster, kingpin inclination, toe–in, toe–out.

Brakes:Types of brakes, Braking requirements, drum brake and disc brakes, brake efficiency, stopping distance, fading of brakes, Mechanical, Hydraulic and Pneumatic brakes, external caliper brakes, Power assisted brakes. Anti-lock braking systems.

Electrical systems: Electrical lighting system, brake lighting system, warning system and indicators.

Exhaust: catalytic converters, emission standards and test, BS-VI norms.

Module IV

Introduction to Hybrid Electric Vehicles: Hybrid Electric Drive-trains and Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis. Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency. Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles. Battery, Fuel Cell, Super Capacitor and Flywheel based energy storage and its analysis, Hybridization of different energy storage devices

References:

1. Newton, Steed and Garette, Motor Vehicle, 2nd edition., Butterworths, (1989).
2. Kirpal singh, Automobile Engineering Vol- I & Vol- II, Standard Publishers Distributors, (2004).
3. Heitner Joseph, Automotive mechanics, 2nd edition, East- west press, (1974).
4. William Harry Crouse, Automotive mechanics, 10th edition, McGraw Hill book Co., (2007).

5. Giri, N.K., Automobile mechanics, 7th Ed, Khanna publishers, (1996).
6. Giles, K.G., Steering, Suspension and Tyres, Illiffe Books Ltd., London, (1988).
7. Gupta, R. B., Automobile Engineering, Tech India publication series, 9th edition, (2014).
8. Young A. P., and Griffiths, Automotive Electrical systems, Elsevier Butterworth Heinemann, 3rd edition, (2004).
9. Iqbal Hussein, *Electric and Hybrid Vehicles: Design Fundamentals*, CRC Press , 2003
10. MehrdadEhsani, YimiGao, Sebastian E. Gay, Ali Emadi, *Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design*, CRC Press , 2004
11. James Larminie, John Lowry, *Electric Vehicle Technology Explained*, Wiley , 2003
12. Chris Mi, M. AbulMasrur, David WenzhongGao, *Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives*, John Wiley & Sons Ltd. , 2011

19-205-0707:COMPUTATIONAL FLUID DYNAMICS

Course Outcomes:

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

1. Understand the classifications of partial differential equations
2. Get an insight on consistency, stability, error analysis and finite difference formulations
3. Use numerical algorithms for the solving Navier Stokes equations
4. Attain information on grid, domain, boundary conditions, solving equations and post processing of the data

Module I

Classification of partial differential equations – system of first and second order partial differential equations – initial and boundary conditions – finite difference formulations – finite difference equations – finite difference approximation of mixed partial derivatives.

Module II

Parabolic partial differential equations – explicit methods – implicit methods – parabolic equation in two space dimensions – consistency, stability and error analysis of finite difference equations – artificial viscosity.

Module III

Elliptic equations – finite difference formulations – solution algorithms – finite difference formulations – splitting methods – multiple step methods.

Module IV

Scalar representation of the Navier-Stokes equations – model equations – numerical algorithms – incompressible Navier-Stokes equation – primitive variable and vorticity - stream function formulations – Poisson equation for pressure – numerical algorithms – boundary conditions – staggered grids.

Reference:

1. Anderson, Computational Fluid Dynamics, 1st edition, Mcgraw Hill Education, (1995).
2. Hoffmann Klaus, Computational Fluid Dynamics for Engineers vol.2, Engineering Education System, (1993).
3. Malalasekhar & Veerstag, Introduction to Finite Volume Method, Pearson, (2010).
4. Sundararajn & Muralidhar, Computational Fluid Flow and Heat Transfer, Narosa Publishing House, (2001).
5. Fletcher, Computational Technique for Fluid Dynamics, Springer- Verlag, (2001).
6. Patankar Suhas, Numerical Heat Transfer and Fluid Flow, CRC Press, (1980).

19-205-0708: QUALITY ENGINEERING AND MANAGEMENT

Course Outcomes:
On completion of this course the student will be able:

1. To understand the concepts of quality, quality control, quality assurance, and quality management.
2. To apply techniques of statistics and probability to assess, analyze and improve quality related issues.
3. To study process capability, process capability indices and use statistical process control to monitor processes.
4. To understand the use and design of acceptance sampling plans.
5. To get the concepts of reliability, failure rate models, probability distributions for reliability, reliability of systems, availability and maintainability and life testing.

Module-1.

Product quality: Quality-definitions, Quality in manufacturing and service organizations, Quality of design, Cost of quality- failure cost, appraisal cost, prevention cost, Total quality management (TQM)- evolution and principles, Quality improvement and employees- Quality circles, KAIZEN, PDCA cycle. Tools for identifying quality problems and causes, ISO 9001:2015.

Module-2.

Shewart's control chart for variables: Fundamentals of the theory of probability and probability distributions, Variables, Attributes, Relationship between sample parameters and Universe parameters, X bar and R charts-control limits ,process in control and out of control; Process capability-Six sigma.

Control chart for fraction defectives: selection of sub groups, choice between p chart and np-chart, control limits, Sensitivity of the P-chart.

Control charts for defects: C chart and U-chart- control limits, preparation and uses.

Module-3

Acceptance sampling: Sampling methods, Operating characteristics curve (OC curve)-producers risk, consumers risk, AQL, RQL, LTPD, AOQL;

Selection of sampling plans: Average Total Inspection (ATI), Choice to minimise ATI, ATI curves for double and sequential sampling plans.

Module-4

Life testing and Reliability: Reliability-definition and concept, Life test analysis, failure distribution, probability of equipment failure-conventional model, failure rate, MTBF,MTTF,MTTR, Exponential reliability function, Series, Parallel and Combinational reliability, Redundant system, Maintainability and Availability.

References:

1. Grant, E. L., Statistical Quality Control, McGraw Hill, (1996).
2. Srinath, L.S., Reliability Engineering, East West Press, (2005).
3. Mahajan, Statistical Quality Control, Dhanpat Rai Publications, (2012).

19-205-0709: HRD AND ORGANISATIONAL BEHAVIOUR

Course Outcomes:

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

1. Apply the principles and techniques as professionals for developing human resources in an organization.
2. Understand and integrate human resource function into business management effectively.
3. Develop an insight for various individual phenomena observed at workplace leading to human behavior.
4. Explore the effects of individual behaviour and attitude on organizational behaviour.

Module I

Human Resource Development - An Introduction; Historical Development; Concept of HRD; Characteristics of HRD; Objectives of HRD; Need for HRD; HRD as a total system; Functions of HRD; HRD and Personnel Management.

Module II

Human Resource Management: Role, Objectives and functions of human resource management.

Training and Development: Introduction; Training as System; Components of Training development; Benefits of training and development.

Motivating Human Resources: Introduction; Motivation at Work; Basic Process; Different Theories; Relationship Between Motivation and Performance.

Module III

Performance Management System: Stakeholder in Performance System; Multi Source Assessment and Feedback; Balanced Scoreboard; Performance Appraisal; Behaviourally Anchored Rating Scale (BARS)

HRM in Mergers and Acquisitions: Introduction to Mergers and Acquisitions; Culture Mixing; Challenge in Managing Human Resource.

Module IV

Definition and Scope of Organizational Behavior, Disciplines contributing to Organizational Behavior, Models of OB.

Foundations of Individual Behavior: Biological foundations of behavior, Causes of Human behavior, Environment effects on behavior, Behavior as an input-output system.

Attitudes: Nature of Attitudes, Components of Attitudes, Functions of Attitudes, Changing Attitudes and ways of changing work related attitudes.

Values: Meaning, Importance and relevance of values to OB, Types of values.

References:

1. Dayal Raghubir, Dynamics of Human Resource Development, Mittal, (1996).
2. Bhatia B.S., Emerging Dimensions of HRD: Role and Orientation, Deep & Deep, (1996).
3. Rao T.V., Readings In Human Resource Development, Oxford and IBH, (1991).
4. Stephans Robbins, Organisational Behavior, Prentice hall Inc. (2007).
5. Davis ,Keith, OB: Human Behaviour at Work, McGraw Hill Inc., (1989).
6. G. Moorhead & Griffith, Organisational Behavior, Houghton Muffin Co., (2007).

19-205-0710:COMPUTATIONAL STATISTICS FOR ENGINEERS

Course Outcomes

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

1. Apply statistical software like R for statistical analysis and exploration
2. Identify and apply principles of data collection and description
3. Illustrate business problems with appropriate probability distributions and statistical terms to make better decisions
4. Distinguish between the various statistical tests and apply an appropriate test in the context of the problem
5. Develop critical and integrative thinking in order to communicate the results of the analysis clearly in the context of the problem

Module I

Statistical Packages/Programs: - Introduction to R Program- Algorithms and basic programming in R. Data Description: Graphical presentation of data - Numerical description of data - Exploratory data analysis.

Classical, relative frequency and axiomatic definitions of probability, addition rule and conditional probability, multiplication rule, total probability, Bayes' Theorem and independence, problems.

Module II

Probability distributions: - Introduction to probability and random variables - Binomial distribution, Poisson distribution, Geometric distribution, Hyper Geometric distribution, Normal distribution, Log-Normal distribution, Uniform distribution, Exponential distribution, Gamma distribution, Beta distribution and Weibull distribution - Random samples and sampling distributions of mean and variance.

Use of R Program to plot PDF, CDF and solve numerical problems.

Module III

Parameter Estimation: Point estimation - Properties of estimators, The method of maximum likelihood, The method of moments, Confidence interval estimation of mean, and variance.

Statistical hypothesis tests: Operations characteristic curve, Tests of hypothesis on the mean of a Normal Distribution, Tests of hypothesis on the means of two Normal distributions, The paired t-test, Tests of hypothesis on one variance, Tests of hypothesis for the equality of two variances, The testing for goodness of fit. Analysis of Variance (ANOVA). Use R program to solve sample problems.

Module IV

Regression methods: Linear and non-linear regression, multiple linear regression, general linear models.

Design and Analysis of Experiments: Design of experiments with several factors - Two factor factorial experiments - General factorial experiments - The 2k Factorial design –Introduction to response surface method in optimal design of parameters.

Use R Program for modelling and analysis.

References:

1. Mark Gardener, Beginning R., The Statistical Programming Language, John Wiley and Sons, (2012).
2. Garcia-Diaz, A and Phillips, D. T., Principles of Experimental Design and Analysis, Chapman&Hall, New York, (1995).
3. Hines, W. W, and Montgomery, D. C., Probability and Statistics in Engineering and Management Science, John Wiley and Sons, New York, (1990).
4. Freund, J. E., Mathematical Statistics, Prentice Hall of India, New Delhi, (1990).
5. Hicks C. R., and Turner, K.V., Fundamental Concepts in the Design of Experiments, Fifth Edition, OxfordUniversity Press, (1999).

6. Anderson, M. J., and Whitcomb, P. J., DOE Simplified: Practical Tools for Effective Experimentation, Productivity Press, (2000).
7. Levin, R. I., and Rubin, Statistics for Management, Seventh Edition, Prentice Hall International edition, (1997).

19-205-0711:FINITE ELEMENT METHOD

Course Outcomes:
On completion of this course the student will be able to:
1. Understand the general steps used in the finite element analysis to model problems in engineering
2. Develop stiffness matrices for spring, truss, beam, plane stress problems and three dimensional problems
3. Apply Finite Element method to solve engineering problems
4. Implement FEM in commercial software
5. Use alternative formulations for 3D problems using FEA

Module I
Linear vector spaces- Linear transformations and functionals- linear, bilinear and quadratic forms- theory of normed spaces- theory of inner products spaces- concepts from variational calculus- variational methods of approximation- Ritz method- weighted residual method- Galerkin method- subdomain method-collocation method.

Module II
Finite element analysis of one dimensional problems- procedure- I-D elements and interpolation functions-analysis of one dimensional second and fourth order equations- approximation errors in FEM- computer implementation.

Module III
Finite element analysis of two dimensional problems- 2-D elements and interpolation functions- 2^{nd} order equations involving a scalar valued function- comments on mesh generation and composition of boundary condition- analysis of plane elasticity and incompressible fluid flow problems- time dependent problems - transient heat transfer- isoparametric elements and numerical integration.

Module IV
Alternative formulations - the least square formulations- the mixed formulation- eigen value problem- non linear problems- 3-D elements and interpolation functions- formulation of 3-D problems (2 & 3-D Navier Stokes equations, 3D heat transfer equations).

References:
1. Reddy J. N., An Introduction to Finite Element Method, McGraw Hill, (2005).
2. Reddy J. N., Applied Functional Analysis and Variational Methods in Engineering, McGraw Hill, (1986).
3. Zienkiewicz, O., Finite Element Method, 5^{th} Edition, Butterworth Heinemann, (2000).
4. Huebner K. H., The Finite Element Method for Engineers, John Wiley, (1975).
5. Saeed Moaveni, Finite element analysis, Prentice Hall, (2014).
6. Rao, S. S., The Finite Element Method in Engineering, 4^{th} Edition, Elsevier, (2005).

19-205-0712:THERMAL ENGINEERING LAB

Course Outcomes:
On completion of this course the student will be able to:
1. Design the required experiments.
2. Conduct different performance tests on engines and refrigeration equipments using the theoretical knowledge
3. Tabulate the data and use necessary theoretical knowledge to find out the results
4. Interpret the results.

Practicals:

1. Determination of flash and fire points of fuels and oils
2. Viscosity of fuels and oils and its variation with temperature
3. Determination of Calorific values of fuels
4. Performance of simple journal bearings
5. Valve timing diagrams of I.C. engines
6. Performance test on Petrol and Diesel engine
7. Forced convection heat transfer for tube flow
8. Performance test on air compressors
9. Test on air conditioning equipment and refrigeration equipment.

19-205-0713:AUTOMATION LAB

Course Outcomes:
On completion of this course the student will be able to:
1. Make the students learn the basic concepts of hydraulic and pneumatic actuators and their applications in product and processes.
2. Make the students learn the basic concepts of stepper motors, AC/DC motors and their applications in products and processes
3. Interface hydraulic, pneumatic actuators, stepper motors, AC/DC motors and sensors with PC/ PLC (Programmable Logic Controllers) based controllers using LabView Software.
4. Learn and use SCADA systems for data acqiuisition and control of product and Processes

Practicals:
Application of hydraulics and pneumatic actuators, stepper motors, A/C and D/C servomotors and various types of sensors and their interface with PC based controllers.

Pneumatic and Hydraulic Circuits
1. Exercises on Pneumatic circuits using Pneumatic trainer unit.
2. Exercises on Hydraulic circuits using Hydraulic tainer unit
3. Exercises on electro pneumatic and electro hydraulic circuits using trainer kits
4. Exercises on Hydraulic and Pneumatic circuits using PLC and PC with LabView

Electromechanical Devices
5 Exercises on Motion controller using AC/DC motor, servo motors and encoders to determine the operating characteristics.
6 Exercises on stepper motor to determine the operating characteristics.
7 Exercises on PC based based data acquisition system and LabView.
8 Study of SCADA and PLC programming
9 Interfacing SCADA with PLC and PC.
10 Controlling variable speed drive through PLC/SCADA

Sensors
11 Study of Sensors and Transducer – Potentiometer, Strain gauge, Torque, LVDT,
Hall – Effect, Speed, Vibration, Pressure, Optical transducer and Temperature transducer.
12 Interfacing various sensors with PC based data aquisition systems and exercises on data aquisition and analysis using Labview Software.

19-205-0714:ENTREPRENEURSHIP DEVELOPMENT

Course Outcomes:
On completion of this course the student will be able to:
1. Develop awareness about the importance of entrepreneurship opportunities available in the society
2. Get acquainted with the challenges faced by the entrepreneur

Exercises:

1) To study the types of entrepreneurs and the factors affecting entrepreneurial growth.
2) To make an assessment of the major motives influencing an entrepreneur
3) To make an overview of the various stress management techniques
4) How to identify and select a good business opportunity?
5) Preparation of a techno economic feasibility report for a given project
6) Preparation of a preliminary project report for a given project
7) To identify the various sources of finance and management of working capital
8) Carry out the costing and break even analysis of a proposed project
9) Preparation of a PERT / CPM chart for the various activities involved in a project
10) To make a study of the various causes and consequences of sickness in small business and identify corrective measures.

References:

1. Roy Rajeev, Entrepreneurship, Second edition, Oxford Latest Edition, (2011).
2. Gordon E. & Natarajan, K., Entrepreneurship Development, Fourth edition, Himalaya, (2007).
3. Coulter, Entrepreneurship in Action, Second edition, PHI, (2008).
4. Jain, P. C., Handbook for New Entrepreneur, OxfordUniversity Press, (2003).
5. Khanka, S. S., Entrepreneurial Development, Fifth edition, S. Chand and Co., (2013).

Note: *There will only be continuous evaluation for this course. The evaluation will be based on the performance of the student in the exercises given above. A minimum of 50% marks is required for a pass.*

19-205-0715:PROJECT PHASE 1

Course Outcomes:
On completion of the Project the student will be able to:
1. Conduct literature survey in a relevant area of one's course of study and finally identify and concentrate on a particular problem.
2. Formulate a project proposal through extensive study of literature and / or discussion with learned resource persons in industry and around.
3. Generate a proper execution plan of the project work to be carried out in Phase II through thorough deliberations and improve presentation skills.

Each batch comprising of 4 to 6 students shall identify a project related to the curriculum of study. At the end of the semester, each student shall submit a project synopsis comprising of the following.

- Application and feasibility of the project
- Complete and detailed design specifications.
- Block level design documentation
- Detailed design documentation including block/line diagrams and algorithms
- Project implementation action plan using standard presentation tools

Guidelines for evaluation:

1.	Attendance and Regularity	10
2.	Quality and adequacy of design documentation	10
3.	Concepts and completeness of design	10
4.	Theoretical knowledge and individual involvement	10
5.	Quality and contents of project synopsis	10
	Total	**50** Marks

Note: Points (1)-(3) to be evaluated by the respective project guides and project coordinator based on continuous evaluation. (4)-(5) to be evaluated by the final evaluation team comprising of 3 internal Examiners.

19-205-0716:INDUSTRIAL INTERNSHIP

Course Outcomes:

On completion of this course the student will be able to:
1. Work safely in industrial environment.
2. Work with various interest groups, disciplines, professionals, managers, technicians etc.
3. Polish the engineering skills by applying the knowledge in day-to-day operation, troubleshooting and minor-modifications.
4. Build relations with University and Industry that will help mutual cooperation over long-term.

Every student shall undergo a summer internship programme of minimum two weeks duration in an engineering industry such as manufacturing industry/ oil & gas industry/ process industry/ thermal plants/ design and research organisations during the May-June vacation before the commencement of the VII semester and submit a report on the status and technical knowledge gained from the respective industry. The evaluation shall be conducted based on the report and presentation.

19-205-0801:COMPRESSIBLE FLUID FLOW

Course Outcomes:

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

1. Understand the significance of governing equations such as continuity, momentum and energy equations in fluid flows with density variation and get concepts of adiabatic flow, isentropic flow, static and stagnation conditions existing in a compressible flow
2. Analyze the occurrence of normal shocks, oblique shocks and expansion waves in propulsive devices
3. Apply the influence of friction and heat transfer in the behaviour of the flow through ducts
4. Get exposed to the devices used for the measurement of pressure, velocity, flow, density, Mach number and temperature

Module I

Introduction to gas dynamics: System and Control Volume approach, Conservation of Mass, Momentum and Energy, Steady Flow Energy Equation, Entropy changes in fluid flow, Stagnation state, Critical state, Mach number, Effect of Mach number on compressibility, Classification of fluid flow based on Mach number, Acoustic wave propagation speed, Mach cone.

Isentropic flow with variable area: Isentropic flow of an ideal gas, Comparison of isentropic and adiabatic processes, Mach number variation with Area, Mass flow rate, Critical state, Geometric choking, Area ratio as a function of Mach number, Impulse function, Isentropic flow through Convergent nozzle and Convergent Divergent nozzle, Isentropic flow through diffusers.

Module II

Normal Shocks: Fundamental relations for normal shock, Prandtl Meyer relation for normal shock, Rankine-Hugoniot relation for normal shock, Change in entropy across a shock, Impossibility of shock in subsonic flow, Strength of a shock, Variation of flow properties across a normal shock.

Oblique Shocks and Expansion waves: Fundamental relations, Prandtl's relation and Rankine-Hugoniot relation for oblique shock, θ-β-M diagram, Reflected shocks, Variation of flow parameters, Expansion of supersonic flow, Supersonic flow around a convex corner, Prandtl Meyer angle, Mach Waves.

Module III

Fanno flow: Adiabatic flow in constant area duct with friction, Fanno line, Fanno relation for perfect gas, Friction choking, Variation of Mach number with duct length, Variation of flow properties.

Rayleigh flow: Frictionless flow in constant area duct with heat transfer, Rayleigh line, Rayleigh equations for a perfect gas, Thermal choking, Maximum heat transfer, Variation of flow properties.

Module IV

Methods of flow measurements: Methods of measurement of pressure, temperature, density and velocity, Pitot tube, Prandtl Pitot static tube, Supersonic Pitot tube, Shock tube, Rayleigh Supersonic Pitot formula, Temperature recovery factor, Hot wire anemometer, Working principle of Shadow graph, Velocimeter, Schlieren apparatus and Interferometer, Wind Tunnels – Subsonic and Supersonic Wind tunnels.

Note: Standard Gas Table is permitted for the examination

References:

1. Shapiro, Dynamics and thermodynamics of compressible fluid flow, 1st edition, Wiley, (1953).
2. John D. Anderson, Modern Compressible Flow, Mc Graw Hill, (2003).
3. Babu, V., Fundamentals of Compressible Flows, Ane Publishers, (2008).
4. James John, Theo Keith, Gas Dynamics, Pearson, (2005).
5. Patrick H. Oosthuizen, William E. Carscallen, Introduction to Compressible fluid flow, Taylor and Francis, (2014).
6. Yahya, S. M., Fundamentals of compressible flows, 2nd edition, New Age International Publishers, (1991).

19-205-0802:MATERIALS MANAGEMENT

Course Outcomes:
On completion of this course the student will be able to:
1. Understand the scope, objectives and phases in material management.
2. Get concept of static inventory problems.
3. Study dynamic inventory problems under risk.
4. Learn about lot sizing in material requirement planning.

Module I
Introduction: Scope, objectives and phases in materials management.
Procurement: purchase procedure, tender, earnest money, security deposit, purchase order, vendor rating. Receipt: Invoice, cash memo, inspection. Storage: methods of storage.
Selective control techniques of inventory – ABC & VED analysis.
Inventory Theory: objectives of keeping inventory, structure of inventory problems and their analysis, relevant cost.

Module II
Static inventory problems under risk : general characteristics, Christmas tree problem, total cost matrix, opportunity cost matrix, cost of risk, mathematical formulation of discrete and continuous cases.
Dynamic inventory problems under certainty: general characteristics, optimal lot size models with constant demand and infinite delivery rate with and without back ordering, quantity discounts.

Module III
Dynamic inventory problems under risk: general characteristics, basic kinds of inventory control systems – demand probability distribution – approximate methods to find optimal P & Q systems of inventory, optimal selling policy with fluctuating prices.

Module IV
Material requirement planning: master production schedule, bill of materials, inventory stock, files, MRP process, logic and computational procedure using simple example, lot sizing in MRP.

References:

1. Deb, A., Materilas Management, Academic Publishers, India, (1974).
2. Starr & Miller, Inventory control: theory and practice, Prentice Hall, (1997).
3. Monks, G., Operations Management, 3rd Edition, McGraw Hill, (1987).
4. Kanishka Bedi, Production & Operations Management, 2nd Ed., OxfordUniversity Press, (2007).

19-205-0803:HYDRAULIC AND PNEUMATIC DRIVES

Course Outcomes:

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

1. Describe the operation of hydraulic and pneumatic system components such as actuators and control valves
2. Identify various components of Pneumatic and Hydraulic control systems
3. Develop simple circuits for hydraulic and pneumatic applications.
4. Design and troubleshoot hydraulic and pneumatic systems

Module I

Introduction to oil hydraulics and pneumatics, their advantages and limitations, ISO symbols and standards in Oil Hydraulics and pneumatics, Recent developments, applications, Basic types and constructions of Hydraulic pumps and motors, Ideal pump and motor analysis, Practical pump and motor analysis, Performance curves and parameters.

Module II

Hydraulic Actuators, Hydraulic control elements – direction, pressure and flow control valves. Valve configurations, General valve analysis, valve lap, flow forces and lateral forces on spool valves, Series and parallel pressure compensation flow control valves, Flapper valve Analysis and Design, Analysis of valve controlled and pump controlled motor, Electro-hydraulic servo valves-specifications, selection and use of servo valves.

Module III

Electro hydraulic servomechanisms – Electro hydraulic position control servos and velocity control servos, Nonlinearities in control systems (backlash, hysteresis, dead band and friction nonlinearities). Basic configurations of hydraulic power supplies – Bypass Regulated and Stroke Regulated Hydraulic Power Supplies, Heat generation and dissipation in hydraulic systems: Design and analysis of typical hydraulic circuits, Use of Displacement – Time and Travels-Step diagrams: Synchronization circuits and accumulator sizing. Meter - in, Meter - out and Bleed-off circuits: Fail Safe and Counter balancing circuits.

Module IV

Components of pneumatic systems: Direction, flow and pressure control valves in pneumatic systems, Development of single and multiple actuator circuits, Valves for logic functions: Time delay valve, Exhaust and supply air throttling, Examples of typical circuits using Displacement – Time and Travel-Step diagrams, Will-dependent control, Travel-dependent control and Time dependent control, combined control, Program Control, Electro-pneumatic control and air hydraulic control, Applications in Assembly, Feeding, Metalworking, materials handling and plastics working.

References:

1. Joji P., Pneumatic controls, Wiley India Pvt. Ltd., (2008).
2. Anthony Esposito, Fluid Power with applications, 7th Edition, Prentice Hall, (2009).
3. Ernst W., Oil Hydraulic Power and its Industrial Applications, 2nd Ed., McGraw Hill, (1960).
4. Lewis E. E. and Stern H., Design of Hydraulic Control Systems, McGraw Hill, (1962).
5. Morse A. C., Electrohydraulic servomechanisms, McGraw Hill, (1963).
6. Pippenger J. J. and Koff, R. M., Fluid Power Control systems, McGraw Hill, (1959).
7. Fitch Jr. E. C., Fluid Power Control Systems, McGraw Hill, (1966).

8. Khaimovitch, Hydraulic and Pneumatic Control of Machine Tools, Pergamon Press, (1965).

19-205-0804AEROSPACE ENGINEERING

Course Outcomes:

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

1. Know the variations of properties in the international standard atmosphere.
2. Gain knowledge 2D viscous flow over bodies.
3. Understand aircraft performance and stability.
4. Learn about the principles of wind tunnel testing.

Module I

The atmosphere: International standard atmosphere, characteristics of troposphere, stratosphere, ionosphere, pressure – temperature - density variations in the atmosphere.

Review of basic fluid dynamics**:** continuity, momentum, and energy equations for compressible and incompressible flows, static, dynamic and stagnation pressure, stagnation enthalpy, temperature, Area – velocity relationship, Area variation as a function of Mach number.

Module II

Aerodynamics: 2D viscous flow over bodies, 2D airfoils, nomenclature and classification, pressure distribution in viscid and real flows, circulation theory of air foils, centre of pressure and aerodynamic centre, 2D air foil characteristics, aspect ratio, induced drag, calculation of induced drag from momentum considerations, skin friction and form drag – Drag divergence - Propellers - Blade element theory, propeller coefficients and charts.

Module III

Aircraft performance**:** Flight envelops, v-n diagrams for manoeuvres, straight and level flight, gliding and climbing, rate of climb, service and absolute ceilings, gliding angle and speed of flattest glider take off, landing performance and length of run way required, range and endurance of aero planes, charts for piston and jet engine aircraft, aircraft instruments, Qualitative ideas of stability.

Module IV

Aircraft engines: thrust equations- thrust power, propulsive power, propulsive efficiency, principle of turbo jet engines, engine performance characteristics – Rocket engines.

Principles of wind tunnel testing: open and closed types of wind tunnels, wind tunnel balances, pressure and velocity measurements, supersonic wind tunnels.

Note: Standard Atmospheric table is permitted in the exam hall.

References:

1. John D Anderson, Introduction to flight, 7th Edition, McGraw Hill, (2011).
2. Kermode, A. C., Mechanics of flight, 11th Edition, Prentice Hall, (2006).
3. Francis J. Hale, Aircraft performance selection & Design, John Wiley & Sons, (1984).
4. Houghton & Brock, Aero dynamics for Engg. Students, 2nd edition, Hodder & Stoughton Educational, (1977).
5. Piercy, N. A. V., Aerodynamics, The English Universities Press, (1944).
6. Dommasch, D. O., Sherby S. S., Connolly T. F., Airplane Aerodynamics, Pitman Publishing, (1967).
7. Hill P., & Peterson C., Mechanics and Thermodynamics of Propulsion, Addision Wesley, (1992).

19-205-0805:CRYOGENIC ENGINEERING

Course Outcomes:

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

1. Understand about the low temperature properties of engineering materials.
2. Learn about the critical components of the gas liquefaction systems.
3. Study cryogenic fluid storage and transfer systems.
4. Get insight on the insulation and transportation of cryogenic storage vessels.

Module I

Introduction to Cryogenic Systems, Historical development, Low Temperature properties of engineering materials, Mechanical properties-Thermal properties-Electric and magnetic properties –Cryogenic fluids and their properties. Applications of Cryogenics: Applications in space, Food Processing, super Conductivity, Electrical Power, Biology, Medicine, Electronics and Cutting Tool Industry.

Module II

Liquefaction systems: ideal system, Joule Thomson expansion, Adiabatic expansion, Linde Hampson Cycle, Claude & Cascaded System, Magnetic Cooling, Stirling Cycle Cryo Coolers.

Gas liquefaction systems: Introduction -Production of low temperatures-General Liquefaction systems-Liquefaction systems for Neon. Hydrogen and Helium – Critical components of Liquefaction systems.

Module III

Cryogenic Refrigeration systems: Ideal Refrigeration systems-Refrigeration using liquids and gases as refrigerant-Refrigerators using solids as working media, cryogenic fluid storage and transfer systems.

Module IV

Cryogenic Storage vessels and Transportation, Thermal insulation and their performance at cryogenic temperatures, Super Insulations, Vacuum insulation, Powder insulation, Cryogenic fluid transfer systems, Pressure flow-level and temperature measurements – Types of heat exchangers used in cryogenic systems. Cryo pumping Applications.

References

1. Klaus D.Timmerhaus, Thomas M. Flynn, Cryogenic Process Engineering, Plenum Press, (1989).
2. Randal F. Barron, Cryogenic systems, McGraw Hill, (1986).
3. Scott, R. B., Cryogenic Engineering, VanNostrand Co., (1962).
4. Flynn T. M., Cryogenic Engineering, Taylor and Francis Inc., (2005).
5. Mamata Mukhopadhyay, Fundamentals of Cryogenic Engineering, Prentice Hall, (2010).
6. Thipse, S. S., Cryogenics – A Text book, Narosa Publishing House, (2013).

19-205-0806:PRODUCTION TECHNOLOGY

Course Outcomes:

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

1. Understand the kinematics of machine tools.
2. Study the non traditional machining processes
3. Learn the basic concepts of powder metallurgy process.
4. Get knowledge on the hydraulic operation of machine tools

Module I

Kinematics of Machine Tools: Selection of range of speeds and feeds, layout of speeds, graphical representation of speed and structural diagrams, ray diagrams for machine tool gear boxes, speed chart, speed box design, feed chart, feed box design, gearing diagram, stepped and step less regulation of speeds, feed and speed mechanisms in lathe, milling and drilling machines.

Module II

Non-traditional machining processes: Principles, machining unit, process characteristics and applications of Electro Discharge Machining, Electro Chemical Machining, Abrasive Jet Machining, Ultrasonic Machining, Electron Beam Machining, Laser Beam Machining, and Plasma Arc Machining-capability analysis of non traditional processes.

Module III

Powder Metallurgy: Definition and basic concept of the powder metallurgy process, powder manufacture, characteristics of metal powders, mixing and blending, compacting, pre-sintering, sintering, hot pressing, secondary P/M operations like infiltration, impregnation, sizing, properties of P/M products, product applications, advantages & disadvantages.

Module IV

Hydraulic operation of Machine Tools: Elements of a hydraulic circuit, JIC symbols hydraulic valves, flow, pressure and direction control valves, oil hydraulic circuits of shaping, drilling and grinding machines.

Estimation and Costing: estimation and costing in foundry shop, sheet metal shop, welding shop, and machine shop- simple examples in lathe, drilling, milling, shaping and grinding machines.

References:

1. Geoffrey Boothroyd, Fundamentals of Metal Machining and Machine Tools, 3rd Ed., CRC Press, (1988).
2. Sen J. N., & Amithab Bhattacharya, Principles of Machine tools, New central book agency, (1988).
3. Mehta, N. K., Machine tool design & Numerical control, Tata McGraw-Hill Education, (2012).
4. Sharma, P. C., A text book of production engineering, 2nd edition, S Chand & Co., (2014).
5. Dalela, Manufacturing Science & Technology Vol II, Umesh Publication, (1999).
6. Kronenberg, M., Machining Science & their application, Pergamon Press, (1966).
7. Jones, E. J. H., Production Engineering: Jig and Tool Design, Read Books, (2009).
8. Cyril Donaldson, Goold, V. C., Tool Design, Mc Graw Hill, (1976).

19-205-0807:MECHANICAL BEHAVIOUR OF MATERIALS

Course Outcomes:

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

1. Understand the elastic deformation of materials and viscoelasticity.
2. Learn about the permanent deformation and slip line field theory.
3. Study dislocations and plastic deformation in single and polycrystalline materials.
4. Learn about high temperature deformation of crystalline materials.

Module I

Elastic deformation-Description of stress at a point-state of stress in two and three dimensions-stress tensor-Mohr's circle-description of strain at a point-Mohr's circle of strain-hydrostatic and deviator component of stress-elastic stress-strain relations-strain energy-anisotropy of elastic behaviour-rubber elasticity-viscoelasticity-mechanical damping.

Module II

Permanent deformation-Flow curve- True stress and true strain-yielding criteria for ductile metals-combined stress tests- yield locus-anisotropy in yielding-yield surface and normality-octahedral shear stress and shear strain-Invariants of stress and strain-Plastic stress –strain relations-Two dimensional plastic flow-slip line field theory.

Module III

Dislocations-Edge, screw and mixed dislocations-Properties of dislocations-dislocation stress fields, energies, forces between dislocations, kinks in dislocations, dislocation velocities-Dislocation geometry and crystal structure-slip systems-partial dislocations, interaction of dislocations, dislocation density and macroscopic strain-Plastic deformation in single and polycrystalline materials-initiation of plastic flow in single crystals-stress strain behaviour of single crystals-plastic flow in polycrystals.

Module IV

High temperature deformation of crystalline materials- creep mechanism, creep in two phase alloys, independent and sequential processes- deformation mechanism map- Engineering aspects of creep design –creep resistance as related to n\material properties and structure, estimates of creep behaviour, strain rate sensitivity and superplasticity, mechanisms of superplasticity.

References:

1. Dieter, G. E., Mechanical Metallurgy, McGraw Hill, (2001).
2. Courtney, T. H., Mechanical Behaviour of Materials, 2nd Edn., Waveland Pr Inc., (2005).
3. Hertzberg R. W., Deformation and Fracture Mechanics of Engineering Materials, 4th Edn., John Wiley & Sons, (1995).
4. McClintock F. A. and Argon A. S., Mechanical Behavior of Materials, 1st Ed., Addison- Wesley Publications, (1966).
5. Reed Hill R. E., Physical Metallurgy Principles, 2nd Ed., Affiliated East-West Press, (2008).
6. Honeycombe R. W. K., Plastic Deformation of Metals, 2nd Edn., Edward Arnold, (1984).

19-205-0808:THEORY OF PLATES AND SHELLS

Course Outcomes:
On completion of this course the student will be able to:
1. Understand the literature and computational codes dealing with plates and shells;
2. Recall the theories from solid mechanics/elasticity theory
3. Derive fundamental equations to analyse problems related with plates and shells;
4. Obtain analytical solutions of some problems regarding plates and shells.

Module I
Introduction of plate: Thin and thick plates, small and large deflections. Small deflection theory of thin plates: Assumptions, Moment Curvature relations. Stress resultants. Governing differential equation in Cartesian coordinates, various boundary conditions, Analysis of Rectangular Plates, Navier solution for plates with all edges simply supported. Distributed loads, point loads and rectangular patch load. Levy's Method: Distributed load and line load. Plates under distributed edge moments. Raleigh- Ritz approach for simple cases in rectangular plates.

Module II
Circular Plates, Analysis of circular plates under axi-symmetric loading. Moment Curvature relations. Governing differential equation in polar coordinates. Simply supported and fixed edges. Distributed load, ring load, a plate with a central hole.

Module III
Introduction of shell: Classification of shells on geometry, thin shell theory, equations to shell surfaces, stress resultants, stress- displacement relations, compatibility and equilibrium equations. Shells of Revolution: Membrane theory, equilibrium equations, strain displacement relations, boundary conditions, cylindrical, conical and spherical shells.

Module IV
Circular cylindrical shells, Circular cylindrical shells: Membrane theory: Equilibrium equations, strain displacement relations, boundary conditions. Bending Theory: Equilibrium equation, strain displacement relations, governing differential equation, solution for a simply supported cylindrical shell.

References:
1. Timoshenko, S.P., Winowsky. S., & Kreger, Theory of Plates and Shells, Mc Graw-Hill, (1990).
2. Flugge, W., Stresses in Shells, Springer Verlag, (1985).
3. Timoshenko, S.P. & Gere, J. M., Theory of Elastic Stability, McGraw-Hill Book Co., (1986).

19-205-0809:PROPULSION ENGINEERING

Course Outcomes:

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

1. Understand the different types of propulsive devices
2. Calculate the thrust and thrust power and also analyse the component efficiencies in various jet engines.
3. Get a concept and operating principles of rocket motors and their performance parameters
4. Explore the aspects of launching and boost dynamics

Module I

Fundamentals of propulsion: Types of propulsive devices - Turbo prop, Turbo jet, Turbo fan, Turbo shaft, Ram jet, Scramjet, Pulse jet, Ram rocket, Comparative study of performance characteristics, Propellers, Advance ratio, Types of combustion chambers, Operating characteristics, Fuel injection in combustion chamber, Factors limiting turbine design, materials for turbine blades, cooling of turbine blades, Surging in compressors and its control, comparison of centrifugal and axial flow compressors.

Module II

Thrust equation, Calculation of thrust and thrust power, propulsive efficiency, thermal efficiency, transmission efficiency, and overall efficiency of turbo jet engines, isentropic flow through nozzles, Thrust Augmentation methods, Analysis of turbo jet engine cycle, Component efficiencies, Diffuser efficiency, Compressor efficiency, Burner efficiency, Turbine efficiency, Nozzle efficiency, Velocity coefficient, Performance characteristics of a turbo jet engine, Analysis of Turboprop, Turbofan and Ramjet engine cycles.

Module III

Rocket Propulsion: General operating principles of rocket motors, performance parameters for rocket motors and their relationship, Rocket equation, Burn out velocity, Specific Impulse, Specific Propellant Consumption, Characteristic Velocity, Thrust Vector Control, Altitude gain, Solid propellant Rocket motor, Grain configuration, Propellant area ratio, Liquid propellant Rocket engines, Gas pressure feed systems, Turbo-pump feed system, Injectors, Hybrid rockets, Nuclear, Solar and Electrical rockets.

Module IV

Liquid fuels, Liquid Oxidizers, Liquid monopropellants, Cryogenic fluids as rocket propellants, Properties of cryogenic rocket propellants, Cryogenic rocket engine, Manufacture of cryogenic fluids, Igniters – Pyrotechnic & Pyrogen Igniters, Combustion instability, Cooling of Thrust Chambers – Radiation cooling, Ablative cooling, Regenerative cooling, Film cooling, Transpiration cooling, Aspects of Launching, Boost dynamics, Orbit equation, Space vehicle trajectories, Kepler's Law, Atmospheric Re-entry of Space vehicles.

Note: *Gas table is permitted in the exam hall.*

References:

1. Zucrow, Air craft and missile propulsion, John Wiley, (1958).
2. Sutton, G. P., Rocket Propulsion Elements, 8th Edition, John Wiley & Sons, (2010).
3. Babu, V., Fundamentals of Propulsion, Ane Publishers, (2009).
4. Hosny, Propulsion Systems, University of South Carolina Press, (1974).
5. Treager, Aircraft Gas Turbine engine technology, 3rd Edition, TMH, (1995).
6. Cohen & Rogers, Gas Turbine Theory, 6th Edition, Pearson, (2008).
7. Hill P., & Peterson C., Mechanics and Thermodynamics of Propulsion, Addision Wesley, (1992).
8. Yahya, S. M., Fundamentals of Compressible Flow, New Age International Publishers, (1991).

19-205-0810:OPERATIONS RESEARCH

Course Outcomes:
On completion of this course the student will be able to:
1. Solve problems using optimization methods
2. Develop mathematical skills to approach real life industrial problems
3. Inculcate ideas to solve problems on Trasportation and Queueing models
4. Import and analyse case studies to solve future problems

Module I
Operations Research models, Phases of OR study; Optimization Problems, Programming Problems, Linear Programming – formulation, graphical solution, multiple, unbounded and infeasible solutions, application of LP in industry.

Module II
Simplex method – Big M method, two phase method, unbounded solution, alternate optima and degeneracy, Duality in LP, Economic interpretation of duality.

Module III
Transportation Problem – formulation and solution, degeneracy, Assignment Problem – formulation and solution, unbalanced problems, comparison with TP models.

Module IV
Dynamic Programming – characterization, Bellman's principle of optimality, Problems with finite number of concentric decisions; Queueing theory – generalized Poisson queueing models, steady state solution of single server models for infinite and finite queue sizes.

References:

1. Taha, H.A., Operations Research: An Introduction, 8th ed., Pearson Education Inc., (2008)
2. Kanti Swarup, Gupta and Manmohan, Operations Research, Sultan Chand and Sons Publishers, New Delhi, (1977).
3. Hillier, F.S., and Lieberman, G.J., Introduction to Operations Research, 8th Ed., Tata McGraw Hill (2005).
4. Ravindran, A., Philips D, D., and Solberg, J.J., Operations Research: Principles and Practice, 2nd Ed., John Wiley and Sons Inc., (1989).
5. Hadley, G., Linear Programming, Addison Wesley Narosa, Narosa Publishing House, (1987)

19-205-0811:NANO TECHNOLOGY AND SURFACE ENGINEERING

Course Outcomes:

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

1. Understand the struture and properties of nano materials
2. Get the concept of synthesis and preparation of nano materials
3. Apply surface engineering by material removal and addition
4. Explore advanced surface engineering practices

Module I

Atomic Structure and atomic size, emergence and challenges of nanotechnology, carbon age-new form of carbon (CNT to Graphene), influence of nano over micro/macro, size effects and crystals, large surface to volume ration, surface effects on the properties, Types of nanostructure and properties of nanomaterials: One dimensional, Two dimensional and Three dimensional nanostructured materials, Quantum Dots shell structures, metal oxides, semiconductors, composites, mechanical-physical-chemical properties, Application of Nanomaterial: Ferroelectric materials, membrane based application, polymer based application.

Module II

Synthesis and preparation of Nanomaterials: Synthesis of bulk nanostructured materials - Sol Gel processing- bulk and nano composite materials - Grinding - high energy ball milling – injection moulding - extrusion - melt quenching and annealing, Synthetic Technique (Physical and Chemical): Self assembly-Self Assembled Monolayers (SAM) - Vapour Liquid Solid (VLS) approach - Chemical Vapour Deposition (CVD) - Langmuir-Blodgett (LB) films - Spin coating - Templated self assembly Electrochemical approaches: Thin films -Epitaxy – Lithography, One dimensional and Two dimensional nanostructures: Nanowires and Nanotubes.

Module III

Surface engineering by material removal: Cleaning, pickling, etching, grinding, polishing, buffing / puffing (principle). Role and estimate of surface roughness, Surface engineering by material addition: From liquid bath - hot dipping (principle and its application). Surface engineering by material addition: Electro-deposition / plating (theory and application), Surface modification of steel and ferrous components: Pack carburizing (principle and application), Surface modification of ferrous and non ferrous components: Aluminizing, calorizing, diffusional coatings, Surface modification using liquid/molten bath: Cyaniding, liquid carburizing (diffusion from liquid state), Surface modification using gaseous medium, Nitriding, Carbonitriding (diffusion from gaseous state).

Module IV

Advanced surface engineering practices, Surface engineering by energy beams: General classification, scope and principles, types and intensity/energy deposition profile, Surface engineering by energy beams, Laser assisted micro-structural modification – surface melting, hardening, shocking and similar processes, Surface engineering by energy beams: Laser assisted compositional modification – surface alloying of steel and non-ferrous metals and alloys, Surface engineering by energy beams: Laser assisted compositional modification – surface cladding, composite surfacing, Surface engineering by energy beams: Electron beam assisted modification and joining, Ion beam assisted microstructure and compositional modification, Surface engineering by spray techniques: Flame spray, Plasma coating.

References:

1. W. Gaddand, D. Brenner, S. Lysherski and G. J. Infrate (Eds), Handbook of nanoscience, Engg. and Technology, CRC Press, (2002).

2. G. Cao, Naostructures and Nanomaterials: Synthesis, properties and applications, Imperical College Press, (2004).
3. J. George, Preparation of thin films, Marcel Dekker, InC., New York, (2005).
4. Ghuzang G.Cao, Naostructures and Nanomaterials: Synthesis, properties and applications, Imperical College Press, (2004).
5. Zhong Lin Wang, Hand Book of Nanophase & Nanostructured materials (Vol. I & II), Springer, (2002).
6. B.D. Cullity, Elements of X-ray diffraction, Addison Wesley, (1977).
7. K.G. Budinski, Surface Engineering for Wear Resistances, Prentice Hall, Englewood Cliffs, (1988).
8. M. Ohring, The Materials Science of Thin Films, Academic Press Inc, (2005).

19-205-0812:MECHANICS OF COMPOSITE MATERIALS

Course Outcomes:
On completion of this course, the students will be able to:

1. Review definitions of stress, strain, elastic moduli and strain energy
2. Develop stress-strain relationships for laminate
3. Establish the failure criteria for laminates.
4. Analyze the vibration characteristics of composite structures

Module 1
Introduction to Composite Materials Constituents, Material forms Processing, Applications Definition –Need – General Characteristics, Applications. Fibers – Glass, Carbon, Ceramic and Aramid fibers. Matrices – Polymer, Graphite, Ceramic and Metal Matrices – Characteristics of fibers and matrices.
Lamina Constitutive Equations: Lamina Assumptions – Macroscopic Viewpoint. Generalized Hooke's Law. Reduction to Homogeneous Orthotropic Lamina – Isotropic limit case, Orthotropic Stiffness matrix (Qij), Typical Commercial material properties, Rule of Mixtures. Generally Orthotropic Lamina –Transformation Matrix, Transformed Stiffness.

Module 2
Definition of stress and moment Resultants. Strain Displacement relations. Basic Assumptions of Laminated anisotropic plates. Laminate Constitutive Equations – Coupling Interactions, Balanced Laminates, Symmetric Laminates, Angle Ply Laminates, Cross Ply Laminates. Laminate Structural Moduli.Evaluation of Lamina Properties from Laminate Tests.Quasi-Isotropic Laminates. Determination of Lamina stresses within Laminates.

Module 3
Introduction - Maximum Stress and Strain Criteria.Von-Misses Yield criterion for Isotropic Materials. Generalized Hill's Criterion for Anisotropic materials. Tsai-Hill's Failure Criterion for Composites. Tensor Polynomial (Tsai-Wu) Failure criterion. Prediction of laminate Failure
Equilibrium Equations of Motion.Energy Formulations.Static Bending Analysis.Buckling Analysis. Free Vibrations – Natural Frequencies

Module 4
Modification of Hooke's Law due to thermal properties - Modification of Laminate Constitutive Equations. Orthotropic Lamina - special Laminate Configurations – Unidirectional, Off-axis, Symmetric Balanced Laminates - Zero C.T.E laminates, Thermally Quasi-Isotropic Laminates

Reference:
1. Jones, R.M., "Mechanics of Composite Materials", McGraw-Hill, Kogakusha Ltd., Tokyo, 1985.
2. Agarwal, B.D., and Broutman, L.J., "Analysis and Performance of Fibre Composites", John Wiley and sons. Inc., New York, 1995.
3. Hyer, M.W., "Stress Analysis of Fiber-Reinforced Composite Materials", McGraw-Hill, 1998.
4. Mechanics of Composite Materials, Autar K. Kaw, 2nd ed., CRC Press, 2006
5. Engineering Mechanics of Composite Materials, I. M. Daniel, O. Ishai, Oxford University Press, 2006.

19-205-0813:ENGINEERING ECONOMICS, ESTIMATION AND COSTING

Course Outcomes:
On completion of this course, the students will be able to:
1. Acquire an insight of economics in general, economics of India particularly for public sector agencies and private sector businesses
2. Perform and evaluate present worth, future worth and annual worth analyses on one of more economic alternatives.
3. Carry out and evaluate benefit/cost, life cycle and breakeven analyses on one or more economic alternatives.
4. Understand the technical specifications for various works to be performed for a project and how they impact the cost of a structure.
5. Quantify the worth of a structure by evaluating quantities of constituents, derive their cost rates and build up the overall cost of the structure.
6. Understand how competitive bidding works and how to submit a competitive bid proposal.

Module 1
Basic Principles and Methodology of Economics, Demand/Supply – elasticity –Government Policies and Application, Theory of the Firm and Market Structure, Basic Macro-economic Concepts (including GDP/GNP/NI/Disposable Income) and Identities for both closed and open economies, Aggregate demand and Supply (IS/LM), Price Indices (WPI/CPI), Interest rates, Direct and Indirect Taxes.
Public Sector Economics –Welfare, Externalities, Labour Market, Components of Monetary and Financial System, Central Bank – Monetary Aggregates; Commercial Banks and their functions; Capital and Debt Markets, Monetary and Fiscal Policy Tools and their impact on the economy – Inflation and Phillips Curve.

Module II
Elements of Business/Managerial Economics and forms of Organizations, Cost & Cost Control –Techniques, Types of Costs, Lifecycle costs, Budgets, Break even Analysis, Capital Budgeting, Application of Linear Programming, Investment Analysis – NPV, ROI, IRR, Payback Period, Depreciation, Time value of money (present and future worth of cash flows), Business Forecasting – Elementary techniques. Statements – Cash flow, Financial. Case Study Method.
Indian economy - Brief overview of post-independence period – plans, Post reform Growth, Structure of productive activity, Issues of Inclusion – Sectors, States/Regions, Groups of people (M/F), Urbanization, Employment–Informal, Organized, Unorganized, Public, Private, Challenges and Policy Debates in Monetary, Fiscal, Social, External sectors.

Module III
Estimation / Measurements for various items- Introduction to the process of Estimation; Use of relevant Indian Standard Specifications for the same, Taking out quantities from the given requirements of the work, Comparison of different alternatives, Bar bending schedules, Mass haul Diagrams, Finishes, Interiors, MEP works; BIM and quantity take-offs; Adding equipment costs; Labour costs; Rate analysis; Material survey-Thumb rules for computation of materials requirement for different applications, Percentage break-up of the cost, Cost sensitive index, Market survey of basic materials, Use of computers in quantity surveying.
Specifications-Types, Requirements and importance, Detailed specifications for industrial structures.

Module IV
Rate analysis-Purpose, Importance and necessity of the same, Affecting factors, Task work, Daily output from different equipment/ productivity.

Tender- Preparation of tender documents, Importance of inviting tenders, Contract types, Relative merits, Prequalification, General and special conditions, Termination of contracts, Extra work and changes, Penalty and liquidated charges, Settlement of disputes, R.A. Bill & Final Bill, Payment of advance, insurance, Claims, Price variation, etc. Preparing Bids- Bid Price buildup: Material, Labour, Equipment costs, Risks, Direct & Indirect Overheads, Profits; Bid conditions, alternative specifications; Alternative Bids. Bid process management. Introduction to Acts pertaining to-Minimum wages, Workman's compensation, Contracts, Arbitration, Easement rights.

References:

1. Mankiw Gregory N., Principles of Economics, Thompson Asia, (2002).
2. Mote V, Paul S, Gupta G., Managerial Economics, Tata McGraw Hill (2004).
3. Misra, S. K. and Puri, Indian Economy, Himalaya (2009).
4. Pareek Saroj, Textbook of Business Economics, Sunrise Publishers, (2003).
5. Chakravarty M., Estimating, Costing Specifications & Valuation, Universal book, (2010).
6. Dutta, B. N., Estimating and Costing (Theory & Practice), UBS Publishers, (2016).

19-200-0814 CONSTITUTIONAL LAW

Course Outcomes:

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

1. Configure the preamble and fundamental rights.
2. Actuate the governance and functioning of constitutional functionaries.
3. Describe the functions of legislative bodies.
4. Decipher the judiciary system and its role in governance.

Module I: Introduction

Constitution Law – Constitutional Assembly Debates – Constitution of India – Basic Features of Indian Constitution – Preamble – Structure and Content of Indian Constitution

Module II: Fundamental Rights

Rights – Fundamental Rights – Definition of State – Fundamental Rights under Indian Constitution – Right to Equality – Untouchability – Title – Right to Life Cultural and Educational Rights of Minorities - Enforcement of Fundamental Rights

Module III: Directive Principles of State Policy & Fundamental Duties

DPSP's – Relationship between DPSP and Fundamental Rights – Conversion of DPSP into Fundamental Rights – Role of Judiciary – Judicial Activism – PIL - Fundamental Duties

Module IV: Constitutional Organs

Legislative Organs – Parliament – Lok Sabha, Rajya Sabha - State Legislatures - Executive Organs - President, Vice President, Council of Ministers - Judicial Organs – Supreme Court and High Courts – Other Constitutional Bodies – Election Commission - Comptroller and Auditor General of India, etc.

References:

1. Durga Das Basu, Introduction to the Constitution of India, 24th Edition. Prentice – Hall of India Pvt. Ltd.New Delhi, 2019.
2. D.C. Gupta, Indian Government and Politics, 8th Edition. Vikas Publishing House, 2018.
3. H.M.Sreevai, Constitutional Law of India, 4th edition in 3 volumes. Universal Law Publication, 2015.

19-205-0815:SEMINAR

Course Outcomes:

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

1. Identify and familiarize with some of the good publications and journals in their field of study.
2. Acquaint oneself with preparation of independent reports, name them based on a central theme and write abstracts, main body, conclusions and reference identifying their intended meaning and style.
3. Understand effective use of tools of presentation, generate confidence in presenting a report before an audience and improve their skills in the same.
4. Develop skills like time management, leadership quality and rapport with an audience.

Students shall individually prepare and submit a seminar report on a topic of current relevance related to the field of Mechanical Engineering. The reference shall include standard journals, conference proceedings, reputed magazines and textbooks and technical reports. The references shall be incorporated in the report following International standards reflecting the state-of-the-art in the topic selected. Each student shall present a seminar for about 30 minutes duration on the selected topic. The report and presentation shall be evaluated by a team of internal experts comprising of 3 teachers based on style of presentation, technical content, adequacy of references, depth of knowledge and overall quality of the seminar report.

19-205-0816:PROJECT PHASE II

Course Outcomes:
On completion of this course the student will be able to:
1. Realize various steps involved in conducting a project work, like literature survey, methodology adopted – field study / survey / experiments / numerical work, analysis of the data to arrive at final results and conclusions, etc.
2. Initiate a habit of proper report writing with all of its major components, proper style of writing and preparation of a distinct abstract and carved out conclusions.
3. Conceive the pros and cons of working in a team and the wonderful results which could evolve through team-work.
4. Present and defend self-prepared and corrected report (with the help of project guide) of a self-created work to a peer audience.

Each batch of students shall develop the project designed during the VII semester. The implementation phase shall proceed as follows:

- A detailed project report in the prescribed format shall be submitted at the end of the semester. All test results and relevant design and engineering documentation shall be included in the report.
- The work shall be reviewed and evaluated periodically

A committee consisting of the Project Coordinator (appointed by the Head of the Department / Division), project guide and at least one senior faculty member will carry out the assessment based on at least one interim review and a final review just before the submission of the project report.

The final evaluation of the project shall include the following.
Presentation of the work
Oral examination
Demonstration of the project against design specifications
Quality and content of the project report.

Guidelines for evaluation:

1.	Regularity and progress of work	20
2.	Work knowledge and Involvement	50
3.	Semester End presentation and oral examination	50
4.	Level of completion & demonstration of Functionality / Specifications	50
5.	Project Report – Presentation style and content	30
Total		**200** Marks

Note: *Points (1) and (2) to be evaluated by the respective project guide and the project coordinator based on continuous evaluation. (3)-(5) to be evaluated by the final evaluation team.*

19-205-0817:COMPREHENSIVE VIVA - VOCE

Course Outcomes:

The student will be able to:

1. Refresh all the subjects covered during the programme
2. Gain good knowledge of theory and practice
3. Develop oral communication skills and positive attitude
4. Face technical interviews with confidence

Each student is required to appear for a comprehensive viva-voce examination at the end of the complete course work. The examination panel shall comprise of a minimum of one internal examiner and one external examiner, both appointed by the University. The examiners shall evaluate the students in terms of their conceptual grasp of the entire course of study and practical/analysis skills in the field.