Curriculum for Undergraduate Degree (B.Tech.) in Mechanical Engineering (w.e.f. AY: 2020-21)

Part III: Detailed Curriculum

Fourth Semester

Course Name:	**Numerical Methods**		
Course Code:	BS-M 404	**Category:**	Basic Science
Semester:	Fourth	**Credit:**	2
L-T-P:	2-0-0	**Pre-Requisites:**	Nil
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	To have knowledge in different numerical methods and approximate methods
2	To gain knowledge about solving different form of differential equations
3	To compute different numerical errors in computations.
4	To learn interpolation techniques.

Course Contents:

Module No.	Description of Topic/ Experiment	Contact Hrs.
1	**Approximation in numerical computation:** Truncation and rounding errors, Fixed and floating-point arithmetic, Propagation of errors.	2L
2	**Interpolation:** Newton's Forward Interpolation, Newton's Backward Interpolation, Lagrange's Interpolation, Newton's Divided Difference Interpolation	4L
3	**Numerical integration:** General Quadrature Formula, Trapezoidal Rule, Simpson's 1/3 Rule, Expression for corresponding error terms	3L
4	**Numerical solution of a system of linear equations:** Gauss Elimination Method, Matrix Inversion, LU Factorization Method, Gauss-Seidel Iterative Method	6L
5	**Numerical solution of Non-Linear equation:** Bisection Method, Regula-Falsi Method, Newton-Raphson Method	4L
6	**Numerical solution of ordinary differential equation:** Euler's Method, Runge-Kutta Methods, Predictor-Corrector Methods, Finite Difference Method	5L
7	**Measure of Central Tendency and Dispersion:** Mean, median, mode and S.D.	3L

8	**Curve Fitting by Method of Least Square:** Fitting a straight line of the form $y = a + bx$, Fitting a curve of the form $y = ax + bx^2$, $y = ab^x$, $y = ae^{bx}$, $y = ax^b$.	3L
Total		**30L**

Course Outcomes:
After completion of the course, students will be able to:
1. Demonstrate understanding of common numerical methods and how they are used to obtain approximate solutions to otherwise intractable mathematical problems. 2. Apply numerical methods to obtain approximate solutions to mathematical problems. 3. Derive numerical methods for various mathematical operations and tasks, such as interpolation, differentiation, integration, the solution of linear and nonlinear equations, and the solution of differential equations. 4. Analyse and evaluate the accuracy of common numerical methods.

Learning Resources:	
1	Grewal, B. S., 2013, Numerical Methods in Engineering Science, 11th Ed., Khanna Publishers.
2	Gupta, R. K., 2019, Numerical Methods: Fundamentals and Applications, 1st Ed., Cambridge Publishers.
3	Sastry, S. S., 2012, Introductory Methods of Numerical Analysis, 5th Ed., Prentice Hall India Learning Pvt. Ltd.
4	A. K. Jalan and Utpal Sarkar, Numerical Methods-A Programming Based Approach, Orient Blackswan Private Ltd.
5	Jain, Iyengar , & Jain: Numerical Methods (Problems and Solution)
6	N. Dutta: Computer Programming & Numerical Analysis, Universities Press.

Course Name:	**Applied Thermodynamics**		
Course Code:	PC-ME 401	**Category:**	Professional Core Course
Semester:	Fourth	**Credit:**	4
L-T-P:	3-1-0	**Pre-Requisites:**	Nil
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	To learn about of I law for reacting systems and heating value of fuels
2	To learn about gas and vapor cycles and their first law and second law efficiencies
3	To understand about the properties of dry and wet air and the principles of psychrometry
4	To learn about gas dynamics of air flow and steam through nozzles

5	To learn the about reciprocating compressors with and without intercooling
6	To analyze the performance of steam turbines

Course Contents:		
Module No.	**Description of Topic/ Experiment**	**Contact Hrs.**
1	**Module 1:** Introduction to solid, liquid and gaseous fuels– Stoichiometry, exhaust gas analysis- First law analysis of combustion reactions- Heat calculations using enthalpy tables- Adiabatic flame temperature- Chemical equilibrium and equilibrium composition calculations using free energy.	8L
2	**Module 2:** Vapor power cycles Rankine cycle with superheat, reheat and regeneration, exergy analysis. Super-critical and ultra-super-critical Rankine cycle- Gas power cycles, Air standard Otto, Diesel and Dual cycles-Air standard Brayton cycle effect of reheat, regeneration and intercooling- Combined gas and vapor power cycles- Vapor compression refrigeration cycles, refrigerants and their properties.	12L
3	**Module 3:** Properties of dry and wet air, use of pschyrometric chart, processes involving heating/cooling and humidification/dehumidification, dew point.	4L
4	**Module 4:** Basics of compressible flow. Stagnation properties, Isentropic flow of a perfect gas through a nozzle, choked flow, subsonic and supersonic flows- normal shocks- use of ideal gas tables for isentropic flow and normal shock flow- Flow of steam and refrigerant through nozzle, super saturation- compressible flow in diffusers, efficiency of nozzle and diffuser.	8L
5	**Module 5:** Reciprocating compressors, staging of reciprocating compressors, optimal stage pressure ratio, effect of intercooling, minimum work for multistage reciprocating compressors.	5L
6	**Module 6:** Analysis of steam turbines, velocity and pressure compounding of steam turbines	3L
Total		**40L**

Course Outcomes:
After completion of the course, students will be able to:
1. After completing this course, the students will get a good understanding of various practical power cycles and heat pump cycles. 2. They will be able to analyze energy conversion in various thermal devices such as combustors, air coolers, nozzles, diffusers, steam turbines and reciprocating compressors.

3.	They will be able to understand phenomena occurring in high speed compressible flows

Learning Resources:	
1	Sonntag, R. E, Borgnakke, C. and Van Wylen, G. J., 2003, 6th Edition, Fundamentals of Thermodynamics, John Wiley and Sons.
2	Jones, J. B. and Duggan, R. E., 1996, Engineering Thermodynamics, Prentice-Hall of India
3	Moran, M. J. and Shapiro, H. N., 1999, Fundamentals of Engineering Thermodynamics, John Wiley and Sons.
4	Nag, P.K, 1995, Engineering Thermodynamics, Tata McGraw-Hill Publishing Co. Ltd

Course Name:	**Fluid Mechanics & Fluid Machines**		
Course Code:	PC-ME 402	**Category:**	Professional Core Course
Semester:	Fourth	**Credit:**	4
L-T-P:	3-1-0	**Pre-Requisites:**	Nil
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	To learn about the application of mass and momentum conservation laws for fluid flows
2	To understand the importance of dimensional analysis
3	To obtain the velocity and pressure variations in various types of simple flows
4	To analyze the flow in water pumps and turbines.

Course Contents:

Module No.	Description of Topic/ Experiment	Contact Hrs.
1	**Module 1:** Definition of fluid, Newton's law of viscosity, Units and dimensions-Properties of fluids, mass density, specific volume, specific gravity, viscosity, compressibility and surface tension, Control volume-application of continuity equation and momentum equation, Incompressible flow, Bernoulli's equation and its applications.	9L
2	**Module 2:** Exact flow solutions in channels and ducts, Couette and Poisuielle flow, laminar flow through circular conduits and circular annuli- concept of boundary layer – measures of boundary layer thickness – Darcy Weisbach equation, friction factor, Moody's diagram, (open channel flow)	9L

3	**Module 3:** Need for dimensional analysis – methods of dimension analysis – Similitude – types of similitude Dimensionless parameters – application of dimensionless parameters – Model analysis.	6L
4	**Module 4:** Euler's equation – theory of Rotodynamic machines – various efficiencies – velocity components at entry and exit of the rotor, velocity triangles – Centrifugal pumps, working principle, work done by the impeller, performance curves – Cavitation in pumps- Reciprocating pump – working principle.	8L
5	**Module 5:** Classification of water turbines, heads and efficiencies, velocity triangles- Axial, radial and mixed flow turbines- Pelton wheel, Francis turbine and Kaplan turbines, working principles – draft tube- Specific speed, unit quantities, performance curves for turbines – governing of turbines.	8L
Total		**40L**

Course Outcomes:
After completion of the course, students will be able to:
1. Upon completion of this course, students will be able to mathematically analyze simple flow situations. 2. They will be able to evaluate the performance of pumps and turbines.

Learning Resources:	
1	Fluid Mechanics and Machinery, R.K.Bansal, Laxmi Publication.
2	Introduction to Fluid Mechanics & Fluid Machines, Som and Biswas, TMH.
3	A Textbook on Fluid Mechanics and Machines, S.Pati, McGrawHill.
4	Fluid Mechanics and Machinery, C.S.P.Ojha, R. Berndtsson and P. N. Chadramouli, Oxford University Press, 2010.
5	Hydraulics and Fluid Mechanics, P M Modi and S M Seth, Standard Book House.

Course Name:	**Strength of Materials**		
Course Code:	PC-ME 403	**Category:**	Professional Core Course
Semester:	Fourth	**Credit:**	4
L-T-P:	4-0-0	**Pre-Requisites:**	Nil
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	To understand the nature of stresses developed in simple geometries such as bars,

	cantilevers, beams, shafts, cylinders and spheres for various types of simple loads.
2	To calculate the elastic deformation occurring in various simple geometries for different types of loading.

Course Contents:		
Module No.	**Description of Topic/ Experiment**	**Contact Hrs.**
1	**Module 1:** Deformation in solids- Hooke's law, stress and strain- tension, compression and shear stresses- elastic constants and their relations- volumetric, linear and shear strains- principal stresses and principal planes- Mohr's circle.	8L
2	**Module 2:** Beams and types transverse loading on beams- shear force and bending moment diagrams- Types of beam supports, simply supported and over-hanging beams, cantilevers. Theory of bending of beams, bending stress distribution and neutral axis, shear stress distribution, point and distributed loads.	8L
3	**Module 3:** Moment of inertia about an axis and polar moment of inertia, deflection of a beam using double integration method, computation of slopes and deflection in beams, Maxwell's reciprocal theorems.	8L
4	**Module 4:** Torsion, stresses and deformation in circular type: solid and hollow shafts, stepped shafts, deflection of shafts fixed at both ends, stresses and deflection of helical springs.	8L
5	**Module 5:** Axial and hoop stresses in cylinders subjected to internal pressure, deformation of thick and thin cylinders, deformation in spherical shells subjected to internal pressure, Column and struts.	8L
Total		**40L**

Course Outcomes:
After completion of the course, students will be able to:
1. Solve problems related to the theory of elasticity, concepts of stress and strain, strength and stiffness, deformations and displacements, strain energy, torsion and springs. 2. Analyze Mohr's circle for an arbitrary two dimensional stress/strain state for combined loading conditions and stresses in thin walled pressure vessels. 3. Identify and formulate structural problem and solve using a range of analytical methods and determination of internal actions in statically determinate structures and draw internal action diagrams like Shear Force (SFD) and Bending Moment Diagrams (BMD) for these structures. 4. Solve deflection of statically determinate and indeterminate beams due to bending moment by different methods. 5. Predict behaviour of the solid bodies subjected to certain types of loading and theories

related to columns and struts.

Learning Resources:	
1	Ferdinand P. Beer, Russel Johnson Jr and John J. Dewole, Mechanics of Materials, Tata McGraw Hill Publishing Co. Ltd., New Delhi 2005.
2	R. Subramanian, Strength of Materials, Oxford University Press, 2007.
3	S S Rattan (2017), Strength of Materials, McGraw Hill Education.

Course Name:	**Metrology and Instrumentation**		
Course Code:	PC-ME 404	**Category:**	Professional Core Course
Semester:	Fourth	**Credit:**	4
L-T-P:	4-0-0	**Pre-Requisites:**	Nil
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	To understand the working of linear and angular measuring instruments.
2	To familiarize with the working of optical measuring instruments and fundamentals of limits and limit gauges.
3	To give basic idea about various methods for measurement of screw thread and surface finish parameters.
4	To give an exposure to advanced measuring devices and machine tool metrology.
5	To provide students an overview of mechanical measurement systems and principle of instruments for motion and dimension measurement.
6	To provide basic idea about working principle and applications of devices for measurement of force and torque; strain and stress and temperature.

Course Contents:		
Module No.	**Description of Topic/ Experiment**	**Contact Hrs.**
1	**Module 1:** Concept of measurement:-Introduction to Metrology; Need for high precision measurements; Terminologies in Measurement- Precision, accuracy, sensitivity, calibration, resolution. Errors in Measurement, types of errors, Abbe's Principle. Basic standards of length- Line standard, End standards, Wavelength standard; Various Shop floor standards. Linear Measurement – Slip gauges, wringing, grades; Surface plate; Dial indicators; Height gauges and Vernier calliper; screw gauge. Comparators- mechanical, electrical, optical and	8L

	pneumatic. Angular Measurement – Bevel protractor; Sine Bar, principle and use of sine bar, sine centre; Angle gauges. Sprit level; Angle Dekkor; Clinometers.	
2	**Module 2:** Limits and Limit gauges – Making to suit, selective assembly, systems of limits and fits; Types of fits; Hole basis system and Shaft basis system. Tolerance, allowance and deviation (as per BIS). Limit Gauges – GO and NO GO gauges; types of limit gauges. Gauge design - Taylor's principle of gauging; Gauge tolerance, disposition of gauge tolerance, wear allowance. Optical Measuring Instruments: - Benefits of light waves as standards; Monochromatic light; Principle of Interference. Interference band, optical flat, surface measurement. Interferometers – NPL, Pitter-NPL, auto collimator.	8L
3	**Module 3:** Screw thread measurement – Screw thread terminology; Measurement of major diameter; root diameter; pitch; effective diameter with two wire method and three wire method. Measurement of flank angle and form by profile projector and microscope. Measurement of surface texture – roughness and waviness; Analysis of surface traces, peak to valley height, R.M.S. value, Centre Line Average and Ra value, Rt, Rz etc. Methods of measuring surface roughness – Stylus probe, Tomlinson surface meter, Talysurf; surface roughness measurement – assessment length, roughness width cut-off, sampling length and evaluation length.	8L
4	**Module 4:** Introduction to Digital Measurement – significance of Digital measurement; methods; Classification. Stages in generalized measuring system – Sensor-Transducer stage, Signal-Conditioning stage, Readout-Recording stage; Types of input quantities; Active and Passive transducers. Performance characteristic of measuring devices. Drift, Resolution, Threshold, Hysteresis, Static calibration. Dynamic characteristics- different order systems and their response-, Measuring lag, Fidelity, Dynamic error; Transducers – Working, Classification of transducers. Motion and Dimension measurement – LVDT – Principle, applications, advantages and limitations.	8L
5	**Module 5:** Strain and Stress Measurement - Electrical resistance strain gauge - Principle, operation. Measurement of Force and Torque – Strain-Gauge Load Cells, Hydraulic and Pneumatic load cells – force measurement using piezoelectric quartz crystal. Torque Measurement – Dynamometers – Mechanical, Hydraulic and Electrical. Vibration measurement – Vibrometers and Accelerometers. Temperature Measurement – Use of Thermal Expansion – Liquid-in-glass thermometers, Bimetallic strip thermometer, Pressure thermometers. Thermocouples – Resistance Temperature Detectors (RTD); Thermistors; Pyrometers.	8L
Total		**40L**

Course Outcomes:
After completion of the course, students will be able to:
1. Understand the working of linear and angular measuring instruments. 2. Know the fundamentals of limits and limit gauges, various methods for measurement of screw thread and surface roughness parameters and the working of optical measuring instruments. 3. Acquire an overview of mechanical measurement systems and principle of instruments for motion and dimension measurement. 4. Get basic idea about working principle and applications of devices for measurement of force and torque; strain and stress and temperature.

Learning Resources:	
1	Anand K Bewoor, Vinay A Kulkarni, Metrology & Measurement, McGraw-Hill, 2009
2	Ernest O. Doebelin, Dhanesh N. Manik, Measurement Systems Application and Design, McGraw-Hill, 2004
3	Galyer J.F.W., Schotbolt C.R., Metrology for Engineers, ELBS,1990
4	Thomas G. Beckwith, John H. L., Roy D. M., Mechanical Measurements, 6/E, Pearson Prentice Hall, 2007
5	R.K. Rajput, Mechanical Measurements & Instrumentation, S.K.Kataria & Sons.
6	R. K. Jain, Engineering Metrology, Khanna Publishers.

Course Name:	**Environmental Science**		
Course Code:	MC 471	**Category:**	Mandatory Course
Semester:	Fourth	**Credit:**	0
L-T-P:	2-0-0	**Pre-Requisites:**	Basic concepts of Environmental Science
Full Marks:	100		
Examination Scheme:	End sem evaluation on 100 marks basis		

Course Objectives:	
1	Purpose: We as human being are not an entity separate from the environment around us rather we are a constituent seamlessly integrated and co-exist with the environment around us. We are not an entity so separate from the environment that we can think of mastering and controlling it rather we must understand that each and every action of ours reflects on the environment and vice versa. Ancient wisdom drawn from Vedas about environment and its sustenance reflects these ethos. There is a direct application of this wisdom even in modern times.
2	Idea of an activity based course on environment protection is to sensitize the students on the above issues through following two type of activities.

Course Contents:
Topic: Population Growth, Resource conservation and Recycling, Sustainable Development, Green house effect and consequences, Air pollution and Control, Water pollution and control, Water Resource management, Biodiversity, Noise pollution and control, Soil erosion **(a) Awareness Activities:** i) Small group meetings about any of the topic. ii) Slogan making event iii) Poster making event iv) Seminar on any of the topic. v) Preparation of a report on any of the topic regarding current scenario. **(b) Actual Activities:** i) Plantation ii) Gifting a tree to see its full growth iii) Cleanliness drive iv) Drive for segregation of waste v) Shutting down the fans and ACs of the campus for an hour or so

Course Outcomes:
After completion of the course, students will be able to:
Learn the importance of environment by gaining knowledge of real time experience.

Learning Resources:	
1	M.P. Poonia & S.C. Sharma, Environmental Studies, Khanna Publishing House, New Delhi, 2019
2	Environmental science by Gillbert G. Master

Course Name:	**Metrology and Instrumentation Lab**		
Course Code:	PC-ME 491	**Category:**	Professional Core Course
Semester:	Fourth	**Credit:**	1.5
L-T-P:	0-0-3	**Pre-Requisites:**	Nil
Full Marks:	100		
Examination Scheme:	Semester Examination: 60	Continuous Assessment: 35	Attendance: 05

Course Objectives:	
1	To make students aware of measurement techniques in different manufacturing processes.

2	To recognize the procedure of different system measurement techniques.

Course Contents:		
Module No.	**Description of Topic/ Experiment**	**Contact Hrs.**
1	Measurement of given sample using different Instrument, and Gauges.	6P
2	Measurement of angles, thread, internal and external radius, etc. using different gauges.	3P
3	Measurement of bore diameter using micrometer and gauge.	6P
4	Measurement of angles using bevel vernier protractor.	3P
5	Measurement of tapered objects using Sine Bar and using balls and rollers, etc.	3P
6	Measurement of effective diameter with the help of screw pitch micrometer.	3P
7	Measurement of gears.	3P
8	Measurement of surface roughness.	3P
9	Measurement of testing sand: Moisture content, permeability, grain fineness number, strength measurement and core hardness testing.	6P
Total		**36P**

Course Outcomes:
After completion of the course, students will be able to:
1. Demonstrate the use of instruments for measuring linear (internal and external), angular dimensions. 2. Formulate some unknown quantity or parameter of engineering interest. 3. Evaluate the surface quality of a given specimen which is important in all kind of manufacturing. 4. Measure different variables of a component.

Learning Resources:	
1	Laboratory manual

Course Name:	**Machine Drawing- I**		
Course Code:	PC-ME 492	**Category:**	Professional Core Course
Semester:	Fourth	**Credit:**	1.5
L-T-P:	0-0-3	**Pre-Requisites:**	Nil
Full Marks:	100		
Examination Scheme:	Semester Examination: 60	Continuous Assessment: 35	Attendance: 05

Course Objectives:	
1	To make students aware of different symbolic operations related to machine drawing utilized in Engineering sectors.
2	To make students aware of CAD software (AUTOCAD) for isometric and orthographic projection views.

Course Contents:		
Module No.	**Description of Topic/ Experiment**	**Contact Hrs.**
1	Introduction for identification of product symbols of standard components in mechanical, civil, electrical, electronic systems etc.	3P
2	Orthographic projections of machine elements, different sectional views- full, auxiliary sections	6P
3	Isometric projection of components; Assembly and detailed drawings of a mechanical assembly	6P
4	Introduction to AUTOCAD	3P
5	Assembly drawing of Screw jack	3P
6	Assembly drawing of Plummer block	3P
7	Assembly drawing of Clapper box	3P
8	Assembly drawing of Knuckle joint	3P
9	Assembly drawing of Tailstock of a lathe	3P
10	Assembly drawing of Steam Stop valve	3P
Total		**36P**

Course Outcomes:
After completion of the course, students will be able to:
Understand the symbolic operations utilized in Engineering sector and able to design components in AUTOCAD software.

Learning Resources:	
1	Laboratory manual