Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Semester-VII

Fourth Year Seventh Semester							
Sl. No.	**Category**	**Subject Code**	**Subject Name**	**Total Number of contact hours**			**Credits**
				L	**T**	**P**	
Theory							
1	Professional Core courses	PC-ME701	Advanced Manufacturing Technology	3	0	0	3
2	Professional Elective courses	PE-ME701	Elective III	3	0	0	3
3	Professional Elective courses	PE-ME702	Elective-IV	3	0	0	3
4	Open Elective courses	OE-ME701	Open Elective- I	3	0	0	3
5	Humanities and Social Sciences including Management courses	HM-HU701	Economics for Engineers	2	0	0	2
	Total Theory			**14**	**0**	**0**	**14**
Practical/ Sessional							
1	Professional Core courses	PC-ME791	Mechanical Engineering Laboratory III (Manufacturing)	0	0	3	1.5
2	Project	PW-ME781	Project-III	0	0	6	3
	Total Practical			**0**	**0**	**9**	**4.5**
	Total of Seventh Semester			**14**	**0**	**9**	**18.5**

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List of Professional Electives in Semester VII for (Elective-III) PE-ME701 and (Elective-IV) PE-ME702

Subject Code	Subject name
Thermo-Fluid Group	
A	Automobile Engineering
B	Gas Dynamics and Jet Propulsion
C	Computational Fluid Dynamics
D	Elements of Atmospheric Fluid Dynamics
Design Group	
E	Selection and Testing of Materials
F	Mechanical Vibration
G	Finite Element Analysis
Manufacturing Group	
H	Advanced Welding Technology
I	Quantity Production Methods
J	CAD/CAM

List of Open Electives (OE-ME701) in Semester VII

Subject Code	Subject Name
A	Industrial Engineering
B	Project Management
C	Introduction to Product Design and Development
D	Non-conventional Energy Sources
E	Biomechanics and Biomaterials
F	Computational Methods in Engineering
G	Artificial Intelligence (AI)
H	Machine Learning
I	Water Resource Engineering

Note: If a student chooses the paper, **Industrial Engineering (Code: A)** as an **Open Elective-I in Semester VII**, its paper code will be **OE-ME701A**.

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Subject Code: PC-ME701	**Category:** Professional Core Courses
Subject Name: Advanced Manufacturing Technology	**Semester**: Seventh
L-T-P: **3-0-0**	**Credit: 3**
Pre-Requisites: Manufacturing Processes, Manufacturing Technology	

Course Objectives:

To introduce principles of material removal mechanism of advanced machining processes such as mechanical, electro-chemical and thermal.

To give basic understanding of the machining capabilities, limitations, and productivity of advanced manufacturing technologies.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	**Mechanical Advanced Machining Processes:** Need and classification of nontraditional machining processes – Material removal in traditional and nontraditional machining processes - considerations in process selection. Ultrasonic machining – Working principle, mechanism of metal removal – Theory of Shaw, elements of the processes, tool feed mechanism, effect of parameters, applications and numerical. Abrasive jet machining, Water jet machining and abrasive water jet machine - Basic principles, equipments, process variables, mechanics of metal removal, MRR, application and limitations.	6
2	**Electro–Chemical Processes:** Principle of ECM process, chemistry of the ECM processes, Parameters of the process, determination of the metal removal rate, dynamics of ECM process, polarization, tool design, advantages and disadvantages, application, electrochemical grinding, electrochemical honing, electrochemical deburring, Application of ECM for deep hole drilling - electrostream drilling and shaped tube electrolytic machining. Chemical machining - Fundamental principle, types of chemical machining, maskants, etchants, advantages, disadvantages, applications	6
3	**Electric Discharge Machining:** Working principle of EDM, Power circuits for EDM - RC pulse generator and controlled pulse generator– Analysis of R-C Circuits – Mechanics of metal removal in EDM, Process parameters, selection of tool electrode and dielectric fluids, surface finish and machining accuracy, characteristics of spark eroded surface and recent development in EDM. Wire EDM – Working principle, process variables, process characteristics and applications. Electric discharge grinding and electric discharge diamond grinding - working principle, process capabilities and applications.	6

4	**Laser, Electron Beam, Ion Beam and Plasma Arc Machining:** General working principle of laser beam machining – Generation of Laser, types of Lasers, process characteristics and applications. Electron Beam Machining - Equipment for production of Electron Beam, theory of EBM, thermal and non-thermal type, process characteristics and applications. Ion Beam Machining - Mechanism of metal removal and associated equipments, process characteristics and applications. Plasma Arc Machining - Metal removal mechanism, process parameters, process characteristics, types of torches, applications.	6
5	**Advanced Finishing Processes:** Abrasive flow Machining (AFM)- working principle, AFM system, process variables, process performance and applications. Magnetic abrasive finishing (MAF)- working principle, MAF system, material removal and surface finish, process variables and applications. Chemomechanical polishing, working principle, material removal and surface finish and applications.	6
6	**Micro-Machining:** Need- evolution- fundamentals and trends in micro technologies- Consequences of the technology and society- challenges to manufacturing technology- evolution of precision in manufacturing, tooling and current scenario, requirements and applications Theory of micromachining- Chip formation- Size effect in micromachining- microturning- microdrilling.	6

Course Outcomes:
Student will be able
1. To understand non- traditional machining processes and the effect of process parameters
2. To differentiate the various non-traditional machining processes
3. To demonstrate micromachining technology

Learning Resources:
1. A. Ghosh and A.K. Mallik, Manufacturing Science, Affiliated East west Press Ltd, 2001.
2. V.K. Jain, Advanced Machining Processes, Allied Publishers Pvt. Ltd. 2002
3. H. El-Hofy, Advanced Machining Processes, McGraw-Hill, New York, 2005.
4. G.F. Benedict, Nontraditional Machining Processes, Marcel Dekker Inc., New York, 1987.
5. J.A. McGeough, Advanced Machining Methods, Chapman and Hakk, London, 1988.
6. M. Adithan, Modern Machining Methods, Khanna Publishers, New Delhi, 2008.
7. P.K. Mishra, Nonconventional Machining, The Institution of Engineers (India) Text Book Series, Narosa Publishing House, New Delhi, 1997.
8. P.C. Pandy and H.S. Shan, Modern Machining Processes, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1980.
9. V. K. Jain, Introduction to Micromachining, Alpha Science International Limited, 2010.
10. J. A. McGeough, Micromachining of Engineering Materials, Taylor & Francis, 2001.

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SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: HM-HU701	**Category:** Humanities and Social Sciences including Management Courses
Subject Name: Economics for Engineers	**Semester**: Seventh
L-T-P: **2-0-0**	**Credit: 1**
Pre-Requisites: Nil	

Course Objectives:

To make general awareness among budding engineers regarding basic principles of economics and that needed to use in an industry.
To give basic understanding of engineering costs, estimation, depreciation analysis and nasic accounting principles.

Course Contents :

Module No.	Description of Topic	Contact Hrs.
1	Economic Decisions Making- Overview, Problems, Role, Decision making process.	2
2	Engineering Costs & Estimation- Fixed, Variable, Marginal & Average Costs, Sunk Costs, Opportunity Costs, Recurring and Nonrecurring Costs, Incremental Costs, Cash Costs vs Book Costs, Life-Cycle Costs; Types of Estimate, Estimating Models - Per- Unit Model, Segmenting Model, Cost Indexes, Power- Sizing Model, Improvement & Learning Curve, Benefits.	4
3	Present Worth Analysis: End-of-Year Convention, Viewpoint of Economic Analysis Studies, Borrowed Money Viewpoint, Effect of Inflation & Deflation, Taxes, Economic Criteria, Applying Present Worth Techniques, Multiple Alternatives.	4
4	Cash Flow & Rate of Return Analysis- Calculations, Treatment of Salvage Value, Annual Cash Flow Analysis, Analysis Periods; Internal Rate of Return, Calculating Rate of Return, Incremental Analysis; Best Alternative Choosing an Analysis Method, Future Worth Analysis, Benefit-Cost Ratio Analysis, Sensitivity and Break Even Analysis. Economic Analysis in the Public Sector- Quantifying and Valuing Benefits & drawbacks.	4
5	Depreciation- Basic Aspects, Deterioration & Obsolescence, Depreciation and Expenses, Types of Property, Depreciation Calculation Fundamentals, Depreciation and Capital Allowance Methods, Straight-Line Depreciation Declining Balance Depreciation, Common Elements of Tax Regulations For Depreciation and Capital Allowances.	4
6	Inflation and Price Change- Definition, Effects, Causes, Price Change With Indexes, Types of Index, Composite vs Commodity Indexes, Use	3

	of Price Indexes in Engineering Economic Analysis, Cash Flows that inflate at different Rates.	
7	Accounting- Function, Balance Sheet, Income Statement, Financial Ratios Capital Transactions, Cost Accounting, Direct and Indirect Costs, Indirect Cost Allocation.	3

Course Outcomes:
Student will be able
1. To understand Economic Decisions Making criteria
2. To know basic principles of engineering costs, estimation and depreciation analysis.
3. To understand basic accounting principles.

Learning Resources:
1. Premvir Kapoor, Sociology & Economics for Engineers, Khanna Publishing House, Delhi.
2. J.L. Riggs, D.D. Bedworth and S.U. Randhawa, Engineering Economics, 4th Edition, McGraw Hill International Edition, 1996.
3. D. Newnan, T. Eschembach and J. Lavelle, Engineering Economics Analysis, Oxford University Press, 2019.
4. J.A. White, K.E. Case and D.B. Pratt, Principle of Engineering Economic Analysis, John Wiley, 2016.
5. W.G. Sullivan, E.M. Wicks and C.P. Koelling, Engineering Economy, 17th Edition, Pearson, 2018.
6. R. Panneerselvan, Engineering Economics, Prentice Hall of India, 1999.
7. M.R. Lindeburg, Engineering Economics Analysis: An Introduction, Professional Publication, 1993.

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(Effective from academic session 2018-19)

Subject Code: PC-ME791	**Category:** Professional Core Courses
Subject Name: Mechanical Engineering Laboratory III (Manufacturing)	**Semester**: Seventh
L-T-P: **0-0-3**	**Credit: 1.5**
Pre-Requisites: Manufacturing Processes, Manufacturing Technology	

Course Objectives:

Students will gain a practical knowledge of various manufacturing processes in a hands-on environment through experiments and simulations.

Course Contents (12 Experiments/ Problems/ Studies are to do):

1. Measurement of Cutting Force in Turning
2. Study of the effect of parametric variation in arc welding
3. Testing of moulding sand
4. Testing for Weld Quality
5. Study of and Solving problems on geometry of robot manipulator, actuators and grippers
6. Programming on CNC Lathe using G and M Codes
7. Programming on CNC Lathe using APT
8. Programming on CNC Milling Machine using G and M Codes
9. Programming on CNC Milling Machine using APT
10. Programming on CNC machine Simulator and to observe virtual machining
11. Robot Programming
12. Experiments on AJM/ USM/ WEDM/ EDM/ ECM/ LBM
13. Design and manufacture of products using Additive Manufacturing

Course Outcomes:

At the end of the course, a student will be able to:

1. Study cutting forces in machining processes
2. Test the quality of weld and moulding sands
3. Develop a practical understanding of advanced manufacturing processes.
4. Understand the working of a robot and its programming
5. Identify and rectify defects in parts and manufacturing processes related problems.

Learning Resources:

1. M.P. Groover, Principles of Modern Manufacturing, 5th edition, Wiley, 2014.
2. E.P. DeGarmo, J.T. Black and R.A. Kohser, DeGarmo's Materials and Processes in Manufacturing, 11th Edition, John Wiley & Sons, 2011.
3. S. Kalpakjian and Schmid, Manufacturing processes for engineering materials, 5th edition, Pearson Education, 2010.

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SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

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Subject Code: PW-ME781	**Category:** Project
Subject Name: Project-III	**Semester**: Seventh
L-T-P: **0-0-6**	**Credit: 3**
Pre-Requisites: All courses	

Course Objectives:

To develop the ability to identify, formulate and analyze engineering problems through literature survey, recent trends in industries and by applying the knowledge of science and engineering fundamentals.
To train students in preparing project reports, to face reviews and viva voce examination.

Course Contents:

It is intended to start the project work early in the seventh semester and carry out both design and fabrication of a mechanical device whose working can be demonstrated. The design and formulation of the problem is expected to be completed in the seventh semester and the fabrication and demonstration will be carried out in the eighth semester. The students in a group of 4 to 6 works on a topic are to be approved by the head of the department under the guidance of a faculty member. The students prepare a comprehensive project report after completing the work to the satisfaction of the supervisor to be submitted at the end of the semester. The progress of the project is evaluated by a committee may be constituted by the Head of the Department. The project work is evaluated based on oral presentation and the project report may jointly by external and internal examiners constituted by the Head of the Department.

Course Outcomes:

Student will be able to carry out some project works based on some design or fabrication or experimental problems in a group building up team spirit and would get sufficient exposure for the way to proceed to solve a practical or design problem.

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SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

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Subject Code : A	**Category:** Professional Elective Courses
Subject Name : Automobile Engineering	**Semester**: Seventh
L-T-P: 3-0-0	**Credit:** 3
Pre-Requisites: Thermodynamics, Kinematics & Theory of Machines	

Course Objective:

To impart knowledge on various types of power-driven vehicles and to familiarize the students with the fundamentals of Automotive Engine System, Chassis and suspension system, braking and transmission system, and cooling system.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	**Introduction:** History & Development of Automobile. Various sub systems of Automobile.	1
2	**Prime Mover:** Engine for Two-Wheeler & Three-Wheeler vehicles, Engine for passenger cars, commercial and other vehicle, Fuel system for carburetted engine, MPFI engine and Diesel engine, Lubrication and cooling system.	5
3	**Auto Electrical:** Electric Motor as prime mover, Battery, generator, Ignition system, Starting system, lighting & signaling	6
4	**Steering System:** Devis steering & Ackerman steering system. Rack & pinion, cam & lever, worm & sector system.	3
5	**Transmission System:** Flywheel & clutch. Gearbox sliding and constant mesh type, Automatic Transmission, Universal joint, Propeller shaft.	6
6	**Differential & Axle:** Construction & function of differential, Different types of front & rear axles.	3
7	**Suspension System:** Conventional and independent suspension system, application.	3
8	**Brake System:** Disc & drum brake, Hydraulic brake, Parking brake. Stopping distance.	3
9	**Power Requirement:** Various resistances such as air resistance, gradient resistance, rolling resistance. Tractive effort. Torque- Speed curve. Horse	3

	power calculation.	
10	**Automotive air conditioning:** Ventilation, heating, air condition, refrigerant, compressor and evaporator. **Wheels and tyres:** Wheel quality, assembly, types of wheels, wheel rims. Construction of tyres and tyre specifications. **Automotive Restraint Systems:** Seat belt, automatic seat belt tightener system, collapsible steering column and air bags.	3

Course Outcomes:

At the end of the course, the student will be able to:

1. Understand the basic lay-out of an automobile.
2. Explain the operation of engine cooling, lubrication, ignition, electrical and air conditioning systems.
3. Illustrate the principles of transmission, suspension, steering and braking systems.
4. Demonstrate automotive electronics.
5. Study latest developments in automobiles.

Learning Resources:

1. K. Newton, W. Steed and T.K. Garrette, Motor Vehicle, 2nd Edition, Butterworth, 1989.
2. A.K. Babu, Automobile Mechanics, Khanna Publishing House, 2019.
3. A. De, Automobile Engineering, Revised Edition, Galgotia Publication Pvt. Ltd., 2010.
4. W.H. Crouse and D.L. Anglin, Automotive Mechanics, McGraw Hill, New Delhi, 2005.
5. J. Heitner, Automotive Mechanics, Affiliated South West Press, New Delhi, 2000.
6. G.B. Narang, Automobile Engineering, Khanna Publishers, New Delhi, 2001.
7. K. Ramakrishna, Automobile Engineering, PHI Learning Pvt. Ltd., New Delhi, 2012.

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SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

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Subject Code: B	**Category:** Professional Elective Courses
Subject Name: Gas Dynamics and Jet Propulsion	**Semester**: Seventh
L-T-P: **3-0-0**	**Credit: 3**
Pre-Requisites: Thermodynamics, Heat Transfer	

Course Objectives:

To provide the student with the knowledge of basic principles of gas dynamics and its importance in jet propulsion applications.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	**Introduction to Gas Dynamics:** Control volume and system approaches acoustic waves and sonic velocity– Mach number– classification of fluid flow based on mach number– Mach cone-compressibility factor– general features of one dimensional flow of a compressible fluid– continuity and momentum equations for a control volume.	3
2	**Isentropic Flow of an Ideal Gas:** Basic equation- stagnation enthalpy, temperature, pressure and density- stagnation, acoustic speed- critical speed of sound- dimensionless velocity- governing equations for isentropic flow of a perfect gas- critical flow area.	6
3	**Steady One Dimensional Isentropic Flow**: Nozzles- area change effect on flow parameters- chocking- convergent nozzle- performance of a nozzle under decreasing back pressure- Delavel nozzle- optimum area ratio- effect of back pressure- nozzle discharge coefficients- nozzle efficiencies. **Simple Frictional Flow:** Governing equations for Adiabatic flow with friction in a constant area duct- fannoline limiting conditions- effect of wall friction flow properties in an Isothermal flow with friction in a constant area duct governing equations- limiting conditions, numerical problems.	7
4	**Steady One Dimensional Flow with Heat Transfer:** Governing equations- Rayleigh line entropy change caused by heat transfer- conditions of maximum enthalpy and entropy. **Effect of Heat Transfer on Flow Parameters:** Intersection of Fanno and Rayleigh lines. Shock waves in perfect gas- properties of flow across a normal shock- governing equations- Rankine Hugoniat equations- Prandtl's velocity relationship-	8

	converging diverging nozzle flow with shock thickness- shock strength.	
5	**Jet Propulsion Aircraft propulsion:** Types of jet engines- thrust equation, Effect of pressure, velocity and temperature changes of air entering compressors, thrust augmentation methods, Performance of turbo propeller engines, ramjet and pulsejet, scramjet engines.	6
6	**Rocket Propulsion:** Rocket engines, Basic theory of equations- thrust equation- effective jet velocity- specific impulse-rocket engine performance- solid and liquid propelant rockets- comparison of various propulsion systems.	6

Course Outcomes:
Upon completion of this course, student will be able to:

1. Understand basic concepts of gas dynamics and describe the basic fundamental equations of one dimensional flow of compressible fluid and isentropic flow of an ideal gas.
2. Analyze the steady one-dimensional is entropic flow, frictional flow and isothermal flow and express the concepts of steady one dimensional flow with heat transfer.
3. Explain the effect of heat transfer on flow parameters.
4. Illustrate the jet propulsion engines
5. Describe the basic concepts of rocket propulsion

Learning Resources:

1. J.D. Anderson, Modern Compressible flow, McGraw Hill, 2003.
2. H.W. Liepman and A. Roshko, Elements of gas dynamics, Wiley, New York, 1957.
3. H. Cohen, G.E.C. Rogers and Saravanamutto, Gas Turbine Theory, Longman Group Ltd.-1980.
4. S.M. Yahya, Fundamentals of Compressible Flow, New Age International (P) Limited-1996.
5. N.J. Zucrow, Principles of Jet Propulsion and Gas Turbines, John Wiley, New York,-1970.
6. S.M. Yahya, Fundamentals of compressible flow with aircraft and rocket propulsion, New Age International (P) Ltd., 2007.
7. M.J. Zucrow, Aircraft & Missile Propulsion, Wiley, New York, 2013.

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Subject Code: C	**Category:** Professional Elective Courses
Subject Name: Computational Fluid Dynamics	**Semester**: Seventh
L-T-P: **3-0-0**	**Credit: 3**
Pre-Requisites: Fluid Mechanics and Fluid Machines, Engineering Mathematics	

Course Objectives:

The objective of the course is to impart knowledge on numerical modeling and its role for the solution of complex engineering problems in the field of heat transfer and fluid dynamics.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	**Introduction:** History and Philosophy of computational fluid dynamics, CFD as a design and research tool, Applications of CFD in engineering, Programming fundamentals, MATLAB programming, Numerical Methods	2
2	**Governing equations of fluid dynamics:** Models of the flow, The substantial derivative, Physical meaning of the divergence of velocity, The continuity equation, The momentum equation, The energy equation, Navier-Stokes equations for viscous flow, Euler equations for inviscid flow, Physical boundary conditions, Forms of the governing equations suited for CFD, Conservation form of the equations, shock fitting and shock capturing, Time marching and space marching.	4
3	**Mathematical behavior of partial differential equations:** Classification of quasi-linear partial differential equations, Methods of determining the classification, General behavior of Hyperbolic, Parabolic and Elliptic equations.	2
4	**Basic aspects of discretization:** Introduction to finite differences, Finite difference equations using Taylor series expansion and polynomials, Explicit and implicit approaches, Uniform and unequally spaced grid points.	3
5	**Grids with appropriate transformation:** General transformation of the equations, Metrics and Jacobians, The transformed governing equations of the CFD, Boundary fitted coordinate systems, Algebraic and elliptic grid generation techniques, Adaptive grids.	4
6	**Parabolic partial differential equations:** Finite difference formulations, Explicit methods - FTCS, Richardson and DuFort-Frankel methods, Implicit methods - Lasonen, Crank-Nicolson	4

	and Beta formulation methods, Approximate factorization, Fractional step methods, Consistency analysis, Linearization.	
7	**Stability analysis:** Discrete Perturbation Stability analysis, von Neumann Stability analysis, Error analysis, Modified equations, Artificial dissipation and dispersion.	3
8	**Scalar representation of Navier-Stokes equations:** Equations of fluid motion, numerical algorithms: FTCS explicit, FTBCS explicit, Dufort-Frankel explicit, McCormack explicit and implicit, BTCS and BTBCS implicit algorithms, applications.	4
9	**Grid generation:** Algebraic Grid Generation, Elliptic Grid Generation, Hyperbolic Grid Generation, Parabolic Grid Generation	3
10	**Finite volume method for unstructured grids:** Advantages, Cell Centered and Nodal point Approaches, Solution of Generic Equation with tetrahedral Elements, 2-D Heat conduction with Triangular Elements.	3
11	**CFD Solution Procedure:** Problem setup – creation of geometry, mesh generation, selection of physics and fluid properties, initialization, solution control and convergence monitoring, results reports and visualization. **Case Studies:** Benchmarking, validation, Simulation of CFD problems by use of general CFD software, Simulation of coupled heat, mass and momentum transfer problem.	4

Course Outcomes:

At the end of the course, student will be able to:

1. Understand the differential equations for flow phenomena and numerical methods for their solution.
2. Analyze different mathematical models and computational methods for fluid flow and heat transfer simulations.
3. Formulate computational problems related to fluid flows and heat transfer.
4. Estimate the accuracy of a numerical solution by comparison to known solutions of simple test problems and by mesh refinement studies.
5. Evaluate forces in both internal and external flows.

Learning Resources:

1. P.S. Ghosdastidar, Computer Simulation of Flow and Heat Transfer, McGraw-Hill, 1998.
2. K. Muralidhar and T. Sundararajan, Computational Fluid Flow and Heat Transfer, Narosa Publishing House, 1995.
3. J.D. Anderson Jr., Computational Fluid Dynamics, McGraw-Hill Book Company, 1995.
4. P. Niyogi, S.K. Chakrabarty and M.K. Laha, Introduction to Computational Fluid Dynamics, Pearson Education, 2006.

5. K.A. Hoffman, and S.T.C. Hiang, Computational Fluid Dynamics, Vol. I, II and III, Engineering Education System, Kansas, USA, 2000.
6. T.J. Chung, Computational Fluid Dynamics, Cambridge University Press, 2003.
7. D.A. Anderson, J.C. Tannehill, and R.H. Pletcher, Computational Fluid Mechanics and Heat Transfer, McGraw Hill Book Company, 2002.

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Subject Code : D	**Category:** Professional Elective Courses
Subject Name : Elements of Atmospheric Fluid Dynamics	**Semester**: Seventh
L-T-P : 3-0-0	**Credit: 3**
Pre-Requisites: Fluid Mechanics, Thermodynamics	

Course Objective:

1. To know about the general structure of the atmosphere and its behaviour.
2. To learn about various types of atmospheric circulations.
3. To know about the effects of earth's rotation and friction on wind movements.
4. To know about the structure of atmospheric boundary layer and turbulence.
5. To learn about smoke dispersion patterns and chimney height determination.
6. To know about the similarity analysis and scaling and wind tunnel simulation & testing.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	General structure of the atmosphere; elements of meteorology- lapse rate of temperature, temperature inversions, isotherms & isobars.	6
2	Atmospheric circulation, vertical convection, centrifugal effects, stability of the atmosphere.	6
3	Effect of earth's rotation, effect of friction. Atmospheric motions; wind scales.	6
4	Atmospheric boundary layer, governing equations; Ekman spiral; logarithmic and power laws; atmospheric turbulence.	6
5	Effect of wind on smoke dispersion; determination of chimney height.	5
6	Basic similarity requirements; dimensional analysis; basic scaling considerations; wind tunnel simulations of atmospheric flows; wind tunnel testing.	7

Course Outcomes:

After completing this course, the students will

1. know about the general structure of the atmosphere and its behaviour.
2. learn about various types of atmospheric circulations.
3. know about the effects of earth's rotation and friction on wind movements.
4. know about the structure of atmospheric boundary layer and turbulence.
5. learn about smoke dispersion patterns and chimney height determination.
6. know about the similarity analysis and scaling and wind tunnel simulation & testing.

Learning Resources:

1. E. Simiu and R.H. Scanlan, Wind Effects on Structures– Fundamentals and Applications to Design, John Wiley & Son, 1996.
2. S. Eskinazi, Fluid Mechanics and Thermodynamics of Our Environment, Academic Press, 1975.

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SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: E	**Category:** Professional Elective Courses
Subject Name: Selection and Testing of Materials	**Semester**: Seventh
L-T-P: **3-0-0**	**Credit: 3**
Pre-Requisites: Materials Engineering, Design of Machine Elements	

Course Objectives:

The subject exposes students to the basics parameter for selection of materials and different classes of materials, and various destructive and non destructive testing methods of materials and its industrial applications.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	**Engineering Materials** Introduction – classification of engineering materials – selection of materials for engineering purposes –selection of materials and shape –classification metal and alloys, polymers, ceramics and glasses, composites, natural materials,-non metallic materials- smart materials - physical, metrical properties of metals.	5
2	**Material Properties** Mechanical properties - fatigue strength - fracture Toughness - Thermal Properties - Magnetic Properties - Fabrication Properties - electrical, optical properties - Environmental Properties, Corrosion properties - shape and size - Material Cost and Availability– failure analysis.	3
3	**Materials Selection Charts and Testing** Ashby material selection charts-Testing of Metallic Materials - Selection of Materials for Biomedical Applications - Medical Products - Materials in Electronic Packaging - Advanced Materials in Sports Equipment - Materials Selection for Wear Resistance - Advanced Materials in Telecommunications - Using Composites - Manufacture and Assembly with Plastics, fiber and Diamond Films	6
4	**Mechanical Testing** Introduction to mechanical testing, Hardness test (Vickers, Brinell, Rockwell), Tensile test, Impact test (Izod, Charpy) - Principles, Techniques, Methods, Advantages and Limitations, Applications. Bend test, Shear test, Creep and Fatigue test - Principles, Techniques, Methods, Advantages and Limitations, Applications.	6
5	**Non Destructive Testing** Visual inspection, Liquid penetrant test, Magnetic particle test,	6

	Thermography test – Principles, Techniques, Advantages and Limitations, Applications. Radiographic test, Eddy current test, Ultrasonic test, Acoustic emission- Principles, Techniques, Methods, Advantages and Limitations, Applications.	
6	**Material Characterization Testing** Macroscopic and Microscopic observations, Optical and Electron microscopy (SEM and TEM) - Principles, Types, Advantages and Limitations, Applications. Diffraction techniques, Spectroscopic Techniques, Electrical and Magnetic Techniques- Principles, Types, Advantages and Limitations, Applications.	6
7	**Other Testing** Thermal Testing: Differential scanning calorimetry, Differential thermal analysis. Thermomechanical and Dynamic mechanical analysis: Principles, Advantages, Applications. Chemical Testing: X-Ray Fluorescence, Elemental Analysis by Inductively Coupled Plasma-Optical Emission Spectroscopy and Plasma-Mass Spectrometry.	4

Course Outcomes:

1. To understand importance of engineering materials.
2. To choose materials for engineering applications.
3. To identify the material properties.
4. To identify suitable testing technique to inspect industrial component.
5. To use different techniques and know its applications and limitations.

Reference Books:

1. L. Gladius, Selection of Engineering Materials, Prentice Hall Inc. New Jersey, USA, 1995.
2. J.A. Charles and F.A.A. Crane, Selection and Use of Engineering Materials, 3rd Edition, Butterworths, London, UK, 1996.
3. M.F. Ashby, Materials Selection in Mechanical Design, 3rd Edition, Elsevier, 2005.
4. B. Raj, T. Jayakumar and M. Thavasimuthu, Practical Non-Destructive Testing, Narosa Publishing House, 2009.
5. ASM Metals Handbook, Non-Destructive Evaluation and Quality Control, American Society of Metals, Metals Park, Ohio, USA.

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SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code : F	**Category:** Professional Elective Courses
Subject Name : Mechanical Vibration	**Semester**: Seventh
L-T-P: 3-0-0	**Credit:** 3
Pre-Requisites: Kinematics & Theory of Machines	

Course Objectives:

To understand the importance of vibrations in mechanical design of machine parts that operate in vibratory conditions through acquiring knowledge on vibratory models of dynamic systems with changing complexities, differential equation of motion of vibratory systems, free and forced (harmonic, periodic, non-periodic) vibration, single and multi degree of freedom linear systems.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	**Introduction:** Causes and effects of vibration, Classification of vibrating system, Discrete and continuous systems, degrees of freedom, Identification of variables and Parameters, Linear and nonlinear systems, linearization of nonlinear systems, Physical models, Schematic models and Mathematical models.	6
2	**SDF systems**: Formulation of equation of motion: Newton -Euler method, De Alembert's method, Energy method, Undamped Free vibration response and Damped Free vibration response, Case studies on formulation and response calculation.	6
3	**Forced vibration response:** Response to harmonic excitations, solution of differential equation of motion, Vector approach, Complex frequency response, Magnification factor Resonance, Rotating/reciprocating unbalances, Force Transmissibility, Motion Transmissibility, Vehicular suspension, Vibration measuring instruments, Case studies on forced vibration,	6
4	**Two degree of freedom systems:** Introduction, Formulation of equation of motion: Equilibrium method, Lagrangian method, Case studies on formulation of equations of motion. Free vibration response, Eigen values and Eigen vectors, Normal modes and mode superposition, Coordinate coupling, decoupling of equations of motion, Natural coordinates, Response to initial conditions, free vibration response case studies, Forced vibration response, undamped vibration absorbers, Case studies on undamped vibration absorbers.	7
5	**Multi degree of freedom systems:**	7

	Introduction , Formulation of equations of motion, Free vibration response, Natural modes and mode shapes, Orthogonally of model vectors, normalization of model vectors, Decoupling of modes, model analysis, mode superposition technique, Free vibration response through model analysis, Forced vibration analysis through model analysis, Model damping, Rayleigh's damping, Introduction to experimental model analysis.	
6	**Continuous systems**: Introduction to continuous systems, Exact and approximate solutions, free vibrations of strings, bars and beams.	4

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

1. Understand the causes and effects of vibration in mechanical systems.
2. Demonstrate schematic models for physical systems and formulate governing equations of motion.
3. Explain the role of damping, stiffness and inertia in mechanical systems
4. Analyze rotating and reciprocating systems and compute critical speeds.
5. Evaluate and design machine supporting structures, vibration isolators and absorbers.

Reference Books:

1. L. Meirovich, Elements of Vibration analysis, 2nd Edition, Mc-Graw Hill, 2007.
2. S.S. Rao, Mechanical Vibrations. 4th Edition, Pearson Education, 2011.
3. W.T. Thompson, Theory of Vibration, CBS Publishers, 2002.
4. C.W. de Silva, Vibration: Fundamentals and Practice, CRC Press, 2000.
5. G.K. Grover, Mechanical Vibrations, 8th Edition, Nemchand & Bros, Roorkee, 2009.
6. F.S. Tse, I.E. Morse and R.T. Hinke, Mechanical Vibrations, 2nd Edition, Chapman and Hall, 1991.
7. V.P. Singh, Mechanical Vibrations, 3rd Edition, Dhanpat Rai & Co., 2006.

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SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: G	**Category:** Professional Elective Courses
Subject Name: Finite Element Analysis	**Semester**: Seventh
L-T-P: **3-0-0**	**Credit: 3**
Pre-Requisites: Engineering Mechanics, Strength of Materials, Mathematics	

Course Objectives:

To apprise the students about the basics of the Finite Element analysis technique, a numerical tool for the solution of different classes of problems in solid mechanics, thermal engineering, and fluid mechanics.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	**Introduction:** Historical background, Relevance of FEA/FEM to design problems, Application to the continuum– Discretization, Matrix approach, Matrix algebra– Gaussian elimination, Governing equations for continuum, Classical Techniques in FEM, Weighted residual method, Ritz method, Galerkin method	6
2	**One dimensional problems:** Finite element modeling– Coordinates and shape functions, Potential energy approach– Element matrices and vectors, Assembly for global equations, Boundary conditions, Higher order elements- Shapes functions, Applications to axial loadings of rods– Extension to plane trusses, Bending of beams– Finite element formulation of stiffness matrix and load vectors, Assembly to Global equations, boundary conditions, Solutions and Post processing, Example Problems.	6
3	**Two dimensional problems– scalar variable problems:** Finite element modeling– CST element, Element equations, Load vectors and boundary conditions, Assembly, Application to heat transfer, Examples	3
4	**Two dimensional problems– vector variable problems**: Vector Variable problems, Elasticity equations–Plane Stress, Plane Strain and Axisymmetric problems, Formulation, element matrices, Assembly, boundary conditions and solutions Examples	7
5	**Isoparametric elements for two dimensional problems:** Natural coordinates, Isoparametric elements, Four node quadrilateral element, Shape functions, Element stiffness matrix and force vector, Numerical integration, Stiffness integration, Displacement and Stress calculations, Examples.	6

6	**Numerical Integration and 2-D problems of Elasticity:** Introduction to numerical integration, two dimensional integrals, plane stress, plane strain, axisymmetric, plate bending problems. **Thermal Applications:** Two- dimensional heat conduction analysis, formulation of functional, element matrices and case studies. **Fluid Mechanics Applications:** Stream function formulation, velocity potential formulation and torsional analysis of a prismatic bar. **Computer implementation:** Pre-processor, Processor, Post-processor. Discussion about finite element packages.	8

Course Outcomes:
Student will be able to

1. Apply finite element method to solve problems in solid mechanics and heat transfer.
2. Formulate and solve problems in one dimensional structures including trusses, beams and frames.
3. Formulate FE characteristic equations for two dimensional elements and analyse plain stress, plain strain, and axi-symmetric and plate bending problems.
4. To learn and apply finite element solutions to structural, thermal, fluid mechanics problem
5. To develop the knowledge and skills needed to effectively evaluate finite element analyses

Text Books:

1. P. Seshu, Textbook of Finite Element Analysis, Prentice Hall of India, 2009.
2. J. N. Reddy, Finite Element Method in Engineering, McGraw Hill, 2009.
3. O.C. Zienkiewicz, R.L. Taylor and J.Z. Zhu, The Finite Element Method for Solid and Structural Mechanics, 4th Edition, Elsevier 2007.
4. R.D. Cook, D.S. Malkus and M.E. Plesha, Concepts and Applications of Finite Element Analysis, Wiley, 2001.
5. T.R. Chandrupatla and A.D. Belegundu, Introduction to Finite Elements in Engineering, Pearson, 2012.
6. C.S. Krishnamoorthy, Finite Element Analysis, McGraw Hill, 1994.
7. K.J. Bathe, Finite Element Procedures, Prentice Hall of India, 1982.

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SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: H	**Category:** Professional Elective Courses
Subject Name: Advanced Welding Technology	**Semester:** Seventh
L-T-P: 3-0-0	**Credit:** 3
Pre-Requisites: Manufacturing Processes	

Course Objective:

To impart knowledge about different welding processes and their applicability.
To make the students understand the mechanism behind weld joints.
To impart ideas of different testing techniques of the welded joint.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	Review of welding processes, joint design.	3
2	Descriptions and Parametric influences on Welding processes: Arc Welding- SMAW, Stud Arc welding, SAW, GMAW, GMAW-P, FCAW, GTAW, GTAW-P. Resistance Welding processes- Spot, Butt, Seam, Projection. Solid State Welding processes- Forge welding, Friction welding, Friction Stir welding, Diffusion welding, Roll welding.	6
3	Arc Welding- Different types of equipment, Power sources, Choice of Polarity, Arc characteristics, Modes of Metal Transfer, Welding Positions, Electrode selection.	5
4	Critical and Precision Welding processes- USW, PAW, LBW, EBW. Underwater Welding- Wet Welding and Dry Welding: Hyperberic and Cavity. Welding of Plastics- Hot Gas Welding, Hot Tool Welding, Hot Press Welding, Friction Welding, Ultrasonic Welding. Joining of Ceramics and Composites.	8
5	Welding Metallurgy, HAZ, Effect of different process parameters on the characteristics of weldment. Weldability of Plain Carbon Steel, Stainless Steel, Cast Iron, Aluminium and its Alloys.	8
6	Welding Defects- Types, Causes, Inspection and Remedial Measures. Testing of Welded Joints- Visual Inspection, Dye-Penetration (DP) Test, Ultrasonic Test and Radiography Test.	3
7	Welding Fixtures, Welding Automation and Robotic Welding. Safe Practices in Welding.	3

Course Outcome:

1. To familiarize different types of welding processes.
2. To familiarize the basic mechanism behind weld joint and influencing factors.
3. To impart the knowledge different tests to judge soundness of the weld joint.

Learning Resources:

1. O.P. Khanna, A Text Book of Welding Technology, Dhanpat Rai & Sons, 2015.
2. R.S. Parmar, Welding Engineering and Technology, Khanna Publishers, 2013.
3. M. Bhattacharyya, Weldment Design, The Association of Engineers, India Publication, Kolkata, 1991.
4. J.C. Lippold and D.J. Kotecki, Welding Metallurgy and Weldability of Stainless Steels, Wiley India (P) Ltd., New Delhi, 2011.
5. H. Udin, E.R. Funk and J. Wulf, Welding for Engineers, John Wiley and Sons, 1954.
6. J.L. Morris, Welding Process and Procedures, 2nd Edition, Prentice Hall, 1955.
7. J. F. Lancaster, The Metallurgy of Welding, 6th Edition, William Andrew Publishing, 1999.
8. B. Raj, V. Shankar, A.K. Bhaduri (Editors), Welding Technology for Engineers, Narosa Publishing House, 2006.

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SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: I	**Category:** Professional Elective Courses
Subject Name: Quantity Production Method	**Semester:** Seventh
L-T-P: 3-0-0	**Credit:** 3
Pre-Requisites: Manufacturing Technology	

Course Objectives:

To provide knowledge on different types of quantity production methods practised in industry.
To make students familiar with planning and scheduling for having high productivity and quality enhancement in industry.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	**Introduction:** Engineering Production; aim and objectives history of progress, definition and requirements. Levels of production; piece, batch, lot, mass and quantity production. Mechanisation and Role of automation in industrial production; need, degree and types of automation.	4
2	**Quantity Production Methods- Concept:** Broad classification of engineering production methods: Major sequential steps in industrial production; Preforming, semi finishing, heat treatment, finishing, assembly and inspection. Quantity production (methods) of common items: (i) shafts and spindles, (ii) automobile parts, engine block, piston, connecting rods and crank shaft, (iii) metallic wires, rods, tubes, bars, plates and sheets, (iv) various types of gears and bearings. Methods of quantity production of cutting tools, tool inserts and tool holders. Small size products: Pins, clips, needles, metallic caps, washers, utensils, chains springs, paste tubes and coins. Large scale production of bolts and nuts. Quantity production by spinning, bulging, magneto forming, hydro forming and explosive forming. Production by powder metallurgical process.	16
3	**Planning and Scheduling:** 3.1 Process planning and scheduling for quantity production using (i) semi-automatic and automatic lathes, (ii) transfer machines (iii) CNC machining systems (including machining centres, DNC	6

	and FMS) 3.2 Design and use of jigs and fixtures for batch production in machine shops	
4	**Productivity and Quality Enhancement in Quantity production:** Group technology; concept and application in large scale production. Inspection and quality control in quantity production. Computerisation and robotization in quantity production.	4
5	**Non-Conventional Manufacturing of Products in Quantity:** Quantity production by non-traditional processes; EDM, Wire-Cut EDM, ECM, AJM, AWJM, WJM, USM, CHM, EBM and PAM. Regenerative Manufacturing; Rapid Prototyping, Rapid Tooling and Rapid Manufacturing. Quantity Production of Ceramic and Polymer Products.	6

Course Outcomes:

At the end of the course, the student will be able to:

1. Gather knowledge about different quantity production methods practised in industry.
2. Understand planning and scheduling methods usually used in industry to have high productivity and to enhance quality.

Learning Resources:

1. M.P. Groover, Fundamentals of Modern Manufacturing, Wiley Pub, 2009.
2. S. Kalpakjian, Manufacturing Engineering and Technology, Pearson, 2002.
3. S.D.El Wakil, Processes and Design for Manufacturing, CRC Press, 2019.
4. R.A. Lindberg, Process and Materials of Manufacture, Pearson 2015.
5. E.P. DeGarmo, J.T. Black and R.A. Kosher, Materials and Processes in Manufacturing, Prentice Hall, 1997.
6. C. Donaldson, Tool Design, 4th Edition, McGraw Hill Publication, 2012.
7. G.C. Sen and A. Bhattacharyya, Principles of Machine Tools, New Central Agency Publication, Kolkata, 2015.
8. P.K. Mishra, Non-Conventional Machining, Narosa Publication, 1997.
9. A. Ghosh, Rapid prototyping, East-West Press Publication, New Delhi, 2016.
10. M. Palay, Metal Cutting Tool Production, MIR Publication, Moscow, 1968.

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SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: J	**Category:** Professional Elective Courses
Subject Name: CAD/CAM	**Semester:** Seventh
L-T-P: 3-0-0	**Credit:** 3
Pre-Requisites: Manufacturing Technology, Elements of Mechanical Design, Mathematics	

Course Objective:

To impart knowledge about computer aided design- geometric modeling, stress analysis.
To give an idea about computer aided manufacturing system, its components including application of robot.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	Fundamentals of CAD- Design process, benefits of computer aided design, graphics standards.	3
2	Geometric modeling- wire-frame, surface and solid modeling Transformation- translation and rotation exercise problems and programming. Stress analysis- basics of FEM, formation of stiffness matrix for two elements.	6
3	Introduction to computer aided manufacturing (CAM) systems, basic building blocks of computer integrated manufacturing (CIM).	4
4	Toolings of CNC machines, tool and work handling systems involving robot, AGV, RTV, AS/RS, ATC, APC.	3
5	Robotics; types, anatomy, drives and applications.	3
6	Computer aided production planning and control, Manufacturing from product design- CADCAM interface, concept of group technology (GT), CAPP.	6
7	Control systems, Process monitoring, Adaptive control systems, etc.	2
8	Automatic inspection systems, use of CMM, Reverse Engineering.	1

Course Outcome:

1. To familiarize the basics of computer aided design- geometric modeling, stress analysis.
2. To familiarize the basics of computer aided manufacturing.
3. To familiarize the components of computer aided manufacturing system including application of robot and control systems.

Learning Resources:

1. P.N. Rao, N.K. Tewari and T.K. Kundra, Computer Aided Manufacturing, McGraw-Hill Publication, 2017.
2. M.P. Groover and E.W. Zimmers Jr., CAD/CAM, Prentice Hall of India, 1983.
3. P. Radhakrishnan, S. Subramanyan and V. Raju, CAD/CAM/CIM, New Age International Publishers, 2007.
4. P.N. Rao, CAD/CAM, McGraw Hill Publication, 2010.
5. M.P. Groover, Automation, Production Systems, and Computer- Integrated Manufacturing, Prentice Hall of India, 2016.
6. I. Zeid, CAD/CAM- Theory and Practice, McGraw-Hill Publishing Co. Ltd., New Delhi, 1991.
7. S.R. Deb and S. Deb, Robotics Technology and Flexible Automation, McGraw-Hill Publication, 2010.
8. S.K. Saha, Introduction to Robotics, McGraw-Hill Publication, 2008.
9. P.B. Mahapatra, Computer-Aided Production Management, Prentice Hall of India, 2010.

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SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: A	**Category:** Open Elective Courses
Subject Name: Industrial Engineering	**Semester:** Seventh
L-T-P: 3-0-0	**Credit:** 3
Pre-Requisites: Basic Engineering Knowledge	

Course Objectives:

To provide introductory knowledge on Industrial Engineering, concept of Productivity and work study.
To make familiar about facility layout and planning, systems of production planning and control and technics of inventory management.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	**Introduction to Industrial Engineering and Productivity:** Definition and Functions of Industrial Engineering, Origin and development of factory system, Contribution of Taylor and Gilbreth Productivity: Definition of productivity, Factors Influencing Productivity, Causes of Low Productivity, Productivity Measurement Models, Productivity Improvement Techniques.	3
2	**Work Study**: Basic Concept, Steps Involved in Work Study, Techniques of Work Study, Human Factors in the Application of Work Study. Method Study: Basic Concept, Steps Involved in Method Study, Recording Techniques, Operation Process Charts, Flow Process Charts, Two-Handed-Process Charts, Multiple Activity Charts, Flow Diagrams. String Diagrams, Principles of Motion Economy, Micro-Motion Study, Therbligs, SIMO Charts. Work Measurement: Basic Concept, Techniques of Work Measurement, Steps Involved in Time Study, Time Study Equipment, Performance Rating, Basic concept and Procedure of Work Sampling Study.	10
3	**Facility Layout and Planning:** Nature, Significance and Scope of Facility layout and design; Steps in facility layout planning, Assembly Line Balancing. Material Handling: Definition, Objective and Principles of Material Handling, Classification of Material Handling Devices.	10
4	**Production Planning and Control:** Introduction to Production Systems, Types of production systems, Need and functions of PPC. Forecasting: Definition and Functions of Forecasting, Forecasting	4

	techniques: linear regression, moving average, exponential smoothing; Analysis of forecast error. Aggregate production planning, Capacity Planning, ERP, Master Production Schedule. Basic sequencing and scheduling techniques.	
5	**Introduction to Inventory Management:** Importance and areas of materials management, Introduction to Inventory: Definitions, Need for inventory, Types of inventory, Inventory costs; Structure of inventory models, Deterministic models; safety stock, inventory control systems; Selective inventory management. MRP and JIT-based production systems, Concept of zero inventory, Fundamental concepts of purchasing, storing, distribution, and value analysis & engineering.	9

Course Outcomes: At the end of the course, the student will be able to:

1. Understand the concepts of Industrial Engineering.
2. Explain production systems and their characteristics.
3. Understand the role of productivity in streamlining a production system.
4. Describe different aspects of work system design and facilities design pertinent to manufacturing industries
5. Apply forecasting and scheduling techniques to production systems.
6. Apply the inventory management tools in managing inventory

Learning Resources:

1. S.C. Sharma, Industrial Engineering and Management, Khanna Book Publication, 2016.
2. O.P. Khanna, Industrial Engineering and Management, Dhanpat Rai Publication, 1980.
3. M.T. Telsang, Industrial Engineering and Production Management, S. Chand Publishing, 2018.
4. K.B. Zandin and H.B. Maynard, Maynard's Industrial Engineering Hand Book, McGraw Hill Education, 2001.
5. ILO, Introduction to Work Study, Oxford and IBH Publishing, 1992.
6. B. Mahadevan, Operations Management: Theory and Practice, Pearson, 2010.
7. S.N. Chary, Production and Operations Management, McGraw-Hill Education, 2019.
8. K. Bedi, Production and Operations Management, Oxford University Press, 2004.
9. A. Tompkins, J.A. White, Y.A. Bozer, and J.M.A. Tanchoco, Facilities Planning, Wiley, 2005.
10. S. Ray, Introduction to Materials Handling, New Age International, 2016.
11. S.L. Narasimhan, D.W. McLeavy and P.J. Billington, Production Planning and Inventory Control, Prentice Hall, 2009.
12. E.A. Silver, D.F. Pyke and R. Peterson, Inventory Management and Production Planning and Scheduling, John Wiley, 1998.

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SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: B	**Category:** Open Elective Courses
Subject Name: Project Management	**Semester:** Seventh
L-T-P: 3-0-0	**Credit:** 3
Pre-Requisites: Basic Engineering Knowledge	

Course Objectives:

To have knowledge about resource allocation, market and demand analysis, technical analysis, economic and ecological analysis related to project management.
To understand optimisation techniques applied to project management.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	**Introduction:** Introduction to Project Management, History of Project Management, Types & Characteristics of Projects, Project Life Cycle. Project Identification and Screening.	4
2	**Project Analysis:** Facets of Project Analysis, Strategy and Resource Allocation, Market and Demand Analysis, Technical Analysis, Economic and Ecological Analysis. Cash flows for project appraisal- Investment evaluation using capital budgeting techniques, net present value, profitability index, internal rate of return, payback period, accounting rate of return.	12
3	**Network Technique for Project Management:** Development of Project Network, Time Estimation, Determination of the Critical Path, PERT Model, CPM Model.	10
4	**Optimisation in Project Management:** Time and Cost trade-off in CPM, Crashing procedure, Scheduling when resources are limited.	5
5	**Organization systems for project implementation:** Work Breakdown, coordination and control, Project Management Softwares.	5

Course Outcomes:

At the end of the course, the student will be able to:

1. Understand the concept of projects and its phases.
2. Analyze project from marketing, operational and financial perspective.
3. Develop network diagrams for planning and execution of a given project.

Learning Resources:

1. P. Chandra, Project: A Planning Analysis, McGraw Hill Book Company, New Delhi, 2017.
2. C.F. Grey, E.W. Larson and G.V. Desai, Project Management the Managerial Process, McGraw Hill Education (India), New Delhi, 1990.

3. K. Harold, Project Management: A Systems Approach to Planning, Scheduling and Controlling, Wiley Student Edition, 2013.
4. J.D. Wiest and F.K. Levy, A Management Guide to PERT/ CPM with PERT/ PDM/ DCPM and Other Networks, PHI Learning Private Limited, 1970.
5. A. Kanda, Project Management: A Life Cycle Approach, PHI, 2010.

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SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code : C	**Category:** Open Elective Courses
Subject Name: Introduction to Product Design and Development	**Semester**: Seventh
L-T-P: 3-0-0	**Credit:** 3
Pre-Requisites: Elements of Machine Design, Basics of Management Principles	

Course Objective:

To have an overall idea about the whole process of product design and development.
To be able to explain concept generation, concept selection and concept testing.
To be able to apply the basic concepts on design for environment.
To become industry-ready to work in product design department.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	Introduction to product design, design and development process, sequential engineering design method, product planning and project selection.	10
2	Identifying customer needs– interpreting raw data; Product specifications– establishing target specifications, setting final specifications.	9
3	Concept generation– activities of concept generation, clarifying problem, exploring the output; Concept selection– concept screening and concept scoring, methods of selection.	9
4	Concept testing– qualitative and quantitative methods including survey, measurement and customer's response; Design for environment– basic concepts.	8

Course Outcomes:

After completing this course, the students will be

1. Identify and analyse the product design and development processes industry.
2. Define the components and their functions of product design and development processes
3. Analyse, evaluate and apply the methodologies for product design, development and management.
4. Undertake a methodical approach to the management of product development to satisfy customer needs.
5. Carry out cost and benefit analysis through various cost models.

Learning Resources:

1. K.T. Ulrich and S.D. Eppinger, Product Design and Development, 7th Edition, McGraw-Hill, 2019.
2. B. Gupta, Concepts in Engineering Design, Dhanpat Rai & Co., New Delhi, 2016.

A.C. Chitale and R.C. Gupta, Product Design and Manufacture, Prentice-Hall, 6th Edition, 2014.

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SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code : D	**Category:** Open Elective Courses
Subject Name: Non-Conventional Energy Resources	**Semester**: Seventh
L-T-P : 3-0-0	**Credit:** 3
Pre-Requisites: Thermodynamics, Fluid Dynamics and Heat Transfer	

Course Objective:

To have an idea about different sources of renewable energy that would be sustainable.
To have the concept of using solar energy for heating as well as Photovoltaic Generation.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	Principles of Renewable Energy: The history of energy scene, energy of the future: sustainable energy, development and role of renewable energy, Scientific Principles of renewable energy.	4
2	Review of principles of thermodynamics, fluid dynamics and heat transfer.	1
3	Solar Radiation: i) Sun-Earth geometry, ii) Extraterrestrial Solar Radiation, iv) Measurement and estimation of solar radiation.	4
4	Solar Water Heating: i) Flat Plate Collectors: Heat Transfer analysis, Testing ii) Evacuated Tube Collectors	5
5	Other Solar Thermal Applications: i) Air heaters, ii) Water Desalination, iii) Space Cooling, iv) Solar Concentrators, v) Solar ponds	3
6	Photovoltaic Generation: i) Photon absorption at Silicon p-n junction, ii) Solar Cell, iii) Application and Systems.	4
7	Wind Power: i) Turbine types & terms, ii) Mechanical & Electrical Power from Wind Turbines.	3
8	Biomass & Biofuels: i) Use of Biomass, ii) Classification & Use of Biofuels.	3
9	Wave Power & Tidal Power: Basic Concepts	3
10	Ocean Thermal Energy Conversion, Geothermal Energy. Energy Storage	6

Course Outcomes:

After completing this course, the students will

1. know about the energy scenario at present and the need of using renewable energy for sustainability.
2. know specifically the use of solar energy for heating as well as photovoltaic generation.

Learning Resources:

1. G. Boyle, Renewable Energy, 2nd Edition, Oxford University Press, 2010.
2. J. Twidell and T. Weir, Renewable Energy Resources, 2nd Edition, Taylor & Francis, 2006.
3. B.H. Khan, Non Conventional Energy Resources, McGraw Hill, 2010.
4. G.D. Rai, Non Conventional Energy Sources, Khanna Publishers, New Delhi, 2017.
5. Ashish Chandra, Non-Conventional Energy Sources, Khanna Publishers, New Delhi, 2019.

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SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code : E	**Category:** Open Elective Courses
Subject Name : Biomechanics and Bio materials	**Semester** : Seventh
L-T-P : **3-0-0**	**Credit: 3**
Pre-Requisites: Biology, Engineering Mechanics	

Course Objective:

To know musculoskeletal anatomy, dynamics to human motion and biomaterial interfaces.
To understand fundamentals of biomaterials science, physico-chemical properties of biomaterials and their testing techniques.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	**Musculoskeletal Anatomy**: Basic Statics and Joint Mechanics (elbow, shoulder, spine, hip, knee, ankle)	6
2	**Basic Dynamics to Human Motion**: Review of linear and angular kinematics; Kinetic equations of motion; Work & energy methods; Momentum methods; Examples in biomechanics; Modern kinematic measurement techniques; Applications of human motion analysis Structure, Function, and Adaptation of Major Tissues and Organs.	6
3	**Fundamental Strength of Materials in Biological Tissues**: Introduction to Viscoelasticity. **Fundamentals of biomaterials science**. Concept of biocompatibility. Classes of biomaterials used in medicine, basic properties, medical requirements and clinical significance. Disinfection and sterilization of biomaterials.	6
4	**Physico-Chemical Properties of Biomaterials**: mechanical (elasticity, yield stress, ductility, toughness, strength, fatigue, hardness, wear resistance), tribological (friction, wear, lubricity), morphology and texture, physical (electrical, optical, magnetic, thermal), chemical and biological properties.	6
5	**Elements in Contact with the Surface of a Biomaterial**: Blood composition, plasma proteins, cells, tissues. **Phenomena at the Biointerfaces**. Molecular and cellular processes with living environment, blood-materials interaction, short and long term reactions to the body.	6

6	**Testing of Biomaterials**: in vitro, in vivo preclinical and in vivo clinical tests. Technologies of biomaterials processing, as implants and medical devices; improvement of materials biocompatibility by plasma processing.	6

Course Outcomes:
Upon completion of this course, the students will be able to:
1. Understand dynamics of human motion with the knowledge of musculoskeletal anatomy and biomaterial interfaces.
2. Understand fundamental characteristics and properties of biomaterials and their testing techniques.

Learning Resources:
1. D.V. Knudson, Fundamentals of Biomechanics, Springer, 1999.
2. N. Ozkaya, M. Nordin, D. Goldsheyder and D. Leger, Fundamentals of Biomechanics: Equilibrium, Motion, and Deformation, Springer, 2012.
3. Y.C. Fung, Biomechanics: Mechanical Properties of Living Tissues, Springer, 1981.
4. M. Nordin and V.H. Frankel, Basic Biomechanics of the Musculoskeletal System, Barnes & Noble, 2011.
5. B.D. Ratner and A.S. Hoffman (Eds.), Biomaterials Science, An Intoduction to Materials in medicine, 3rd Edition, Academic Press, New York, 2012.

Maulana Abul Kalam Azad University of Technology, West Bengal

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SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code : F	**Category:** Open Elective Courses
Subject Name : Computational Methods in Engineering	**Semester** : Seventh
L-T-P : **3-0-0**	**Credit: 3**
Pre-Requisites: Mathematics- IB, Mathematics- IIB, Mathematics- III	

Course Objective:

To learn about different numerical techniques.
To learn about the application of numerical techniques in different fields of mechanical engineering.
To learn about different transformation techniques.
To understand concept of linear regression and statistical analysis.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	**Approximations:** Accuracy and precision, round off and truncation errors, error propagation.	3
2	**Linear algebraic equations:** Formulation and solution of linear algebraic equations, Gauss elimination, LU decomposition, iteration methods– convergence, Eigen values and Eigen vectors.	4
3	**Interpolation methods**: Newton's divided difference, interpolation polynomials, Lagrange interpolation polynomials.	5
4	**Differentiation and Integration:** High accuracy integration formula, extrapolation, derivatives of unequally spaced data, Gauss quadrature and integration.	5
5	**Numerical solution of Algebraic equation:** Bisection method, Regula-Falsi method, Newton-Raphson method.	4
6	**Transform techniques**: Continuous Fourier series, frequency and time domains, Laplace transform, Fourier integral and transform, Discrete Fourier Transform, fast Fourier Transform.	6
7	**Differential Equations:** Initial and boundary value problems, eigen value problems, solutions to elliptical and parabolic equations, partial differential equations.	5
8	**Regression methods**: Linear and non-linear regression, multiple linear regression, general linear test squares. **Statistical methods**: Statistical representation of data, modelling and analysis of data, ANOVA, test of hypotheses.	4

Course Outcomes:

On completion of this course the students will be able to

1. understand the concept of truncation and round off errors; fixed and floating point arithmetic and propagation of error and interpolation or extrapolation.
2. integrate different functions numerically and understand the error expressions.
3. solve systems of linear, algebraic and ordinary differential equations.
4. apply Laplace and Fourier transformation techniques.
5. use linear and non-linear regression techniques and do analysis of variance (ANOVA).

Learning Resources:

1. S.K. Gupta, Numerical Methods for Engineers, New Age International, 2005.
2. S.C. Chapra and R.P. Canale, Numerical Methods for Engineers, McGraw Hill, 1989.
3. R.J. Schilling and S.L. Harris, Applied Numerical Methods for Engineering using MATLAB and C, Brooks/Cole Pub., 2000.
4. W.W. Hines and Montgomery, Probability and Statistics in Engineering and Management Studies, John Wiley, 1990.

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SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: G	**Category:** Open Elective Courses
Subject Name: Artificial Intelligence (AI)	**Semester:** Seventh
L-T-P: 3-0-0	**Credit:** 3
Pre-Requisites: Basic Programming in Python, Data Structures	

Course Objectives:

This course will give an opportunity to gain expertise in one of the most fascinating and fastest growing areas of Computer Science through classroom program that covers fascinating and compelling topics related to human intelligence and its applications in industry, defence, healthcare, agriculture and many other areas. This course will give the students a rigorous, advanced and professional graduate-level foundation in Artificial Intelligence.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	**Introduction:** Concept of AI, history, current status, scope, agents, environments, Problem Formulations, Review of tree and graph structures, State space representation, Search graph and Search tree.	2
2	**Search Algorithms**: Random search, Search with closed and open list, Depth first and Breadth first search, Heuristic search, Best first search, A* algorithm, Game Search.	7
3	**Probabilistic Reasoning:** Probability, conditional probability, Bayes Rule, Bayesian Networks- representation, construction and inference, temporal model, hidden Markov model.	10
4	**Markov Decision process:** MDP formulation, utility theory, utility functions, value iteration, policy iteration and partially observable MDPs.	10
5	**Reinforcement Learning:** Passive reinforcement learning, direct utility estimation, adaptive dynamic programming, temporal difference learning, active reinforcement learning- Q learning.	7

Course Outcomes:

At the end of the course, the student will be able to:

1. Build intelligent agents for search and games.
2. Solve AI problems through programming with Python.
3. Learning optimization and inference algorithms for model learning.
4. Design and develop programs for an agent to learn and act in a structured environment.

Learning Resources:

1. S. Russell and P. Norvig, Artificial Intelligence: A Modern Approach, 3rd Edition, Prentice Hall, 2009.
2. E. Rich, K. Knight and K. Knight, Artificial Intelligence, McGraw Hill, 1991.
3. M.C. Trivedi, A Classical Approach to Artificial Intelligence, Khanna Publishing House, New Delhi, 2018.
4. S. Kaushik, Artificial Intelligence, Cengage Learning India, 2011.
5. D. Poole and A. Mackworth, Artificial Intelligence: Foundations for Computational Agents, Cambridge University Press, 2010.
6. Websites for reference: https://nptel.ac.in/courses/106105077
7. Websites for reference: https://nptel.ac.in/courses/106106126
8. Websites for reference: https://aima.cs.berkeley.edu

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SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code : H	**Category:** Open Elective Courses
Subject Name : Machine Learning	**Semester** : Seventh
L-T-P : **3-0-0**	**Credit: 3**
Pre-Requisites: Mathematics- IB, Mathematics- IIB, Mathematics- III	

Course Objective:

To introduce students to the basic concepts and techniques of Machine Learning.
To have a thorough understanding of the Supervised and Unsupervised learning techniques.
To study the various probability based learning techniques.
To understand graphical models of machine learning algorithms.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	Introduction: Learning– Types of Machine Learning– Supervised Learning– The Brain and the Neuron– Design a Learning System– Perspectives and Issues in Machine Learning– Concept Learning Task– Concept Learning as Search– Finding a Maximally Specific Hypothesis– Version Spaces and the Candidate Elimination Algorithm– Linear Discriminants– Perceptron– Linear Separability– Linear Regression.	8
2	Linear Models: Multi-layer Perceptron– Going Forwards– Going Backwards: Back Propagation Error– Multilayer Perceptron in Practice– Examples of using the MLP– Overview– Deriving Back Propagation– Radial Basis Functions and Splines– Concepts– RBF Network– Curse of Dimensionality– Interpolations and Basis Functions– Support Vector Machines.	7
3	Tree and Probabilistic Models: Learning with Trees– Decision Trees– Constructing Decision Trees– Classification and Regression Trees– Ensemble Learning– Boosting– Bagging– Different ways to Combine Classifiers– Probability and Learning– Data into Probabilities– Basic Statistics– Gaussian Mixture Models– Nearest Neighbor Methods– Unsupervised Learning– K means Algorithms– Vector Quantization– Self Organizing Feature Map.	7

4	Dimensionality Reduction and Evolutionary Models: Dimensionality Reduction– Linear Discriminant Analysis– Principal Component Analysis– Factor Analysis– Independent Component Analysis– Locally Linear Embedding– Isomap– Least Squares Optimization. Evolutionary Learning– Genetic algorithms– Genetic Offspring- Genetic Operators– Using Genetic Algorithms– Reinforcement Learning– Overview– Getting Lost Example– Markov Decision Process.	7
5	Graphical Models: Markov Chain Monte Carlo Methods– Sampling– Proposal Distribution– Markov Chain Monte Carlo– Graphical Models– Bayesian Networks– Markov Random Fields– Hidden Markov Models– Tracking Methods.	7

Course Outcomes:
Upon completion of this course, the students will be able to:
1. Distinguish between, supervised, unsupervised and semi-supervised learning
2. Apply the appropriate machine learning strategy for any given problem
3. Suggest supervised, unsupervised or semi-supervised learning algorithms for any given problem
4. Design systems that uses the appropriate graph models of machine learning
5. Modify existing machine learning algorithms to improve classification efficiency

Learning Resources:
1. Jeeva Jose, Introduction of Machine Learning, Khanna Publishing House, 2019.
2. S. Marsland, Machine Learning– An Algorithmic Perspective, 2nd Edition, Chapman and Hall/CRC Machine Learning and Pattern Recognition Series, 2014.
3. T.M. Mitchell, Machine Learning, First Edition, McGraw Hill Education, 2013.
4. P. Flach, Machine Learning: The Art and Science of Algorithms that Make Sense of Data, First Edition, Cambridge University Press, 2012.
5. J. Bell, Machine learning– Hands on for Developers and Technical Professionals, First Edition, Wiley, 2014.
6. E. Alpaydin, Introduction to Machine Learning (Adaptive Computation and Machine Learning Series), 3rd Edition, MIT Press, 2014.

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SYLLABUS FOR BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

(Effective from academic session 2018-19)

Subject Code: I	**Category:** Open Elective Courses
Subject Name: Water Resource Engineering	**Semester:** Seventh
L-T-P: 3-0-0	**Credit:** 3
Pre-Requisites: Fluid Mechanics	

Course Objectives:

The objective of this course is to provide an understanding of the concepts of closed conduit flow, open channel flow, surface water hydrology and rainfall, and also groundwater hydrology and its charactristics.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	**Fluid Mechanics:** Review of fluid statics, Review of fluid dynamics; dimensional analysis.	4
2	**Closed Conduit Flow:** Closed conduit flow, Design of water distribution systems, pipe network analysis: Hardy Cross Method, Design of Network Reservoir pipeline.	9
3	**Open Channel Flow:** Continuity, momentum equations, Chezy, Mannings and energy equations, Water surface profiles.	9
4	**Surface Water Hydrology:** Rainfall depth, duration, distribution, determination of average rainfall depth by Arithmatic, Mean Method, Thiessen Polygon Method and Isohyetal Method, Rainfall/ runoff equations, Rainfall/ runoff models, unit hydrograph, hydrologic routing models.	10
5	**Groundwater Hydrology:** Porosity and water content, Equations of ground water flow (unconfined aquifers/ confined, aquifers/ unsaturated flow), Estimation of aquifer parameters using graphical and analytical approach.	4

Course Outcomes:

At the end of the course, the student will be able to:

1. Understand characteristic features of closed conduit flow and open channel flow.
2. Know different features of surface water hydrology and rainfall.
3. Study about groundwater hydrology and its characteristic relationships.

Learning Resources:

1. S.K. Garg, Hydrology and Water Resources Engineering, Khanna Pub., 1973.
2. R.A. Wurbs and W.P. James, Water Resources Engineering, Pearson, 2001.
3. K. Subramanya, Engineering Hydrology, 4th Edition, McGraw-Hill, New Delhi, 2013.

4. C.S.P. Ojha, R. Berndtsson and P. Bhunya, Engineering Hydrology, Oxford University Press, 2008.
5. M.J. Deodhar, Elementary Engineering Hydrology, Pearson Education, 2008.
6. K. Subramanya, Flow in Open Channels, 5th Edition, McGraw-Hill, 2019.
7. R. Srivastava, Flow through Open Channels, Oxford University Press, 2008.
8. V.T. Chow, Open-Channel Hydraulics, The Blackburn Press, 2009.
9. Elements of Water Pollution Control Engineering, Khanna Publishing House, 2019.