M.Tech. Programme in **Mechanical Engineering**  
Mechanical Engineering Department, IIT Patna

<table>
<thead>
<tr>
<th>Semester</th>
<th>Courses</th>
<th>Credits</th>
<th>Total</th>
</tr>
</thead>
</table>
| **Semester I** | Core Theory courses (3-0-0-6) : 2  
Elective Theory courses (3-0-0-6): 3  
ME Lab : I (0-0-3-3)  
HSS Elective (2-0-0-4) | 2×6 = 12  
3×6 = 18  
3  
4 | **37** |
| **Semester II** | Core Theory courses (3-0-0-6) : 2  
Elective Theory courses (3-0-0-6): 3  
ME Lab : II (0-0-3-3)  
Seminar (0-0-4-4) | 2×6 = 12  
3×6 = 18  
3  
4 | **37** |
| **Semester III** | Project phase I (24) | 24 | **24** |
| **Semester IV** | Project phase II (24) | 24 | **24** |

**Total credit = 122**

**Name of courses**

- **Core Courses**
  1. MH503: Advanced Engineering Mathematics (3-0-0-6)
  2. ME519: Advanced Engineering Software Lab (1-0-4-6)
  3. ME521: Advanced Fluid Mechanics (3-0-0-6) for **Thermo-Fluids** stream
  4. ME523: Advanced Dynamics & Vibration (3-0-0-6) for **Solid Mechanics & Design** stream
  5. ME525: Metal Cutting & Analysis (3-0-0-6) for **manufacturing** stream
  6. ME522: Advanced Heat Transfer (3-0-0-6) for **Thermo-Fluids** stream
  7. ME524: Theory of Elasticity (3-0-0-6) for **Solid Mechanics & Design** stream
  8. ME526: Metal Forming & Analysis (3-0-0-6) for **manufacturing** stream

- **Lab & Seminar Courses**
  ME529: Thermo-Fluids Lab-I (0-0-3-3) for **Thermo-Fluids** stream
  ME531: Manufacturing Lab I (0-0-3-3) for **manufacturing** stream
  ME538: Solid Mechanics & Design Lab-I (0-0-3-3) for **Solid Mechanics & Design** stream
  ME530: Thermo-Fluids Lab-II (0-0-3-3) for **Thermo-Fluids** stream
  ME532: Manufacturing Lab II (0-0-3-3) for **manufacturing** stream
  ME539: Solid Mechanics & Design Lab-II (0-0-3-3) for **Solid Mechanics & Design** stream
  MH507: Seminar (0-0-4-4)
ME603: Project phase I
ME604: Project phase II

- **Electives I-III**
A student should select three courses from three different groups. If there is no appropriate course in the department, he can choose course from other department.

<table>
<thead>
<tr>
<th>Group</th>
<th>Courses</th>
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</thead>
</table>
| Group A | ME503: Computational Fluid Dynamics  
ME504: Vehicle Dynamics and Multi-body Systems |
| Group B | ME533: Finite Element Analysis  
ME535: Acoustics |
| Group C | ME742: Advanced Manufacturing Processes  
ME501: Robotics: Advanced Concepts & Analysis  
ME581: Bio Mechanics and Bio Mechatronics  
ME537: Refrigeration and Air-Conditioning |

- **Electives IV-VI**
A student should select three courses from three different groups. If there is no appropriate course in the department, he can choose course from other department.

<table>
<thead>
<tr>
<th>Group</th>
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</tr>
</thead>
</table>
| Group A | ME 542: Aerodynamics  
ME512: Mobile Robotics  
ME534: Wear & Lubrication of Machine Components  
ME506: Emerging Smart Materials for Mechatronics Applications  
ME502: Industrial Automation |
| Group B | ME546: Multiphase Flow & Heat Transfer  
ME554: Rotor Dynamics |
| Group C | ME541: Turbulent Shear Flow  
ME536: Non-linear Systems Dynamics |

**Detailed Syllabus**
(Core courses)

**MH503: Advanced Engineering Mathematics**  
(3-0-0-6)
Prerequisite NIL
Linear Algebra: Matrix algebra; basis, dimension and fundamental subspaces; solvability of $Ax = b$ by direct Methods; orthogonality and QR transformation; eigenvalues and eigenvectors, similarity transformation, singular value decomposition, Fourier series, Fourier Transformation, FFT. Vector Algebra & Calculus: Basic vector algebra; curves; grad, div, curl; line, surface and volume integral, Green’s theorem, Stokes’s theorem, Gauss-divergence theorem. Differential Equations: ODE: homogeneous and non-homogeneous equations, Wronskian, Laplace transform, series solutions, Frobenius method, Sturm-Liouville problems, Bessel and Legendre equations, integral
transformations; PDE: separation of variables and solution by Fourier Series and Transformations, PDE with variable coefficient.

Numerical Technique: Numerical integration and differentiation; Methods for solution of Initial Value Problems, finite difference methods for ODE and PDE; iterative methods: Jacobi, Gauss-Siedel, and successive over-relaxation.

Complex Number Theory: Analytic function; Cauchy’s integral theorem; residue integral method, conformal mapping.

Statistical Methods: Descriptive statistics and data analysis, correlation and regression, probability distribution, analysis of variance, testing of hypothesis.

Text Books:

ME 521 Advanced Fluid Mechanics (3-0-0-6)

Concepts of fluids: Definitions of fluids, concept of continuum, different types of fluid, tensor analysis, governing laws of fluid mechanics in integral form, Reynold’s transport theorem, mass, momentum and energy equations in integral form and their applications, differential fluid flow analysis, continuity equation, Navier-Stokes equation and exact solutions. Potential flow analysis: Two-dimensional flow in rectangular and polar coordinates, continuity equation and the stream function, irrotationality and the velocity potential function, complex potential function, vorticity and circulation, flow over immersed bodies and D’ Alembert’s paradox, aerofoil theory and its application. Viscous flow analysis: Low Reynold’s number flow, approximation of Navier-stokes equation, approximate solutions of Navier-Stokes equation, Stokes and Oseen flows, hydrodynamic theory of lubrication, Prandtl’s boundary layer equations, Large Reynold’s number flow approximation, flow instabilities and onset of turbulence. Compressible fluid flow: One dimensional isentropic flow, Fanno and Rayleigh flows, choking phenomenon, normal and oblique shocks. Micro and nano flow: Physical aspects of micro and nano flows, governing equations, surface tension driven flows, modeling of micro and nano flows.

Text Books:
ME523 Advanced Dynamics and Vibration (3-0-0-6)
Review of Newtonian mechanics for rigid bodies and system of rigid bodies; coordinate transformation between two set of axes in relative motion between one another; Euler angles; angular velocity, angular acceleration, angular momentum etc. in terms of Euler angle parameters; Newton-Euler equations of motion; elementary Lagrangian mechanics: generalized coordinates and constraints; principle of virtual work; Hamilton’s principle; Lagrange’s equation, generalized forces. Lagrange’s equation with constraints, Lagrange’s multiplier. Nonlinear effects in Dynamics. Review of the single DOF system and simple Multi-DOF lumped parameter systems. Equations of motion for free and forced vibration of distributed parameter systems: axial vibration of a bar, transverse vibration of a string, torsional vibration of a shaft, transverse vibration of beams. Boundary-value problem and boundary conditions. Differential eigenvalue problem, eigenfunction and natural modes. Orthogonality of eigenfunctions and expansion theorem. Rayleigh quotient. Response to initial conditions and external excitations. Discretization of distributed parameter system: Algebraic eigenvalue problem, eigenvalue and eigenvectors. Introduction to Modal analysis.

Text Books:

ME525 Metal Cutting and analysis (3-0-0-6)
Single and multipoint tool geometry (ASA, ORS, NRS, MRS), conversion of tool angles; mechanics of chip formation (for ductile and brittle materials): Levy Lodes’ theorem, fracture mechanics; Orthogonal and oblique cutting mechanics; dynamometry (strain gauge, piezo etc); Surface roughness in machining; Thermal aspects of machining; Machinability; Cutting fluids: properties, types, application techniques, emissions and its adverse effects; Chip breaker; Recent advances in machining: hard turning, high speed machining, diamond turning, machining of advanced materials, machining with minimum quantity cutting fluids and cryogenic fluids; Grinding: mechanics, forces, specific energy, temperature, wheel wear and surface finish; Broaching: mechanics;

Text Books:

ME519 Advanced Engineering Software Laboratory (1-0-4-6)
CAD/CAM: 2D and 3D geometric transformation, Composite Transformation, Projections; Curves: Cubic, Bezier, Splines; Surfaces: Quadric, Coons patch, Super Quadric, Bezier, B-Splines. Process planning, CL data generation, Automatic CNC code generation.
FEM: Solid model creation, different types of elements, chunking of model, meshing, mesh quality, different kinds of analysis: static, dynamic, transient, thermal, electro-magnetic, acoustics, sub-structuring and condensation. Error and convergence. Non-linear static and dynamic analysis, contact analysis, multi-physics problem, rigid body analysis of flexible element.

CFD: Different types of CFD techniques, various stages of CFD techniques (i) pre processor: governing equations, boundary conditions, grid generation, different discretization techniques (ii) processor: solution schemes, different solvers (iii) post-processing: analysis of results, validation, grid independent studies etc. Developing codes using commercial/open source software for solving few problems of laminar and turbulent flow with heat transfer applications.

Engineering softwares related to CAD/CAM, FEM, CFD, with both GUI and script like languages, are to be used for laboratory assignments.

Text Books:
8. S. Biringen and C Chow, An Introduction to Computational Fluid Mechanics by Example

ME522 Advanced Heat Transfer (3-0-0-6)
Conduction: Equations and boundary conduction in different coordinate systems; Analytical Solutions: separation of variables, Laplace Transform, Duhamel’s theorem: Non-impulse initial conditions; Numerical Methods: Finite difference and flux conservation; Interfacial heat transfer. Convection: Conservation equations and boundary conditions; Heat transfer in laminar developed and developing boundary layers: duct flows and external flows, analytical and approximate solutions, effects of boundary conditions; Heat transfer in turbulent boundary layers and turbulent duct flows; Laminar and turbulent free convection, jets, plumes and thermal wakes, phase change. Radiation: Intensity, radiosity, irradiance, view factor geometry and algebra; formulations for black and non–black surfaces, spectrally–selective surfaces (solar collectors); Monte Carlo methods for radiation exchange; The radiative transfer equation, extinction and scattering properties of gases and aerosols, overview of solution methods and applications. Interaction between conduction, convection and radiation: Coupled problems; Examples in manufacturing and electronic cooling applications; Micro channels and micro fins.

Text Books:

ME524 Theory of Elasticity (3-0-0-6)
Stress and strain tensors, equations of equilibrium and compatibility in rectangular and curvilinear coordinates, Cauchy’s formula, stress transformation, principal stresses, Lame’s stress ellipsoid, Cauchy stress quadratic, octahedral stress, stress-strain relations, basic equations of elasticity, Boundary value problem, Uniqueness of solutions, Torsion of non-circular sections, St. Venant’s theory of torsion, Scalar and Vector potentials, Strain potentials. Plane state of stress and strain, Airy’s stress function for problems, Representation of biharmonic function using complex variables, Kolosoff-Mushkelishvili method. Thermal stress, Applications to problems of curved beam, thick cylinder and rotating disc, stress concentration. Introduction to numerical methods in elasticity. Contact problems, energy and variational principles Theory of Elasticity:

Text Books:

ME526 Metal Forming and Analysis (3-0-0-6)

Texts Books:
[2] G. W. Rowe, Principles of Industrial Metal working processes, CBS publishers and Distributors

Lab Courses

ME538 Solid Mechanics & Design Lab-I (0-0-3-3)
1) Measurement of Mode I fracture toughness of an Aluminum alloy and PMMA using a compact tension (CT) specimen.
2) Measurement of fatigue crack growth and determination of Paris law parameters for an Aluminum alloy using a CT specimen.
3) Measurement of strains using strain gauges.
4) Determination of ductile to brittle transition temperature of Mild Steel and Aluminum using Charpy Impact Testing Machine.
5) Torsion of bars of non-circular cross-section.
6) Measurement of stress concentration factor in a specimen with holes using photo elasticity method.
7) Observation of mode shapes and measurement of natural frequencies of vibration of a circular plate.
8) Detection of location and size of crack in a cracked beam using deflection measurement method.
9) Scanning Electron Microscopy examination of fracture surfaces of specimens fractured in experiment nos. 1), 2) and 4) above.

Texts Books:
3 Dally, Riley, and McConnell, Instrumentation for engineering measurements, 2e, John Wiley & Sons., 1993
4 Figiola, R.S. and Beasley, D.E., Theory and design for mechanical measurements, 2(e), John Wiley, 1995

ME539 Solid Mechanics & Design Lab-II

1) DAQ and its components, feedback motion control of DC motor, low pass and high pass filters, spectrum analysis.
2) Fault Detection in Rotating Machinery.
3) Electrical motor current signature analysis on Machine Fault Simulator
4) Experimental investigation of Oil whirl-Oil whip in Machine Fault Simulator
5) Study of Air Bearing apparatus and its onset whirl
6) Experimental investigation of Rider's comfort through Active mass suspension
7) To determine the frequency response function of a Cantilever Beam
8) To measure the sound pressure level of shop floor/machine with different weighting scale and validation of inverse proportionality law
9) Dynamic Balancing (on MFS) and Field balancing of Rotating machinery
10) Experimental setup built by students themselves / a precursor to M-Tech. project.

Texts Books:
2. Dally, Riley, and McConnell, Instrumentation for engineering measurements, 2e, John Wiley & Sons., 1993
3. Figiola, R.S. and Beasley, D.E., Theory and design for mechanical measurements, 2(e), John Wiley, 1995

ME531 Manufacturing Laboratory I

Determination of chip reduction coefficient, fabrication single point cutting tool, re-sharpening of twist drill, cutting force measurement using DAQ and Labview, measurement of cutting temperature using DAQ and Labview, estimation of tool life, optimal design of chip breaker, study on Machinability

Texts Books:

ME532 Manufacturing Laboratory II (0-0-3-3)

Direct extrusion and indirect extrusion, effect of lubrication on die pressure and load, rolling, drawing, forging load estimation, sheet bending Estimation, deep drawing analysis, and Forming limit diagram, spinning, blanking and piercing operation.

Text/reference Books
1. G. W. Rowe, Principles of Industrial Metal working processes, CBS publishers and Distributors, New Edition

ME529 Thermal Fluid Laboratory (0-0-3-3)


Texts Books:
3. Dally, Riley, and McConnell, Instrumentation for engineering measurements, 2e, John Wiley & Sons., 1993

ME530 Thermal Fluid Laboratory II (0-0-3-3)


Texts Books:
2. Dally, Riley, and McConnell, Instrumentation for engineering measurements, 2e, John Wiley & Sons., 1993
3. Figiola, R.S. and Beasley, D.E., Theory and design for mechanical measurements, 2(e), John Wiley, 1995
Elective Courses

ME503 Computational Fluid Dynamics (3-0-0-6)

Concept of Computational Fluid Dynamics: Different techniques of solving fluid dynamics problems, their merits and demerits, governing equations of fluid dynamics and boundary conditions, classification of partial differential equations and their physical behavior, Navier-Stokes equations for Newtonian fluid flow, computational fluid dynamics (CFD) techniques, different steps in CFD techniques, criteria and essentialities of good CFD techniques.

Finite Difference Method (FDM): Application of FDM to model problems, steady and unsteady problems, implicit and explicit approaches, errors and stability analysis, direct and iterative solvers.


Prediction of Viscous Flows: Pressure Poisson and pressure correction methods for solving Navier-Stokes equation, SIMPLE family FVM for solving Navier-Stokes equation, modelling turbulence.

CFD for Complex Geometry: Structured and unstructured, uniform and non-uniform grids, different techniques of grid generations, curvilinear grid and transformed equations.

Lattice Boltzman and Molecular Dynamics: Boltzman equation, Lattice Boltzman equation, Lattice Boltzman methods for turbulence and multiphase flows, Molecular interaction, potential and force calculation, introduction to Molecular Dynamics algorithms.

Text Books:

ME537 Refrigeration and Air conditioning (3-0-0-6)

Pre-requisites: Nil

Refrigeration
Refrigeration systems: Vapour compression, vapour absorption and air refrigeration system, Thermoelectric refrigeration, Cryogenics.
Refrigeration Hardware: Refrigerant compressors, refrigerant condensers, refrigerant evaporators, receiver, expansion devices, filter-drier, moisture indicator etc.

Refrigeration Controls: HP/LP cut-out, Solenoid valve, evaporator pressure regulator, Accumulators, Suction pressure regulator.

Capacity control techniques: Hot gas by-pass scheme, Cylinder loading scheme, suction gas throttling scheme

Refrigerants: Classification and nomenclature, desirable properties of refrigerants, common refrigerants, environmental issues-Ozone depletion and global warming

Alternative refrigerants: low GWP and zero ODP newer refrigerants.

Applications of Refrigeration: Industrial refrigeration, Transport refrigeration, food preservation (cold storage)

**Air-conditioning**

Review of Basic psychrometry: Sensible cooling/heating processes, humidification /dehumidification processes on psychrometric chart etc.

Classification of air-conditioners: unitary systems (Window type/self-contained/single-package unit), split-unit and Central air conditioning system


Duct Design: Design considerations and procedures

Air Conditioning controls: basic elements, types of control systems

**Texts and References:**


**ME535 Acoustics**


**Text Books:**

**ME536 Nonlinear System Dynamics**

(3-0-0-6)

Introduction to Nonlinear Dynamical System: Linear vs. nonlinear behavior, Classification of nonlinear Systems, Examples of structural, fluid-mechanical and chemical/biological systems, Existence and uniqueness of solutions.

First-order nonlinear systems: Autonomous systems: Equilibrium points, linear systems, invariant sets, linearization, phase diagrams and velocity fields, behavior dependence on parameters, bifurcations of equilibria (saddle-node, pitchfork and transcritical), implicit function theorem. Nonautonomous systems.

Second-order nonlinear conservative/nonconservative systems: Phase plane analysis, equilibrium points, linearization, stability, periodic orbits and saddle points, potential function and phase portrait, parameter-dependent conservative systems, local bifurcations, examples of global bifurcations, effect of dissipative forces.

First-order system in the plane: General phase plane analysis, linearization, general solution for linear systems, classification of equilibrium points, limit cycles, Bendixon's criterion and Poincare Bendixon theorem. Point mapping techniques, exact transformations, and Poincare mappings.

One-dimensional linear and nonlinear mappings: Fixed points, linearization, stability, parameter-dependent mappings, bifurcations.


General linear systems with constant and periodic coefficients: Concepts of stability (Lyapunov, Poincare, etc.), stability by linearization, boundedness of solutions, Mathieu's equation, transition curves and periodic solutions for Mathieu-Duffing system.

Relaxation oscillations: The van der Pol oscillator.

Multi degree of freedom systems: Examples, various types of resonances – external, internal, and combination, etc., response prediction using methods of averaging and multiple scales.

Text Books:

ME534 Wear and Lubrication of Machine components (3-0-0-6)

Text Books:
1. Tribology, Principles and Design Applications, by Arnell et al.
2. Principles and Applications of Tribology, by B. Bhushan
3. Tribology Handbook, by B. Bhushan
   Contact Mechanics KL Johnson, 1985 Cambridge
4. Basic Lubrication Theory, By A. Cameron, 1976

ME742 Advanced Manufacturing Processes (3-0-0-6)
Advanced Engineering Materials & the limitations of Conventional manufacturing processes; Classification of advanced manufacturing processes; Water jet & abrasive water jet machining; Ultrasonic machining; Electrical discharge machining; Ion Beam, Electron Beam & Laser beam in manufacturing; PVD & CVD; Micro and Nano Manufacturing.

Text Books:
ME501 Robotics: Advanced Concepts and Analysis (3-0-0-6)

**Introduction to robotics:** brief history, types, classification and usage and the science and technology of robots.

**Kinematics of robot:** direct and inverse kinematics problems and workspace, inverse kinematics solution for the general 6R manipulator, redundant and over-constrained manipulators.

**Velocity and static analysis of manipulators:** Linear and angular velocity, Jacobian of manipulators, singularity, static analysis.

**Dynamics of manipulators:** formulation of equations of motion, recursive dynamics, and generation of symbolic equations of motion by a computer simulations of robots using software and commercially available packages.

**Planning and control:** Trajectory planning, position control, force control, hybrid control

**Industrial and medical robotics:** application in manufacturing processes, e.g. casting, welding, painting, machining, heat treatment and nuclear power stations, etc; medical robots: image guided surgical robots, radiotherapy, cancer treatment, etc;

**Advanced topics in robotics:** Modelling and control of flexible manipulators, wheeled mobile robots, bipeds, etc. Future of robotics.

Reference Books:


ME504: Vehicle Dynamics and Multi-body Systems (3-0-0-6)

**Introduction to vehicle dynamics:** Vehicle coordinate systems; loads on axles of a parked car and an accelerating car. Acceleration performance: Power-limited acceleration, traction-limited acceleration.

**Tire models:** Tire construction and terminology; mechanics of force generation; rolling resistance; tractive effort and longitudinal slip; cornering properties of tire; slip angle; camber thrust; aligning moments.

**Aerodynamic effects on a vehicle:** Mechanics of airflow around the vehicle, pressure distribution, aerodynamic forces; pitching, rolling and yawing moments; crosswind sensitivity.

**Braking performance:** Basic equations for braking for a vehicle with constant deceleration and deceleration with wind-resistance; braking forces: rolling resistance, aerodynamic drag, driveline drag, grade, tire-road friction; brakes, anti-lock braking system, traction control, braking efficiency.

**Steering systems and cornering:** Geometry of steering linkage, steering geometry error; steering system models, neutral steer, under-steer, over-steer, steering ratio, effect of under-steer; steering system force and moments, low speed and high speed cornering; directional stability of the vehicle;
influence of front-wheel drive.

**Suspension and ride:** Suspension types—solid axle suspensions, independent suspensions; suspension geometry; roll centre analysis; active suspension systems; excitation sources for vehicle rider; vehicle response properties, suspension stiffness and damping, suspension isolation, active control, suspension non-linearity, bounce and pitch motion.

**Roll-over:** Quasi-static roll-over of rigid vehicle and suspended vehicle; transient roll-over, yaw-roll model, tripping.

**Multi-body systems:** Review of Newtonian mechanics for rigid bodies and system of rigid bodies; coordinate transformation between two set of axes in relative motion between one another; Euler angles; angular velocity, angular acceleration, angular momentum etc. in terms of Euler angle parameters; Newton-Euler equations of motion; elementary Lagrangian mechanics: generalised coordinates and constraints; principle of virtual work; Hamilton’s principle; Lagrange’s equation, generalized forces. Lagrange’s equation with constraints, Lagrange’s multiplier.

**Text Books**


**Reference Books:**


**ME506: Emerging Smart Materials for Mechatronics Applications**

**Introduction:** Smart materials and their application for sensing and actuation, Mechatronics aspects.

**Piezoelectric materials:** Piezoelectricity and piezoelectric materials, Constitutive equations of piezoelectric materials, Piezoelectric actuator types, Control of piezoelectric actuators, Applications of piezoelectric actuators for precise positioning and scanning.

**Shape memory alloys (SMA):** Properties of shape memory alloys, Shape memory effects, Pseudoplasticity in SMA, Design of shape memory actuator, selection of materials, Smart actuation and control, Applications of SMA in precision equipments for automobiles, trains and medical devices.

**Electro-active polymers (EAPs):** Ionic polymer metal composites (IPMC), Conductive polymers, Carbon nanotubes, Dielectric elastomers, Design & control issues for EAP actuators, Applications of EAP for biomemetic, tactile display and medical devices.

**Magnetostrictive materials:** Basics of magnetic properties of materials, magnetostriction: constitutive equations, types of magnetostrictive materials, Design & control of magnetostrictive actuators, Applications of magnetostrictive materials for active vibration control.

**Summary, conclusion and future outlook:** Comparative analysis of different smart materials based actuators, Conclusions, Future research trend and applications trends of smart materials and smart...
Materials based actuator technology.

Texts Books:


ME502: Industrial Automation (3-0-0-6)

Unit 1: Automation: Introduction, automation principles and strategies, basic elements of advanced functions, levels modeling of manufacturing systems.

Unit 2: Material handling: Introduction, material handling systems, principles and design, material transport system: transfer mechanisms automated feed cut of components, performance analysis, uses of various types of handling systems including AGV and its various guiding technologies.

Unit 3: Storage system: Performance, location strategies, conventional storage methods and equipments, automated storage systems.

Unit 4: Automated manufacturing systems: Components, classification, overview, group technology and cellular manufacturing, parts classification and coding, product flow analysis, cellular manufacturing, application considerations in G.T.

Unit 5: FMS: Introduction, components, application, benefits, planning and implementation, transfer lines and fundamentals of automated production lines, application, analysis of transfer line without internal storage (numerical problems).

Unit 6: Inspection Technology: Introduction, contact and non-contact conventional measuring, gauging technique, CMM, surface measurement, machine vision, other optical inspection techniques, non-contact non-optical inspection technologies versus.

Unit 7: Manufacturing support system: Process planning and concurrent engineering- process planning, CAPP, CE and design for manufacturing, advanced manufacturing planning, production planning and control system, master production schedule, MRP.

Unit 8: Capacity planning, shop floor control, inventory control, MRP-II, J.I.T production systems, lean and agile manufacturing.

Text Books:


References Books:

ME 512 Mobile Robotics        (3-0-0-6)

Objectives: Mobile robots are now enabling human beings to physically reach and explore unchartered territories in the Universe. Be a place as distant as Mars, in abyssmal depths of ocean, or shrouded by thick glaciers of Antarctic, mobile robots help exploring everything; yet this is just the beginning. Even in day to day life autonomous cars hold a potential to revolutionize transportation and domestic mobile robots help humans in cleaning, elderly help, etc. National defense is an area replete with the use of mobile robots. This course will present various aspects of design, fabrication, motion planning, and control of intelligent mobile robotic systems. The focus of the course is distributed equally on the computational aspects and practical implementation issues and thereby leads to a well rounded training. The course will give students an opportunity to design and fabricate a mobile robotic platform and program it to apply learned theoretical concepts in practice as a semester long project.

Syllabus:

Robot locomotion: Types of locomotion, hopping robots, legged robots, wheeled robots, stability, maneuverability, controllability;
Mobile robot kinematics and dynamics: Forward and inverse kinematics, holonomic and nonholonomic constraints, kinematic models of simple car and legged robots, dynamics simulation of mobile robots.
Perception: Proprioceptive/Exteroceptive and passive/active sensors, performance measures of sensors, sensors for mobile robots like global positioning system (GPS), Doppler effect-based sensors, vision based sensors, uncertainty in sensing, filtering;
Localization: Odometric position estimation, belief representation, probabilistic mapping, Markov localization, Bayesian localization, Kalman localization, positioning beacon systems.
Introduction to planning and navigation: path planning algorithms based on A-star, Dijkstra, Voronoi diagrams, probabilistic roadmaps (PRM), rapidly exploring random trees (RRT), Markov Decision Processes (MDP), stochastic dynamic programming (SDP);
Robotics Project: Students will work on a semester long project consisting of design, fabrication, and programming a mobile robotic platform.

Texts Books:


ME541 Turbulent Shear Flows        (3-0-0-6)

Students who may find this course useful: PhD, M. Tech and 3rd/4th–year B. Tech. Students from Mechanical, Civil and Chemical Engineering Departments.

Pre-requisite: ME204 (Fluid Mechanics I) of IIT Patna or an equivalent basic course in Fluid Mechanics

Course Contents:

1. Flow instability and transition to turbulence
2. Nature of turbulence
3. Indicial notation for tensors
4. Fourier transforms and Parseval’s theorem
5. Governing equations of turbulence
6. Eulerian Lagrangian and Fourier descriptions of turbulence
7. Statistical description of turbulence (Reynolds-averaged Navier-Stokes and Reynolds stress evolution equations)
8. Kolmogorov’s hypotheses
9. Filtered description of turbulence (Bridging methods and large eddy simulation)
10. Boundary layer flow and other important turbulent shear flows (wake, jet, channel flow, etc.)
11. Development of turbulence closure models (Boussinesq approximation and Reynolds-stress evolution equation closures)
12. Rapid distortion theory (RDT) of turbulence

Turbulence processes (Cascade, dissipation, material element deformation, mixing, etc.)

Texts Books:


ME581 Biomechanics and Biomechatronics (3-0-0-6)


Texts Books:


ME 554 Rotor Dynamics (3-0-0-6)


Texts Books:


Reference Books:


ME542 Aerodynamics (3 0 0 6)

Pre-requisites: ME 204, ME 206, ME 305 or equivalent

Review of Fluid Mechanics: Navier-Stokes equations, Potential flows, Concepts of lift and drag, Boundary layer theory, Application of potential flow and boundary layer theory in design of airfoils, Turbulence, Compressible flows, Shock and expansion waves,

Incompressible Flow Applications: Incompressible flow over airfoils: Kutta condition, Kelvin’s circulation theorem, Classical thin airfoil theory, Incompressible flow over finite wings: Prandtl’s classical lifting line theory, Three-dimensional incompressible flows, Panel methods and numerical techniques, Wind tunnel experimentation, Dynamic stall, Delta wings.

Compressible Flow Applications: Introduction to subsonic compressible flow over airfoils, Supercritical Airfoil, Supersonic flows.


Texts and References

ME546  Multiphase Flow and Heat Transfer      (3-0-0-6)
Prerequisites: ME 204 and ME 305, or equivalent
Fundamentals: Introduction to liquid-vapor phase change fundamentals, kinetic theory, interfacial
tension, wettability, boiling, nucleate boiling, critical heat flux and dryout mechanisms, transition
boiling, Leidenfrost, film boiling, nucleation theory, convective flow boiling fundamentals, flow
patterns and regime map, condensation, film-wise condensation vs. dropwise condensation theory.
Devices and applications areas: introduction to devices and application areas, boilers and condensers,
nuclear reactor, thermosyphons, heat pipes, and vapor chambers. Practical considerations: effect of
non-condensable gas and surface aging. Current trends: Heat transfer coefficient enhancement
techniques, heat and mass transfer at microscopic length scales and gravity levels, microchannels,
modeling techniques

Texts Books:

Reference Books:
   ISBN: 9780471457282
   9713835-2-9

ME533 Finite Element Analysis                          ( 3-0-0-6)
Matrix methods review, Rayleigh-Ritz and Galerkin’s method, weak formulations, FEM formulation
in one dimension, interpolation, Multipoint constraints, applications to solid mechanics, heat transfer
and fluid mechanics problems, Solution to truss and frame elements, temperature effect, Euler
Bernoulli and Timoshenko beam element, C0 and C1 elements, Hermite cubic spline functions, shear
locking. Eigen value problem and applications, semidiscrete FEM models, Time approximation
schemes, Problems in 2-D, plane stress, plane strain, torsion problems, isoparametric formulations,
axisymmetric elements, higher order elements, Serendipity elements, quarterpoint element, hybrid
element, numerical intergration, reduced integration, convergence and accuracy, norms, modeling
consideration, computer implementation: example problems in different fields: solid mechanics, heat
transfer, fluid flow etc. Review of equations of elasticity, velocity pressure formulation, LMM and
PM model, Limitations of FEM.

Text Book:

Reference Books:
2. Cook, K.D., Malkus, D.S. and Plesha, M.E., “Concept and Applications of Finite Element
5. Fish, J. and Belytschko, T., “A First Course in Finite Elements”, 1st Ed., John Wiley and
   Sons. 2007.
   2008.