DIT UNIVERSITY
Dehradun

COURSE STRUCTURE
OF
M.TECH. IN CAD/CAM
Batch: 2018-20

Approved by the Academic Council at its 9th Meeting held on 14.04.2018
Department of Mechanical Engineering
Course Structure and Syllabus of M.Tech.-CAD/CAM
Batch: 2018-2020

Year: 1st  Semester: I

<table>
<thead>
<tr>
<th>Course Category</th>
<th>Course Code</th>
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Year: 1st  Semester: II

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List of PG Electives for First Year

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<td>ME656</td>
<td>Modeling And Simulation</td>
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<td>ME657</td>
<td>Rapid Prototyping</td>
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Department of Mechanical Engineering  
Course Structure and Syllabus of M.Tech.-CAD/CAM  
Batch: 2018-2020

Year: 2\textsuperscript{nd}  
Semester: III

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Year: 2\textsuperscript{nd}  
Semester: IV

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List of PG Electives for Second year

- ME751 Mechanism Design
- ME752 Mechanical Vibrations
- ME753 Computational Fluid Dynamics
- ME754 Advanced Optimization Techniques
- ME755 Composite Materials
- ME756 Work Engineering And Ergonomics
- ME757 Product Design And Development
- ME758 Fracture And Failure Analysis
- ME759 System Design And Analysis

Summary of the Credits

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<th>Year</th>
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Finite Difference Method: Classification of Partial Differential Equations, Solutions of elliptic, Hyperbolic & parabolic PDE using Finite Difference Method. (08)

Introduction to Finite Element Method: Introduction to Variational calculus, Euler-Lagrange equation, Geometric & natural boundary conditions, Basics of Finite Element Method, Potential energy; 1D elements, Derivation of Stiffness and Mass matrices for bars, beams and shafts, Comparison with analytical results; Interpolation and Shape functions; Solution of static problems and case studies in stress analysis of Mechanical components; Introduction to FEA using 2D and 3D elements. (10)

Isoparametric Elements and Analysis using Isoparametric Elements. (06)

Importance of Finite Element Mesh, Automatic meshing techniques; Case studies using FEM for Design of simple element geometries such as a tapered bar, a plate with a hole. (08)

Approximate Solution Methods: Ritz and Rayleigh Ritz methods, Method of weighed residuals, General concepts, Point collocation, Subdomain collocation, Least squares,Galerkin method. (10)

Recommended Books:
1. C. S. Krishnamoorty, Finite Element Analysis, Tata McGraw-Hill
4. Huebner, K. H., Dewhirst, D. L., Smith, D. E. and Byrom, T. G.,
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<table>
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<th>Subject Code</th>
<th>ME612</th>
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Course Objective:-  
- Advanced knowledge in the field of manufacturing  
- Part Programming at basic and advanced level  
- Basic information about Numeric Control at obsolete and advanced level  
- Integration of CAD Design and machine tools

Course Outcome:-  
- Students will be able to understand the difference and requirement of automation in the field of manufacturing  
- Students will be able to do manual part programming  
- Students will be able to generate the part program which would be used in machine tool from the modelling software.

Introduction: Introduction to numerical control, basic concepts, advantages of NC, Structure of NC Systems. (07)

N.C. Machine Tools: Types, Definition and designation of control axes, Constructional details of N. C. m/c tools, MCU structure and functions, Methods of improving accuracy and productivity using NC, Problems with conventional NC. (09)

Part Programming: Block format and codes, Tool length and radius compensation, Flexible tooling, Tool path simulation on lathe and milling, Advanced programming features. Tooling For N. C. Machines: Tool and zero presetting, Work holding and setting up of CNC machine. (09)

Numerical Control of M/c Tools: NC, Functioning of NC, MCU Organization, CNC, DNC, Adaptive control types, Uses & benefits, Advantages of CNC, DNC their structure, Combined CNC/DNC systems, CNC part programing (09)

Computer Assisted Part Programming: Automatic NC program generation from CAD models; The APT language, Machining of surfaces, Introduction to Mould, Casting and Die design and manufacture using CAD/CAM software. (09)

Recommended Books:

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<table>
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</table>

**Course outcomes:** After the successful completion of this course, the students will be able to Select & identify suitable automation hardware for the given application, Describe & explain control valves and circuit method to develop any automated application through hydraulic and pneumatic. Differentiate various control aspects of automation, and demonstrate the self-learning capability of Industrial Automation.

**Introduction to Factory Automation:** Basic Concepts, Types of automation, Automation strategies.


**Design of pneumatic logic circuits** for a given time displacement diagram or sequence of operation. Pneumatic safety and remote control circuits and their applications to clamping, Traversing and releasing operations. Automatic Transfer Systems: Automatic transfer, Feeding and orientation devices.

**Automatic transfer machines:** Classifications, Analysis of automated transfer lines, without and with buffer storage, Group technology and flexible manufacturing system.

**Assembly automation:** Types of assembly systems, Assembly line balancing, Performance and economics of assembly system.

**Recommended Books:**

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<table>
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<td>Semester</td>
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**Introduction:** Introduction: Definition of a Robot, Robot classifications and applications, Economic aspects.  
**Robot Kinematics:** Homogeneous co-ordinates and co-ordinate transformations  
**Forward Kinematics:** Dot and cross products, coordinate frames, Rotations, Homogeneous coordinates, link coordinates, D-H Representation, The ARM equation. Direct kinematic analysis for Four axis SCARA Robot and six axis Articulated Robots.  
**Inverse Kinematics:** The inverse kinematics problem, General properties of solutions. Tool configuration, Inverse kinematics of four axis SCARA robot and six axis Articulated robot.  
**Workspace Analysis:** Workspace Analysis of a four axis SCARA robot and a five axis articulated robot Workspace fixtures, the pick and place operations, continuous path motion, Motion interpolation  
**Robot Dynamics:** Introduction to Lagrange and Newton-Euler formulations. Link inertia Tensor, link Jacobian, Manipulator inertia tensor. Generalized forces, Dynamic models of a Two-axis planar robot

**Recommended Books:**
3. P.A. Janaki Raman, Robotics and Image Processing An Introduction, TMH  
Objective: To expose students to the application of programming in CAD applications.

List of Practical's:

1. Utilization of Matlab for mathematical operations on Arrays (with a problem as example).
2. Using Script Files in Matlab (with a problem as example).
3. Programming in Matlab & forming User Defined Functions in Matlab (with a problem as example).
4. Polynomials Curve Fitting and Interpolation using Matlab Applications (with an example problem).
5. Application of Matlab in Numerical Analysis (with an example problem).
6. Genetic Algorithm optimization in Matlab (with an example problem).
7. Application of Matlab programming and optimization methodology in machine design of mechanical components (Mini project)

Course Outcome: Students will be able to understand & relate the application of MATLAB in their domain of research.
Introduction: Types of production systems and their automation, CAD/CAM integration, Concept of FMS and CIMS.

Elements of a General CIM System: Types of CIM systems, CAD-CAM link for CIMS. Benefits of CAM, FMS and CIMS. Automated material handling systems, equipment and their functions (ROBOT’s and AGVS), Integration of Robots in CIMS, Automatic Storage and Retrieval Systems (AS/RS), Carousel, Palletization and fixtures

CIMS configurations: DNC based factory management and control, Integrated CAD/CAM system and shared database.

Group Technology: Concept and terminology, Part family formation, Classification and coding systems for components, Group Technology machine cells.


Computer Aided Production Planning and Control: Inventory control and MRP. Computer aided shop floor control, process monitoring. Computer aided Inspection & Quality Control. Shop floor data collection systems, Shop floor control, Sensors used, Tool management system, automatic identification systems, Barcode system.


Recommended Books:
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<table>
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<th>Subject Code</th>
<th>ME617</th>
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Introduction: What is Mechatronics? Measurement System; Control Systems; Microprocessor based Controllers; Mechatronics Approach. (04)

Sensors and Transducers: Sensors & Transducers; Performance Terminology; Photoelectric Transducers, Flow Transducers, Optical Sensors & Transducers, Semiconductor Lasers, Selection of Sensors, Mechanical/Electrical switches, Inputting data by switches. (10)

Actuators and Mechanisms: Actuation Systems; Pneumatic and Hydraulic Systems; Process Control Valves; Rotary Actuators; Mechanical Actuation Systems; Electrical Actuation Systems (06)

Signal Conditioning: Signal Conditioning; Filtering Digital Signal; Multiplexers; Data Acquisition; Digital Signal Processing; Pulse Modulation; Data Presentation Systems. (08)

Microprocessors and Microcontrollers: Control; Microcomputer Structure; Microcontrollers; Applications; Programmable Logic Controllers. (08)

Design and Mechatronics: Input/output Systems; Computer Based Modular Design; System Validation; Remote Monitoring and Control; Designing; Possible Design Solutions; Case Studies. (08)

Recommended Books:
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<th>Subject Code</th>
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Over view of CAD/CAM systems

Role of Computer Graphics in CAD/CAM, configuration of graphic workstations, menu design and Graphical User Interfaces (GUI), customization and parametric programming.

Product life cycle, CAD/CAM systems and applications, 3D modeling concepts, PLM and associated databases

Computer graphics


Simple programs in C – drawing line & Circle – transformations.

Geometric modeling – Surfaces

Curve entities and representation, analytic curves – line, circle, ellipse, parabola, synthetic curves – Hermite cubic spline, Bezier curve, B-spline curve, NURBs, Curve manipulations Surface entities and representation, surface analysis, Analytical surfaces, synthetic surfaces – Hermitebicubic surface, Bezier surface, B-spline surface, Coons surface, surface manipulations.

Geometric modeling – Solids

Solid models, solid entities, solid representation, Fundamental of solid modeling, Set theory, half spaces, boundary representation (B-rep), Constructive solid geometry (CSG), Sweep representations, solid manipulations, displaying, segmentation, trimming and intersection. Editing, design and engineering applications.

Product data exchange

Introduction, evolution of data exchange format, shape based format, product data based format, ISO standard, IGES- description, Data representation, file structure and format, GKS,PDES.

Recommended Books:


Systems in Organizations: Local and Global context. Additional perspectives as benefits from Technical Trends and innovations, Special characteristics and enigmas of information. Information System and Business Processes: Analyzing information system from a business perspective using work centered analysis of systems. (06)


System Analysis And Design: Information System Planning, Introduction challenges, Strategic issues, Selecting systems, Project management issues, Methodology and implications of system analysis and design, SDLC, Prototyping, End user Development, Off the shelf software, Outsourcing and application software. (06)

Tools for Information System Development: Structural tools for analysis and design, Tools to represent system data and process, Tools for structured programming, Tools to convert programs specification into code. (04)


ERP: Introduction, Concepts, Applications, Advantages and disadvantages. (04)

Recommended Books:
1. Alter, S., Information System of Management, Benjamin Curmmings
2. Laudon and Laudon, MIS: A Managerial Perspective, Pearson Education
4. Davis and Olson, Management Information System, McGraw Hill

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Machine tool Drives and Mechanisms: Machine tool drives, hydraulic transmission elements, mechanical transmission elements, machine tool layout, Regulation of speed and feed  

Design of Machine Tool Structures and Components: Design criteria, materials, static and dynamic stiffness, design of elements like beds, columns and rams.  

Design of guideways and power screws: Design of guideways, slideway protection, power screws for machine tools.  

Design of Spindle systems: Spindles and spindle supports, different types of bearings.  

Machine tool dynamics: Dynamic characteristics of elements and systems, equivalent elastic system, Dynamic characteristics of the cutting process and machine tool, cutting fluids, Stability analysis.

Recommended Books:
2. Sen and Bhattacharya, Machine Tool Design, Central Book Agency
5. Acherkhan, N.S., Machine Tool Design, Mir Publishers
Overview of history and goals of AI: Artificial Intelligence: Definition, components, scope, and application areas; Turing's test; Review of AI successes and failures. (03)

State Spaces, Production Systems, and Search: State space representation of problems; Problem solving using search; Definition and examples of production systems; Heuristic search techniques i.e. generate-and-test, hill climbing, best-first search, constraint satisfaction and mean-ends analysis. (08)

Knowledge Representation: Definition of knowledge; Issues in knowledge representation; Procedural vs declarative knowledge and their representation; Predicate logic, production rules, semantic nets, and frames; Meta-knowledge. (09)

Reasoning and Inference Strategies: Forward vs backward reasoning; Depth first, breadth first, min-max etc.; Non-monotonic reasoning; Symbolic reasoning under uncertainty; Probability and baye’s theorem; Certainty factors, dempster-shafer theory; Fuzzy logic etc. (10)

Expert Systems and their Applications: Justification; Structure; Knowledge sources; Expert knowledge acquisition; Expert system languages; ES building tools/shells; Applications of AI in CAD, CAPP, process selection, GT, MRP II, adaptive control, robotics, process control, fault diagnosis, failure analysis, etc. (12)

Recommended Books:
# Advanced Mechanics of Solids

**Course Code:** ME655  
**Subject Title:** Advanced Mechanics of Solids  
**LTP:** 4 0 0  
**Credit:** 4  
**Subject Category:** DC  
**Year:** 1  
**Semester:** I / I

## Three-Dimensional Stress Analysis:
Stresses on an arbitrary plane, Principal stresses and stress invariant, Mohr’s stress circles, Differential equations of equilibrium in Cartesian and cylindrical coordinates, Three-dimensional strain analysis, Rectangular strain components, Principal strains and strain invariant, Compatibility conditions. Stress-Strain Relations: Generalized Hooke’s law, Stress-strain relations for isotropic materials. (10)

## Unsymmetrical Bending:
Flexure formula for unsymmetrical bending, Shear center and its determination for various sections. (06)

## Curved Flexural Members:
Winkler-Bach formula, Stresses in curved beams having rectangular, Circular and trapezoidal sections, Stresses in rings and chain links. (06)

## Torsion of Non-circular Members:
Torsion of prismatic bars, Elastic membrane analogy, Torsion of sections composed of narrow rectangles (04)

## Thick Cylinders and Rotating Discs:
Lame’s theory for stresses in thick cylinders, Composite tubes, Shrink fits and Laminated cylinders, Thin rotating rings, Stresses in rotating discs and cylinders, Discs of uniform strength. (09)

## Energy Methods:
Principle of superposition, Work done by forces- elastic strain energy stored, Maxwell-Betti’s theorem, Castigliano’s theorems, Strain energy expressions, Fictious load method, Statically indeterminate problems. (10)

## Text Books:
5. Ryder, G.H., Strength of Materials, B.I. Publishers

System Simulation: Techniques of simulation, Monte Carlo method, Experimental nature of simulation, Numerical computation techniques, Continuous system models, Analog and Hybrid simulation, Feedback systems, Computers in simulation studies, Simulation software packages. (08)


Simulation of Mechanical Systems: Building of Simulation models, Simulation of translational and rotational mechanical systems, Simulation of hydraulic systems. (08)

Simulation of Manufacturing Systems: Simulation of waiting line systems, Job shop with material handling and Flexible manufacturing systems, Simulation software for manufacturing, Case studies. (08)

Text Books:
3. System Modelling and Control J. Schwarzenbach and K.F. Gill Edward Arnold
4. Modelling and Analysis of Dynamic Systems Charles M Close and Dean K. Frederick Houghton Mifflin
5. Simulation of manufacturing Allan Carrie John Wiley & Sons
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<table>
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<td>ME657</td>
<td>Rapid Prototyping</td>
<td>LTP 4 0 0 Credit 4 Subject Category DC Year 1st Semester I / II</td>
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**Classifications of Different RP Techniques:** Based on Raw Material, Based on layering technique (2D or 3D) and energy sources. (08)

**Process Technology in RP:** Comparative study of Stereo-lithography (SL) with photo-polymerization, SL with liquid thermal polymerization, Selective laser sintering, Selective powder binding, Ballistic particle manufacturing : both 2D and 3D, Fused Deposition Modeling, Shape Melting, Laminated Object Manufacturing, Solid Ground Curing, Repetitive Masking and deposition, Beam Inference Solidification, Holographic Interference Solidification, Special Topic on RP using metallic alloys, Programming in RP, Modelling, Slicing, Internal Hatching, Surface Skin Fills, Support Structure . (12)

**CAD Data and Programming techniques for RP:** Data requirements, Solid modeling for RP, Surface modeling, Geometric processes, Interface formats, Model preparation, Slicing methods, Design of support structures, Internal hatching and surface skin fills. (08)

**Materials for RP:** Plastics, Ceramics, Resins, Metals, Selection criterions for materials for different processes, the advantages and Limitations of different types of materials. (08)

**Recommended Books:**
4. Upcraft, S. and Ranky, P. G., Rapid Prototyping Solutions, CIMware USA, Inc
5. Jacob, P. F., Rapid Prototyping and Manufacturing, Fundamentals of Sterolithography, SME
6. Rapid Prototyping Reports, CAD/CAM Publishing

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<table>
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<th>Subject Title</th>
<th>Industrial Safety Management</th>
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**CONCEPTS AND TECHNIQUES**
Evolution of modern safety concept, Safety as integral part of business-Safety policy- Safety Organization-line and staff functions for safety- Safety Committee-budgeting for safety. Incident Recall Technique (IRT), disaster control, Job Safety Analysis (JSA), safety survey, safety inspection, safety sampling, Safety Audit

**ACCIDENT INVESTIGATION AND REPORTING**
Concept of an accident, reportable and non-reportable accidents, contribution factor for accident principles of accident prevention, Supervisory role- Role of safety committee – Accident causation models - Cost of accident. Overall accident investigation process - Response to accidents, India reporting requirement, Planning document, Planning matrix, Investigators Kit, functions of investigator, four types of evidences, root cause analysis, Records of accidents, accident reports- Class exercise with case study.

**SAFETY PERFORMANCE MONITORING**
Reactive and proactive monitoring techniques - Permanent total disabilities, permanent partial disabilities, temporary total disabilities -Calculation of accident indices, frequency rate, severity rate, frequency severity incidence, incident rate, accident rate, safety “t” score, safety activity rate – problems, modern tool usage, accident data analysis.

**SAFETY EDUCATION AND TRAINING**

**EFFECTIVE SAFETY MANAGEMENT SYSTEM AND ETHICS**

**Recommended Books:**

Approved by the Academic Council at its 9th Meeting held on 14.04.2018
Objective:
1. To impart knowledge in the friction, wear and lubrication aspects of machine components
2. To understand the material properties which influence the tribological characteristics of surfaces?
3. To understand the analytical behavior of different types of bearings and design of bearings
4. Based on analytical/theoretical approach


High pressure contacts and elasto hydrodynamic lubrication: Rolling contacts of Elastic solids– contact stresses – Hertzian stress equation– Spherical and cylindrical contacts–Contact Fatigue life– Oil film effects– Elasto Hydrodynamic lubrication Theory Soft and hard EHL-Reynolds equation for elasto hydrodynamic lubrication– Film shape within and outside contact zones–Film thickness and friction calculation– Rolling bearings– Stresses and Deflections–Traction drives

Outcome:
1. Ability to select material/surface properties based on the tribological requirements
2. Methodology for deciding lubricants and lubrication regimes for different operating conditions
3. Analysis ability of different types of bearings for given load/speed conditions.

Recommended Books:
Department of Mechanical Engineering
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**Introduction to Kinematic Motion and Mechanisms:** The four bar Linkage, The science of Relative motion, Kinematic diagrams, Six-bar chains, Degrees of freedom, Analysis vs. Synthesis. (08)

**Mechanism Design Philosophy:** Stages of design, The synthesis process, Design categories and mechanism performance parameters. (08)


**Dynamics of Mechanisms:** Inertia forces, Kineto-static Analysis by complex numbers, Superposition method, Matrix Method. Time response, Modification of time response of mechanisms. Virtual work. Lagrange Equations of motion. (10)

**Spatial Mechanisms:** Review of transformations for spatial mechanisms, Analysis of spatial mechanisms. Link and Joint Modeling with Elementary Matrices, Kinematic analysis of an Industrial Robot, Position, Velocity and Acceleration analysis. (08)

**Recommended Books:**
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**Introduction:** Review of basic concepts, Periodic motion, harmonic motion, superposition of simple harmonic motions, beats, Fourier analysis. Single Degree Freedom System: Free vibration, Natural frequency, Equivalent Systems, Energy method for determining natural frequency, Response to an initial disturbance, Torsional vibrations, Damped vibrations, Damping models – Structural, Coulomb and Viscous damping, Vibrations of system with viscous damping, Logarithmic decrement, Viscous dampers. (10)

**Single Degree Freedom:** Forced Vibration: Forced vibration, Harmonic Excitation with viscous damping, Steady state vibrations, Forced vibrations with rotating and reciprocating unbalance, Support excitation, Vibration isolation, Transmissibility, Vibration measuring instruments- Displacement, Velocity, Acceleration and Frequency measuring instrument. (08)

**Two Degree Freedom System:** Introduction, Principal modes, Double pendulum, Torsional system with damping, Coupled System, Undamped dynamic, vibration absorbers, Centrifugal pendulum absorber, Dry friction damper, Untuned viscous damper. (08)

**Multi degree Freedom System:** Exact Analysis Undamped free and forced vibrations of multi degree system, Influence numbers, Reciprocal Theorem, Torsional vibration of multi rotor system, Vibration of geared system, Principal coordinates, Continuous systems- Longitudinal vibration of bars, Torsional vibrations of Circular shafts, Lateral vibration of beams. (09)

**Multi degree Freedom System:** Numerical Analysis: Rayleigh’s, Dunkerley’s, Holzer’s and Stodola’s methods, Rayleigh – Ritz method. Critical Speed of Shafts: Shafts with one disc with and without damping, Multi-disc shafts, Secondary critical speed. (10)

**Text Books:**
1. Mechanical Vibration – P. Srinivasan – TMH  
3. Mechanical Vibration – W.T. Thomson  
4. Mechanical Vibration – Theory & Application – Tse, Morse & Hinkle  

Approved by the Academic Council at its 9th Meeting held on 14.04.2018
Introduction: Motivation and role of computational fluid dynamics, Concept of modeling and simulation. (08)

Governing Equations of Fluid Dynamics: Continuity equation, Momentum equation, Energy equation, Various simplifications, Dimensionless equations and parameters, Convective and conservation forms, Incompressible inviscid flows Basic flows, Source panel method, Vortex panel method. (10)

Nature of Equations: Classification of PDE, General behavior of parabolic, Elliptic and hyperbolic equations, Boundary and initial conditions. (08)

Finite Difference Method: Discretization, Various methods of finite differencing, Stability, Method of solutions. (08)

Incompressible Viscous Flows: Stream function-vorticity formulation, Primitive variable formulation, Solution for pressure, Applications to internal flows and boundary layer flows. (09)

Recommended Books:
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**Linear Programming:** Geometry of linear programming, Graphical method, Linear programming (LP) in standard form, Solution of LP by simplex and revised simplex methods, Exceptional cases in LP, Duality theory, Dual Simple method, Sensitivity analysis. (08)

**Network Analysis:** Transportation problem (with transshipment), Assignment problem, Traveling-salesman problem, Shortest route problem, Minimal spanning tree, Maximum flow problem. (08)

**Integer Programming:** Branch and bound algorithm, Traveling salesman problem. (06)

**Dynamic programming:** Forward recursions, General problem, Reliability problem, Capital budgeting problem, Cargo-loading problem. (06)

**CPM and PERT:** Drawing of networks, Removal of redundancy, Network computations, Free slack, Total slack, Crashing, Resource allocation. (08)

**Non-Linear Programming:** Characteristics, Concepts of convexity, maxima and minima of functions of n-variables using Lagrange multipliers and Kuhn-Tuker conditions, One dimensional search methods, Fibonacci, golden section method and gradient methods for unconstrained problems. (08)

**Text Books:**
3. Rardin, Ronald L., Optimization in Operations research, Pearson Education

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**Introduction** – classifications, terminologies, manufacturing processes (in brief).  
Macro mechanical analysis of lamina – Hooke’s law for anisotropic, monoclinic, orthotropic, transversely isotropic and isotropic materials–2D Unidirectional and angle ply lamina – Strength theories of lamina.  
**Macro mechanical analysis of laminates** – Laminate code, Stress strain relations – In-plane and Flexural modulus, hydrothermal effects.  
**Failure Analysis and Design** – Special cases of laminates, symmetric, cross ply, angle ply and ant symmetric laminates, failure criteria and failure modes

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**Recommended Books:**


Approved by the Academic Council at its 9th Meeting held on 14.04.2018
Introduction

Productivity: Definition, reasons for low productivity, methods to improve productivity, work-study and productivity. Human factor in work-study: Relationship of work-study man with management, supervisor & workers, qualities of a work-study man.

Method-study
Definition, objectives, step-by-step procedure, questioning techniques, charts and diagrams for recording data. Like outline process charts, flow process charts, multiple activity charts, two handed process chart, string diagram, travel chart, cycle graph, Chrono-cycle graph, therbligs, micro motion study and film analysis, Simo chart, principles of motion economy. Development and installation of new method.

Work-Measurement:
Definition, various techniques of work-measurement work-sampling, stopwatch time study & its procedure, Job selection, Equipment and forms used for time study, rating, methods of rating, allowances and their types, standard time, numerical problems, predetermined - time standards and standard data techniques.

Incentive: Meaning, objectives of an incentive plan, various types of incentive plans.

Ergonomics-I
Introduction, history of development, man-machine system and its components. Introduction to structure of the body- features of the human body, stress and strain, and metabolism, measure of physiological functions- workload and energy consumption, biomechanics, types of movements of body members, strength and endurance, speed of movements. NIOSH lifting equation, Lifting Index, Maximum acceptable Weights and Forces, Distal upper extremities risk factors, Strain Index, RULA, REBA

Ergonomics-II

Recommended Books:
The process of product design, Design by evolution, Limitations of evolutionary method in modern design situation, Structure of design process, Morphology of design, Standards of performance, Environmental factors, Creativity techniques in design problem, Strategies for search of design concepts, Physical realizability

Economic and financial feasibility, Designing for function, Iterative value engineering, Designing for production, Tolerance analysis, Use, Maintenance, Designing for handling and installing, Economics of design

Human factors in design, Optimization of design, Reverse engineering of ergonomic shape designs.

Use of CAD / CAM /CAE software for Concurrent Engineering design. Case studies in Design of products for manufacture, Aesthetics, Surface styling and shaping tools in modern CAD software.

Exercises in Design, Design optimization using automated CAE software, Analysis, Reverse engineering a product using CAD, CAM, CAE, 3D scanner, Reverse Engineering and Surface design and review software.

**Recommended Books:**
Sources of failures: Deficiencies in design, Material, Processing, Service and maintenance. Stages of failure analysis, Classification and identification of various types of fracture - overview of fracture mechanics concepts, Ductile and brittle fracture, Fracture origin, Initiators, Characteristics of ductile and brittle fracture.


Failure of Forging, Casting and Weldments: Causes of failure in forging like material characteristics, Deficiencies in design, Improper processing / fabrication or deterioration resulting from service conditions, Failure of iron and steel castings, Effect of surface discontinuities, Internal discontinuities, Microstructure, Improper composition, Improper heat treatment, Stress concentration and service conditions. Failure of weldments - reasons for failure procedure for weld failure analysis.


Recommended Books: