Syllabus of M. Tech. (CAD/CAM/CAE)
### Semester - 1

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<th>Course Code</th>
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<th>Teaching scheme</th>
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<td>MEC501</td>
<td>Advanced Machine Design</td>
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<td>Design of experiments &amp; Research Methodology</td>
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<td>Finite Element Analysis</td>
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<td>MEC509</td>
<td>Elective – I Advanced Materials &amp; Processes</td>
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<td>Engineering</td>
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<td>MEMS &amp; Nanotechnology</td>
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<td>Mechatronic System Design</td>
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<td>3D Modeling and CNC Code Generation Lab.</td>
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<td>Design &amp; Analysis Lab.-I</td>
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<td>MEC555</td>
<td>Seminar I</td>
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** Average contact hours/week/student

Total contact hours/week : 26  
ISE = In Semester Evaluation, MSE = Mid Semester

Total credits : 24  
Examination, ESE = End Semester Examination
### Semester - II

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<td>Optimization Techniques</td>
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<td>Industrial Automation &amp; Robotics</td>
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<td>Manufacturing Systems Design</td>
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<td>Product Lifecycle Management</td>
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<td>MEC510</td>
<td>Elective – II Computational Fluid Dynamics</td>
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<td>MECS512</td>
<td>Rapid Manufacturing</td>
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<td>MECS514</td>
<td>Quality &amp; Reliability Engineering</td>
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<tr>
<td>MEC516</td>
<td>System Dynamics &amp; Simulation</td>
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<td>MEC518</td>
<td>Artificial Intelligence</td>
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<td>MECS520</td>
<td>Automatic Control Engineering</td>
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<td>MEC522</td>
<td>CAD/CAM/CAE Practices in Metal Forming</td>
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<td>Design &amp; Analysis Lab. - II</td>
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<td>MEC556</td>
<td>Seminar II</td>
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** Average contact hours/week/student

Total contact hours/week : 26

Total credits : 24
1. **Analysis of Stress & Strain:**
   State of stress at a point, stress components on an arbitrary plane, principal stresses, Mohr’s circle, plane stress, differential equations of equilibrium, boundary conditions. State of strain at a point, dilation, plane strain, compatibility conditions.

2. **Stress-Strain Relations:**
   Generalizes Hooke’s Law, relations between elastic constants, displacement equations of equilibrium.

3. **Theories of Failure:**
   Theory of dislocations, Maximum principal stress theory, maximum shear stress theory, maximum elastic strain theory, octahedral shearing stress theory, distortion energy theory, Mohr’s theory, significance of theory of failure, use of factor of safety in design, selection of materials for engineering applications.

4. **Energy Methods:**
   Elastic strain energy, Maxwell-Betti-Rayleigh reciprocal theorem, Castigliano’s theorems, strain energy due to axial force, shear force, torsion, bending moment, theory of virtual work.

5. **Axi-symmetric Problems:**
   Thick-walled cylinders, shrink fits, rotating discs.

6. **Fatigue Considerations in Design:**
   Variable loads- basic concepts; Load and Stress variations- different patterns; Cyclic stressing/straining- material response and the origin of fatigue failure; S-N curve - fatigue strength and endurance limit; Factors influencing fatigue, endurance strength modification factors; Fatigue stress concentration; Effect of mean stress- Goodman and Soderberg relations; Design approach to fatigue- design for infinite and finite life; Design of members under combined loading.
Tutorial

One hour per week per batch tutorial is to be utilized for problem solving to ensure that students have properly learnt the topics covered in the lectures. This shall include assignment, tutorials, quiz, surprise test, declared test, seminar, final orals and any others. The teacher may add any of other academic activity to evaluate student for his/her in semester performance.

Minimum six assignments based on the above topics including two exercises involving analysis and design modification for critical components using reverse engineering approach. (e.g. need to change material specifications of a connecting rod, etc.)

References:

1. CAM
CNC machine tools, Principle of operation of CNC, Construction features including structure, drive system, tool-work movement actuation system, Work holding features, Tool holding features, Feedback system, machine control system, 2D and 3D machining on CNC.

2. Theory of metal cutting
Types of work materials, Chip formation and types of chips, Thermal aspects of metal cutting, Tool wear and failure, Cutting fluids, economics of machining parameters – optimizing cutting parameters for minimum cost and maximum production, effect of heat treatment on machining operations.

3. CNC Part Programming -
Detailed Manual part programming on Lathe and machining centers using G & M codes, FAPT programming (FANUC)

4. CNC Tooling:-
Modern cutting tool materials and their applications, ISO nomenclature of tools and tool grades, Different types of tools and tool holders used on CNC Machines, parameters for selection of configuration of cutting tools, Modular tools and fixtures, use of pallets for work holding, palletizing of fixtures.
Advanced CNC processes - EDM, Wire cut M, Abrasive water jet, LASER cutting, (Working principles, construction or set up of process, applications)

5. Co-ordinate Measuring Machine –
Working principle, Drives, Controls, Types and applications of CMM software and utilities; CMM Inspection routines for measuring straightness, roundness, concentricity, center distance and pitch circle diameters of holes, parallelism and perpendicularity of surfaces and bore axes etc.
Process planning using CNC machines: Differences with respect to conventional machines; Design for manufacturing and assembly - Concept with case studies.
6. Geometric Dimensioning and Tolerancing –
    Functional importance of various types of fits, Geometrical dimensioning and tolerancing, Tolerance stacking – types and remedies.
    Computer aided CNC part programming – Introduction to common CNC controllers like FANUC, SIEMENS, MAZAK etc., Generation of tool path, generation of G & M codes, Optimization of tool path (to reduce machining time), (Features available on a typical CAM software).

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References:

4. Reference Manuals of FANUC, Siemens, Mazak, etc.
1. Introduction:

2. Research Design:
Meaning, Need, Concepts related to it, categories; Literature Survey and Review, Dimensions and issues of Research Design, Research Design Process – Selection of type of research, Measurement and measurement techniques, Selection of Sample, Selection of Data Collection Procedures, Selection of Methods of Analysis, Errors in Research.

3. Research Modeling:
(a) Mathematical – Classification of Models, Development of Models, Stages in Model building, Principles of Modelling, Use of Analogy, Models as Approximations, Data consideration and Testing of Models

4. Experimentation:

5. Process Optimization:

6. Analysis:

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Reference Books:
1. Introduction to Finite Element Method:
   Basic Concept, Historical Background, Engineering applications, general Description, comparison with other methods.

   Integral Formulation and Variation Methods:
   Need for weighted-integral forms, relevant mathematical concepts and formulate, weak formulation of boundary value problems, variation methods, Rayleigh-Ritz method and weighted residual approach.

2. Finite Element Techniques:
   Module boundary value problem, finite element decartelization, element shapes, sizes and node locations, interpolation functions, derivation of element equations, connectivity, boundary conditions, FEM solutions, post processing, Compatibility and completeness requirements, convergence criteria, highe order and isoparametric elements, natural coordinates, Lagrange and Hermit Polynomials

3. Applications to Solid and Structural Mechanics Problems:
   External and internal equilibrium equations, one-dimensional stress-strain relations, plane stress and strain problems, axis symmetric and three dimensional stress strain problems, strain displacement relations, boundary conditions compatibility equations, analysis of trusses, frames and solid of revolution, computer programs.

4. Applications to Heat Transfer Problems:
   Variational approach, Galerkin approach, one dimensional and two dimensional steady state problems for conduction, convection and Radiation, transient problems.

5. Applications to Fluid Mechanics Problems:
   Inviscid incompressible flow, potential function and stream function formulation, incompressible viscous flow, stream function, velocity-pressure and stream function vorticity
formulation, solution of incompressible and compressible fluid flow lubrication problems, Additional Applications: Steady state and transient field problem.

6. Parameters Affecting Accuracy of the FEA results:
   How to validate and check accuracy of FEA results? Computational accuracy: strain energy norm, residuals, Reaction forces and moments; convergence test, Average and unaverage stress difference. Correlation with actual testing: strain gauging-stress comparison; natural frequency comparison; Dynamic response comparison, Temperature and Pressure distribution comparison.

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References:

1. Finite Element Analysis – Theory & Practice by Fagan (Longman Scientific & Technical)
2. Fundamentals of Finite Element Analysis, David Hutton, TMH
7. Finite Element Analysis by P. Seshu (PHI)
8. Practical Finite Element Analysis - Nitin Gokhale (Finite To Infinite, Pune)
9. Introduction to Finite Elements in Engineering by Chandrupatala and Belegundu.


3. **Composites**:
   - **Fibers**-glass, boron, carbon, organic, ceramic and metallic fibers- **Matrix materials**- polymers, metals and ceramics. Processing of polymer matrix composites: open mould process, bag molding, compression molding with BMC and SM- filament winding, pultrussion- centrifugal casting, injection molding, applications of PMC’s. Processing of metal matrix polymers: solid state fabrication techniques- diffusion bonding, powder metallurgy techniques, plasma spray, chemical and physical vapor deposition of matrix on fibers, Liquid state fabrication methods, Infiltration, squeeze casting, Rheo casting, compo casting. Applications of MMC’s.

4. **Selection of Materials**:

   Motivation for selection, cost basis and service requirements- selection for mechanical properties, strength, toughness, fatigue and creep. Selection for surface durability, corrosion and wear resistance. Relationship between materials selection and processing. Case studies in material selection with reference to aero, automobile, marine, machinery and nuclear applications.

**Classification and Types of Conventional Manufacturing Processes**- forging, rolling, extrusion, wire drawing, sheet metal processes. Manufacturing
automation, Non traditional manufacturing processes. Economics of non traditional and automated manufacturing. Introduction to micromachining and MEMS. Introduction to coatings and tribology

Types of prototypes, principles and advantages and different types of generative manufacturing processes, viz. stereolithography, FDM, SLS etc. Factors concerning to RP: consideration for adaptations, advantages, accuracy, economic considerations.


Special Processes and Electronic Fabrication: Principles, salient features, advantages and applications of abrasive floor machining, magnetic abrasive finishing, wire EDM, electrochemical grinding, honing, lapping and super finishing. Principles, elements, process, advantages, applications and surface preparation etc. of physical vapor deposition, chemical vapor deposition, electro less coating and thermal metal spraying.

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References:
1) “HMT Handbook” – Production Technology (TMH)
2) Willer, “Non- traditional Machining Processes”, SME publications.
3) G.F.Benidict, “Advanced Manufacturing Processes”, Marcel Dekker Publisher
5) Geoff Eckold “Design & Manufacturing of Composite Structures”, (Jaico Publishing House)
6) S. Kalpaljian & Steven R. Schmidt, (Pearson Education) “Manufacturing
M. Tech. (CAD/CAM/CAE) SEM I

MEC 511 : Tribology and Surface Engineering

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1. **Friction Wear and Corrosion:** Theory of friction- sliding and rolling friction, Tabor’s model of friction, Friction properties of metallic and non metallic materials, friction in extreme conditions, Wear, types of wear, mechanisms of wear, wear resistant materials, Mechanisms and types of corrosion, Measurement and testing of Friction, Wear and Corrosion, Prevention of wear and Corrosion.

2. **Lubrication Theory:** Lubricants and their physical properties, lubricants standards, Lubrication regimes, Hydrodynamic lubrication, Reynolds equation, Thermal, inertia and turbulent effects, Elasto, Plasto and magneto hydrodynamic lubrication, Hydrostatic, Gas lubrication. Design of fluid film bearings, Design of air bearing and gas bearing.


4. Introduction to Surface Engineering: Concept and Scope of Surface Engineering, Mathematical modeling and manufacturing of surface layers, The solid surface- geometrical, mechanical and physico chemical concept, Three dimensional structure of surface, The superficial layer and its parameters.


6. Thin Layer Engineering Processes: Laser and electron beam hardening, its process parameters and their effects, Physical vapour deposition, Thermal evaporation Arc vapourisation, Sputtering, Chemical vapour deposition, ion implantation technique, Coating of tools, TiC, TiN, Al2O3 and Diamond coating properties, applications of thin Coatings.

**Tutorial**

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References

1. Concepts of Technology Management:
   Description, Scope & Implications, Its relation to business management, systems Holistic Model of Management of Technology (MOT), Operational and Management Issues, Classification of Technology, Technology cycle, Industry-Institute partnership for targeted basic research.

2. Strategic Management of Technology:
   Technology-strategy relationship, Elements of technology strategy and formulation of a technology strategy, Integration of technology strategy and business strategy for competitive success technology, the environment and sustainable development

3. Organizational Aspects of Technology Management:
   Human dimension of technology and concepts of the entrepreneur, Organizational cultures and structures for promotion of creativity and innovation, the learning organization, the imperative of knowledge management

4. Acquiring Technology through Technology Transfer:
   Definition, Source, Model of TT, System of TT with Public and Private Enterprises, Success and failure factors in technology transfer

Acquiring Technology Through Research and Development:
   The concepts of invention and innovation, Definition and classifications of research and development, new product development, Challenges in commercializing research results

5. Intellectual Property Rights:
   Patentable and non-patentable inventions, statutory exceptions, Persons entitled to apply for patents.

   National innovation systems for facilitating technology-based development
   Concepts of the national innovation system (NIS) and science and technology
infrastructure, Various Government Schemes.

6. Analytical Hierarchical Process (AHP):

Introduction to AHP, self AHP for Technology Selection cases like Information Technology – Software & Hardware, Machine Tools, and Industrial Products.

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References:


8. Strategic Management of Technology and Innovation by Robert A. Burgelman, Clayton M. Christensen, Steven C. Wheelwright, and Modesto A. Maidique


1. **Introduction**: Micro-Electro-Mechanical Systems (MEMS), Microsystems and their products, miniaturization, applications, mechanical MEMS, thermal MEMS, micro-opto electro-mechanical systems, magnetic MEMS, radio frequency (RF) MEMS, micro fluidic systems, bio and chemo devices, Nanotechnology – definition, nanoscale, consequences of the nanoscale for technology and society, need and applications of nano electromechanical systems (NEMS)

2. **Micro Fabrication Processes & Materials**: Materials for MEMS – substrate and wafers, silicon as a substrate material, crystal structure, single crystal and polycrystalline, mechanical properties, silicon compounds, silicon piezo-resistors, gallium arsenide, quartz, piezo-electric crystals, polymers, packaging materials; **Fabrication Processes** – Bulk micro manufacturing, photolithography, photoresists, structural and sacrificial materials, X-ray and electron beam lithography, Thin film deposition – spin coating, thermal oxidation, chemical vapour deposition (CVD), electron beam evaporation, sputtering; Doping – diffusion, ion implantation; Etching – wet etching, dry etching; Surface micromachining, bulk vs. surface micromachining; Wafer bonding – glass-frit, anodic and fusion bonding; LIGA process and applications.

3. **Microsensors and actuators**: Sensing and actuation, Chemical sensors, Optical sensors, Pressure sensors, Thermal sensors – thermopiles, thermistors, micromachined thermocouple probes, thermal flow sensors, MEMS magnetic sensor, Piezoelectric material as sensing and actuating elements – capacitance, piezomechanics, Piezoactuators as grippers, microgrippers, micromotors, microvalves, micropumps, microaccelerometers, microfluidics, shape memory alloy based optical switch, thermally activated MEMS relay, microspring thermal actuator, data storage cantilever.

4. **Microsystem Design**: Design constraints and selection of materials, selection of manufacturing process, selection of signal transduction technique, electromechanical system And packaging.

5. **Nanomaterials**: Molecular building blocks to nanostructures – fullerenes, nanoscaled biomolecules, chemical synthesis of artificial nanostructures, molecular switches and logic
gates, nanocomposites; Carbon nanotubes - structure, single walled, multi walled, properties of carbon nanostructures and their synthesis, Potential applications of nano structures.

6. Nanofinishing Techniques: Abrasive flow machining, magnetic abrasive finishing, magnetorheological finishing, elastic emission machining, ion beam machining, chemical mechanical polishing, Nanomanipulation, Nanolithography, Top-down versus bottom – up assembly, Visualisation, manipulation and characterization at the nanoscale; Applications – in Energy, Tribology, Informatics, medicine, etc

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References:
1. **Mechatronic system:**
evolution, scope and components of mechatronic systems, mechatronics in product and measurement system, control system and modes of control, traditional design and mechatronic design

**Actuators, Sensors and Transducers:** Hydraulic, pneumatic and electrical actuators and their system modeling, performance terminology, system modeling of sensors; displacement, position and proximity sensors, velocity and acceleration sensors, flow sensors, force sensors, temperature sensors, ultrasonic and fiber-optic sensors, selection of sensor, piezo-electric sensors.

2. **Hardware Components:**
Number systems in Mechatronics, binary logic, Karnaugh map minimization, transducer signal conditioning process, principals of analogue and digital signal conditioning, protection, filtering, operational and instrumentation amplifiers and their gains, analogue to digital and digital to analogue conversion, multiplexers, pulse modulation.

3. **Programmable Logic Controller:**
Review of logic gates, basic structure, features, input/output processing, programming, functional block diagram (FBD), ladder diagram, logic functions, latching, sequencing, jumps, internal relays, counters, shift registers, master and jump control, data handling, data movement, data comparison, arithmetic operations, code conversion, analog input and output, applications for automation, diagnostics and condition monitoring.

4. **Microcontroller:**
Comparison between microprocessor and microcontroller, organization of microcontroller system, architecture of MCS 51 controller, pin diagram of 8051, addressing modes, programming of 8051, interfacing input and output devices, interfacing D/A converters and A/D converters, Various applications for automation and control purpose.
5. **Real-Time Interfacing:**


6. **Advanced Applications in Mechatronics:**

Mechatronic control in automated manufacturing, Artificial Intelligence in mechatronics, Fuzzy Logic application in Mechatronics, Microsensors in Mechatronics, Case studies of Mechatronic systems.

**Tutorial**

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**References**

1) Mechatronics, 3/e --- W. Bolton (Pearson Education)
2) Mechatronics -Dan Necsulescu (Pearson Education)
6) Process Control & Instrumentation Technology –Critis D. Johnson (Pearson Education)
7) Mechatronics System Design - Devdas Shetty, Richard A. Kolk (Thomson)
8) Computer Control of Manufacturing Systems - Yoram Koren (McGraw Hill)
10) Industrial Automation – David W. Pessen (John Wiley & Sons)
12) Handbook of Industrial Automation – Richard L. Shell & Ernest L. Hall (Marcel Decker Inc.)
13) Programmable Logic Controllers” Programming Methods and Applications (with CD
M. Tech. I (CAD/CAM/CAE) SEM I

MEC 551 : 3D Modeling and CNC Code Generation Lab.

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1. **Introduction to Modeling software**:
   1. 2D drawing and drafting using sketcher workbench – 2 drawings
   2. 3D modeling and drafting using 3D features – 5 models
   3. Assembling and drafting of 2 assemblies with interference checking.
   4. Surface modeling – 4 exercises

2. **Computer aided manufacturing**:
   1. CNC Lathe – 4 exercises
   2. CNC Machining Center – 4 exercises
   3. Generation of tool path, generation of NC code, Optimization of tool path (to reduce machining time) using any CAM software
Minimum eight assignments are to be completed on following area using appropriate software.

1. Structural Analysis
2. Thermal Analysis
3. Fluid Flow Analysis
4. Coupled Field Analysis
5. Modal Analysis

- Minimum two problems shall be solved with hand calculations.
- In addition to above a visit to some facility where any of the above is actually used to prepare report of the same.
- Term work shall be assessed on the basis of completion of above assignments and submission of reports.
- Practical examination: Duration 3 hours – Each candidate shall carry out analysis using suitable FEA software followed by oral examination.
Seminar I shall be delivered on one of the advanced topics chosen in consultation with the guide after compiling the information from the latest literature. The concepts must be clearly understood and presented by the student. All modern methods of presentation should be used by the student. A hard copy of the report (25 to 30 pages A4 size, 12 fonts, Times New Roman, single spacing both side printed, preferably in IEEE format) should be submitted to the Department Research Committee (DRC) before delivering the seminar. Seminar work will be assessed by both Internal and External Examiners. A PDF copy of the report in soft form must be submitted to the guide along with other details if any.
1. **Classical Optimization Techniques:**
   Single-variable and Multi-variable Optimization, Hessian Matrix, Saddle Point, Lagrange Multipliers Method, Kuhn-Tucker Conditions

2. **Single-variable Optimization Techniques:**

3. **Multi-variable Optimization Techniques:**

4. **Constrained Optimization Techniques:**
   Interior Penalty Function Method, Exterior Penalty function Method

5. **Search Techniques:**
   Genetic Algorithm, Simulated Annealing, Artificial Neural Networks

6. **Theory of Constraints:**
   Introduction to TOC, Optimized Production Technology (OPT), Nine principles of OPT, Five Focusing Steps (The 5FS) of TOC, Capacity Constrained Resources and the Time Buffer, Modeling the Time Buffer, Modeling Return-On Investment (ROI) in TOC, Comparison of TOC and Local Optimization Approaches

**Tutorial**
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References:
1. Introduction: Automated manufacturing systems, fixed /programmable /flexible automation, need; Basic elements of automated systems- power, program and control; Advanced automation functions, Levels of automation; Industrial control systems in process and discrete manufacturing industries, Continuous and discrete control; Low cost automation, Economic and social aspects of automation.

2. Transfer Lines: Fundamentals, Configurations, Transfer mechanisms, storage buffers, control, applications; Analysis of transfer lines without and with storage buffers.
   Assembly Automation: Types and configurations, Parts delivery at workstations- Various vibratory and non-vibratory devices for feeding and orientation, Calculations of feeding rates, Cycle time for single station assembly machines and partially automated systems; Product design for automated assembly.


5. Robotic End Effectors and Sensors: Transducers and sensors- sensors in robotics and their classification, Touch (Tactile) sensors, proximity and range sensors, force and torque sensing, End Effectors- Types, grippers, Various process tools as end effectors; Robot-End effector interface, Active and passive compliance, Gripper selection and design.

6. Robot Programming & Kinematics: Lead through method, Robot program as a path in space, Methods of defining positions in space, Motion interpolation, branching; Textual robot programming languages. Forward and reverse transformations.

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References:

1. **Fundamentals**: Manufacturing Systems: Structural aspects, transformational aspects, procedural aspects, integrated manufacturing systems; Modes of Production- Jobbing/Intermittent/Continuous; Mass Production- Economies of Scale, Optimum production scale, Mass Customization; Multi-Product Small Batch Production- Economies of Scope with Diversification; Logistic Systems- Material flow: conversion / transportation / storage


3. **Manufacturing Optimization**: Criteria for Evaluation, Optimization of single stage manufacturing- Unit production time and cost; Optimization of multistage manufacturing system- Scope, basic mathematical models; Cost Estimating- Classical metal cutting cost analysis, Industrial cost estimation practices, Estimating material, setup and cycle times.

4. **Design of Inventory system**: dependant and independent demand, Inventory models, Design of Q and P system of inventory, MRP logic and MRP system

5. **Layout design/Planning**: basic layouts: type sand flow design. Design of process layout, Tools and techniques, developing the product layout models, line balancing. Computerized layout planning

6. **Modern approaches in Manufacturing**: Cellular Manufacturing- Group Technology, Composite part, Rank Order Clustering Technique, Hollier method for GT cell layouts; Flexible Manufacturing- Concept, components, architecture; Lean Production- concept, principles, Agile Manufacturing- concept, principles and considerations for achieving agility. Design considerations in JIT and lean manufacturing system.

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References:

M. Tech. (CAD/CAM/CAE) SEM II
MEC 508 : Product Life cycle Management


2. Product Development Process : Integrated Product development process - Conceive – Specification, Concept design, Design - Detailed design, Validation and analysis (simulation), Tool design, Realize - Plan manufacturing, Manufacture, Build/Assemble, Test (quality check), Service - Sell and Deliver, Use, Maintain and Support, Dispose.

3. Product Development Approaches: Bottom-up design, Top-down design, Front-loading design workflow, Design in context, Modular design. Concurrent engineering, partnership with supplier, collaborative and Internet based design, work structuring and team deployment, Product and process systemization, problem, identification and solving methodologies, improving product development solutions

4. Product Modelling: Product Modelling - Definition of concepts - Fundamental issues - Role of Process chains and product models - Types of product models – model standardization efforts - types of process chains - Industrial demands. Foundation technologies and standards (e.g. visualization, collaboration and enterprise application integration),

5. Product Data Management (PDM) Technology - Product Data Management – An Introduction to Concepts, Benefits and Terminology, PDM functions, definition and architectures of PDM systems, product data interchange, portal integration, PDM acquisition and implementation. Information authoring tools (e.g., MCAD, ECAD, and technical publishing), Core functions (e.g., data vaults, document and content management, workflow and program management), Functional applications (e.g., configuration Management)

6. Recent Advances : Intelligent Information Systems - Knowledge based product and process models - Applications of soft computing in product development process - Advanced
database design for integrated manufacturing.

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**References:**

MEC 510: Computational Fluid Dynamics

1. **Review of Fundamentals** Classification of partial differential equations, governing equation of fluid dynamics, boundary condition, finite difference equation stability analysis error analysis grid generation structured grid elliptic, parabolic and hyperbolic equations Navier Stokes equation, Finite Volume method

2. **Transformation of the equation of the fluid motion** - generalized coordinate transformation, equation for the matrices, non-dimensionalizing of the equation of the fluid motion Navier stokes equation, linearization, invicid and viscous jacobian metrics, thin layer approximation, parabolised Navier-stokes equation,

3. **Euler Equations** – model equation quasi one dimensional Euler equation, boundary condition application, diverging nozzle flow analysis, grid clustering two dimensional planner and axisymmetric Euler equation finite difference formulation matrix manipulation, Jacobian Eigine vector matrices

4. **Navier stokes Equations** – Governing equations of motion, stream wise pressure gradient, numerical algorithm, boundary condition, extension to three dimensions, numerical damping term, shock fitting procedure, application Maccormack explicit formulation, explicit and implicit flux vector splitting scheme, higher order approximation, LU decomposition

5. **Grid Generation unstructured grids** -- domain nodalization, domain triangulation, the advancing front method, simply and multiply domain connected domains, Delaunay method geometrical description outline of the algorithm with an illustrative example

6. **Discretization methods of scalar and vector conservation laws** – a brief history of numerical methods for hyperbolic conservation laws, Lax–Friedriches method, Lax-wendroff method, Godunov approach, upwind schemes, flux vector splitting scheme, approximate Riemann solver, second order upwind schemes, High resolutions schemes, TVD and flux limiters

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References:

6. Computational Fluid Dynamics Vol 1 and 2, K. A. Hoffmann and S. T. Chiang, Engineering Education system
1. **Introduction to Rapid Manufacturing:** Definition of rapid manufacturing (RM), rapid prototyping (RP) and rapid manufacturing, areas of application.

2. **Design Potential of Rapid Manufacturing:** Conventional design for manufacturing and assembly (DFM, DFMA), impact of RM on DFA and DFMA, Geometrical freedom, design complexity/optimization, parts consolidation, body fitting customization and multiple assemblies manufactured as one, Customer input and customization, CAD environment for RM.


4. **Materials in RM:** Issues, viscous flow, photo-polymerization, sintering, infiltration, mechanical properties, Materials for RM processes, Prototype properties: Material properties, color, dimensional accuracy, stability, surface finish, machinability, environmental resistance, operational properties; Functionally graded materials (FGM composites), processing technologies for FGMs, laser sintering, thermal and mechanical properties of FGM, Deposition systems and applications.

5. **Applications of RP & RM:** Design, Concept Models, Form and fit checking, Ergonomic Studies, Functional testing, CAD data verification, Automotive applications- Parts of racing cars, Applications in Aerospace industry, Construction industry, Retail industry, Archeology, Paleontology and forensic science, miniaturization.

6. **Rapid Tooling:** Mold making, Metal spraying, Rapid tooling for die, squeeze and permanent mold casting, Rapid manufacturing of sheet metal forming tools, casting pattern plates by rapid tooling, RP for series production investment casting.

**Management Issues of RM:** Machine costs for RM, material cost, labour cost, comparison of cost of RM with cost of injection molding; Cost of manufacturing by RM, overheads, stock and WIP, location and distribution, supply chain management in RM.

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surprise test, declared test, seminar, final orals and any others. The teacher may add any of other academic activity to evaluate student for his/her in semester performance.

References:


8. ANNALS of the ORADEA UNIVERSITY. Fascicle of Management and Technological Engineering, Volume VI (XVI), 2007


11. Using RP for Series Production Investment Castings, Tom Mueller, Express Pattern

2. Steps in Robust Design: Quality Characteristics and Objective Functions, Control Factors and their Levels, Noise Factors and Testing Conditions, Planning and

3. The Reliability Function: Failure Rate, Hazard Rate, Bath-tub Curve, Relationship between Various Reliability Characteristics


6. Maintained Systems, Classification of Maintenance Activities: Breakdown, Preventive and Predictive Maintenance, Condition Monitoring, Maintainability and Availability, Reliability-centered Maintenance

Tutorial

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References:

1. **Dynamics:**

2. **Simulation:**

**Tutorial**
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**References:**
1. AI and Internal Representation:
   Artificial Intelligence and the World, Representation in AI, Properties of Internal Representation,
   The Predicate Calculus, Predicates and Arguments, Connectives Variables and Quantification,
   How to Use the Predicate Calculus, Other Kinds of Inference Indexing, Pointers and Alternative
   Notations, Indexing, The Isa Hierarchy Slot-Assertion Notation, Frame Notation

2. Neural Networks and Fuzzy Systems:
   Neural and fuzzy machine Intelligence, Fuzziness as Multivalence, The Dynamical Systems
   approach to Machine Intelligence, The brain as a dynamical system, Neural and fuzzy systems as
   function Estimators, Neural Networks as trainable Dynamical system

3. Fuzzy Theory:
   Fuzzy systems and applications, Intelligent behavior as Adaptive Model free Estimation,
   Generalization and creativity, Learning as change, Symbol Vs Numbers, Rules Vs Principles,
   Expert system Knowledge as rule trees, Symbolic Vs Numeric Processing, Fuzzy systems as
   Structured Numerical estimators, Generating Fuzzy rules with product space Clustering, Fuzzy
   Systems as Parallel associators, Fuzzy systems as Principle based Systems.

4. Neural Network Theory:
   Neuronal Dynamics: Activations and signals, Neurons as functions, signal monotonicity,
   Biological Activations and signals, Neuron Fields, Neuron Dynamical Systems, Common signal
   functions, Pulse-Coded Signal functions

5. Genetic Algorithms:
   A simple genetic algorithm, A simulation by hands, similarity templates(Schemata), Mathematical
   foundations, Schema Processing at work, The two- armed and k- armed Bandit Problem, The
   building block hypothesis. Applications of genetic algorithm, De Jong and Function Optimization,
   Improvement in basic techniques, Introduction to Genetics based machine learning, applications of
   genetic based machine leaning.

6. Data Mining:
Introduction to Data Mining, Computer systems that can learn, Machine learning and methodology of science, Concept learning, Data warehouse, designing decision support systems, Client server and data warehousing, Knowledge Discovery Process, Visualization Techniques, K-nearest neighbor, Decision tree, OLAP tools, Neural networks, Genetic algorithm, Setting up a KDD environment, Real life applications.

Tutorial:
One hour per week per batch tutorial is to be utilized for problem solving / programming exercises using a suitable language to ensure that students have properly learnt the topics covered in the lectures. This shall include case study on applications of AI and ES in CAD/CAM or Manufacturing Management. Assignments, tutorials, quiz, surprise test, declared test, seminar, final orals and any others also can be included. The teacher may add any of other academic activity to evaluate student for in semester performance.

References:

1. “Introduction to Artificial intelligence”, Eugene Charniak, Drew McDermott Addison Wesley
2. “Neural Networks and fuzzy systems-A dynamical systems approach to machine Intelligence” by Bart Kosko- PHI
4. “Data Mining” by Pieter Adriaans and Dolt Zantinge - Pearson Education Asia
5. “Data Warehousing in the Real World” by Sam Anahory and Dennis Murray.
9. “Understanding Neural Networks and Fuzzy Logic:”, Stamatios V. Kartalopulos-Prentice Hall India.
1. **Automatic Control Systems**: Basic definition, Structure of a feedback systems, closed loop and open loop control systems. Laplace Transformation, Building blocks and transfer functions of mechanical, electrical, thermal and hydraulic systems. Mathematical models of physical systems, control systems components. Systems with dead time, control hardware and their models, Electro-hydraulic valves, hydraulic servomotors, synchros, LVDT, electro-pneumatic valves, pneumatic actuators.

2. **Basic characteristic of feedback control systems**: Stability, steady state accuracy, transient accuracy, disturbance rejection, insensitive and robustness, Basic models of feedback control systems: Proportional, integral, derivative and PID, feed forward and multi loop control configurations, stability, concept of relative stability.


4. **Design of Lead lag compensators**, OpAmp based and digital implementation of compensators, Tuning of process controllers.

5. **Design, sample data control systems**, stable variable analysis and design, optimal control systems.

6. **Non linear control systems**, discrete time systems and Z-Transformation methods, Microprocessor based digital control, State space analysis, Optimal and adaptive control systems.

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**References:**

3. I.J.Nagrath, M.Gopal, ”Control Systems Engineering”.
1. **Introduction:** Process Modeling, The finite element method, Solid formulation and hollow formation, metal forming and FEM

**Metal forming Processes:** Introduction, Metal forming operations as a system, Classification and Description of metal forming processes, Casting process

2. **Analysis and Technology in Metal Forming:** Introduction, Flow stress of metals, Friction in metal forming, Temperatures in metal forming, Impression and closed die forging, Hot extrusion of Rods and Shapes, Cold forging and extrusion, Rolling of strip, plate and shapes, Drawing of Rod, wire, shapes and Tubes, Sheet metal forming, fine blanking

3. **Plasticity and Visco-plasticity:** Introduction, Stress, strain and strain rate, The yield criteria, Equilibrium and Virtual work rate principle, Plastic potential and flow rate, Strain Hardening, Effective stresses and Effective strain, Visco-plasticity

**Method of Analysis:** Introduction, Upper Bound method, Hills General Method, FEM

4. **Analysis Technology in Metal Casting:** Introduction, Castability of important Ferrous and Non-ferrous metal, Shrinkage, Effect of Temperature, Effect of composition

**Finite Element Method:** Introduction, Finite Element Procedures, Elements and shape function, Element strain rate matrix, Elemental stiffness equation, Numerical integrations, Assemblage and Linear matrix solver, Boundary conditions, Direct / Iteration method, Time investment and Geometry updating, Rezoning

5. **Plane – Strain Problems:** Introduction, Finite Element formulation, Closed die forging with flash, Sheet Rolling, Plate Bending, Side pressing

**Axi-symmetric Isothermal Forging:** Introduction, Finite Element formation, Pre-form design method, Die design, Shell nosing at room temperature, Plane strain rolling, Axially Symmetric forging

6. **Steady State Processes of Extrusion and Drawing:** Introduction, Method of Analysis, Bar Extrusion, Bar Drawing, Multi pass bar drawing and Extrusion, Applications to process design

**Sheet Metal Forming:** Introduction, Plastic Anisotropy, In-plane deformation process, Axi-symmetric but of plane deformation, Axi-symmetric Punch stretching and deep
drawing process, Sheet metal forming of General shapes, Square – cup drawing process

**Metal Casting:** Introduction, Casting Design, FEA analysis, Die / pattern Design, Casting Simulation – Gating Design, Die / Pattern manufacture

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**References:**

1. Mechanical Metallurgy (2/e)– by Dieter (McGraw Hill)
2. Metal Casting – Dr. B. Ravi – (Prentice Hall of India)
4. Technology of Metal Forming Processes, -Surender Kumar (EEE)(PHI)
The laboratory work shall consist of exercises as given below

1) Design of hydraulic / pneumatic circuits for different machine tools, automation projects and their performance testing
2) Study, design / simulation of automation projects in material handling/packaging
3) Exercise on flexible automation using PLC, different sensors and actuators
4) Exercise on control of electrical motors using microcontroller / microprocessor.
5) Simulation of Robotic system for automation using a suitable software
6) Simulation of Electrohydraulic / Electropneumatic circuits using a suitable software (like FESTO PneuSim & HydroSim: Demo versions available on Internet)
M. Tech. Mechanical (CAD/CAM/CAE) SEM II
MEC 554 : Design and Analysis Lab II

Minimum eight exercises are to be completed on following topics using suitable software packages.

1. Transient Thermal Analysis
2. Dynamic Analysis
3. Non-Linear Analysis
4. Design Optimization through FEA (Two Exercises)
5. Computational Fluid Dynamics (Optional)
6. A Composite project based on Exercises of Design & Analysis Laboratory I and II.

The Term work shall be assessed on the basis of completion of above exercises and submission of report.

Practical Examination duration: 3 Hours

The candidate shall carry out analysis using suitable software package followed by oral examination.
Seminar II shall be delivered on one of the advanced topics chosen in consultation with the guide after compiling the information from the latest literature. The concepts must be clearly understood and presented by the student. All modern methods of presentation should be used by the student. A hard copy of the report (25 to 30 pages A4 size, 12 fonts, Times New Roman, single spacing both side printed, preferably in IEEE format) should be submitted to the Department Research Committee (DRC) before delivering the seminar. Seminar work will be assessed by both Internal and External Examiners. A PDF copy of the report in soft form must be submitted to the guide along with other details if any.