M.TECH –ENGINEERING DESIGN

DEPARTMENT OF MECHANICAL ENGINEERING

This program is designed to enable an engineering graduate to develop specific capabilities in design, synthesis and analysis of a wide variety of mechanical engineering systems. The program focuses on developing design methodologies which involve high degree of research orientation supplemented with practical insights. Besides core courses (which are mandatory), a variety of electives are also offered to suit the taste of each individual student so that he/she can specialize in a particular area of Engineering Design. The students are periodically assessed by the teachers who are experts in chosen areas of Engineering Design, to ensure quality of education. On the whole, the Masters Program is committed to produce design engineers with excellent creative capabilities and calibre to solve real life problems curtailing to industry requirements, in tune with the objectives envisioned by the University

CURRICULUM

<table>
<thead>
<tr>
<th>FIRST SEMESTER</th>
<th>Course Code</th>
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Credits 18

*Non Credit Course
## SECOND SEMESTER

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**Total Credits** 64
### LIST OF COURSES

#### FOUNDATION CORE

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#### SUBJECT CORE

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#### ELECTIVES

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<td>Introduction to Nonlinear Dynamics and Chaos</td>
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<td>Fracture Mechanics</td>
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<td>18ED730</td>
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*Students undertaking and registering for a Live-in-Lab project, can be exempted from registering for an Elective course.**MOOC courses can be allowed in electives with suitable monitoring and assessment procedure.

**PROJECT WORK**

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<tr>
<td>18ED799</td>
<td>Dissertation</td>
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Implementing optimization algorithm using Matlab / Programming: Design optimization - Robust design - Optimization in manufacturing / machining – Multi objective optimization - Structural optimization - Shape optimization - Optimization in production planning and control.

TEXT BOOKS/ REFERENCES:


Analysis of stress, Analysis of stain, Elasticity problems in two dimension and three dimensions, Mohr’s circle for three dimensional stresses. Stress tensor, Air’s stress function in rectangular and polar coordinates.

Energy method for analysis of stress, strain and deflection The three theorem’s -theorem of virtual work, theorem of least work, Castiglioni’s theorem, Rayleigh Ritz method, Galekin’s method, Elastic behavior of anisotropic materials like fiber reinforced composites.

Torsion of prismatic bars of solid section and thin walled section. Analogies for torsion, membrane analogy, fluid flow analogy and electrical analogy. Torsion of conical shaft, bar of variable diameter, thin walled members of open cross section in which some sections are prevented from warping, Torsion of noncircular shaft.

Concept of shear center in symmetrical and unsymmetrical bending, stress and deflections in beams subjected to unsymmetrical bending, shear center for thin wall beam cross section, open section with one axis of symmetry, general open section, and closed section.
Governing equations, stress in thick walled cylinder under internal and external pressure, shrink fit compound cylinders, stresses in rotating flat solid disk, flat disk with central hole, disk with variable thickness, disk of uniform strength, Plastic action in thick walled cylinders and rotating disc.
Geometry of contact surfaces, method of computing contact stresses and deflection of bodies in point contact, stress for two bodies in line contact with load normal to contact area and load normal and tangent to contact area. Introduction to Analysis of low speed impact.

TEXT BOOKS/REFERENCES:

18ED651 FAILURE ANALYSIS AND DESIGN 3 0 0 3


TEXT BOOKS/REFERENCES:
Need for developing products – the importance of engineering design – types of design – the design process – relevance of product lifecycle issues in design – designing to codes and standards – societal considerations in engineering design – generic product development process – various phases of product development – planning for products – establishing markets – market segments – relevance of market research


TEXT BOOKS/REFERENCES:

TEXT BOOKS/REFERENCES:


18ED654 DESIGN FOR MANUFACTURE AND ASSEMBLY 3-0-0-3


TEXT BOOKS/ REFERENCES:


18ED655 FINITE ELEMENT TECHNIQUES 3-0-0-3


TEXT BOOKS/REFERENCES:

18ED656 SYSTEMS ENGINEERING 2-0-0-2

hydraulics and acoustics. Multibody Dynamics - linkage mechanism, Quarter Car Model & Half Car model. Solving flow and thermal problems using system simulation tools. Future of Systems Engineering

**TEXT BOOKS/REFERENCES:**


**18ED661 ENGINEERING DESIGN LAB-I**

Practical Stress Analysis:
Verification of stresses under mechanical loading using strain gauges, Calibration of torsional load cell.

Machine Condition Monitoring:
Machine condition monitoring studies using FFT analyzer and virtual instrumentation tools.

Advanced Vibrations Testing Lab
Experimental modal analysis for determination of natural frequency, logarithmic decrement & damping factor, damping ratio, and mode phase; Simulation of mode shapes using software packages.

**18ED662 ENGINEERING DESIGN LAB-II**

Mechanism Modeling and Analysis Lab:

Finite Element Analysis:
Exercises covering structural analysis, dynamic analysis, and thermo-mechanical coupled analysis using FEA packages, Finite element modeling of metal forming and metal cutting operations.

**18ED663 ENGINEERING DESIGN LAB-III**

Computational Fluid Dynamics:
Exercises covering computational fluid dynamics simulations involving meshing, internal flow, external flow over bluff bodies and flat plate, flow through nozzle, flow with heat transfer (convection & radiation). Basics of open source code-Open Foam.

**18RM600 RESEARCH METHODOLOGY**

Unit I:

Unit II: 
Problem Formulation, Understanding Modeling & Simulation, Conducting Literature Review, Referencing, Information Sources, Information Retrieval, Role of libraries in Information Retrieval, Tools for identifying literatures, Indexing and abstracting services, Citation indexes

Unit III: 
Experimental Research: Cause effect relationship, Development of Hypothesis, Measurement Systems Analysis, Error Propagation, Validity of experiments, Statistical Design of Experiments, Field Experiments, Data/Variable Types & Classification, Data collection, Numerical and Graphical Data Analysis: Sampling, Observation, Surveys, Inferential Statistics, and Interpretation of Results

Unit IV:
Preparation of Dissertation and Research Papers, Tables and illustrations, Guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript. References, Citation and listing system of documents

Unit V:

TEXT BOOKS/ REFERENCES:

18ED701 FUNDAMENTALS OF ANALYTICAL DYNAMICS 3-0-0-3

coordinates, rotating coordinate systems, motion relative to moving frames. Rigid body dynamics – Rigid body kinematics, linear and angular momentum, translation theorem for angular momentum, kinetic energy of a rigid body, principal axes, equations of motion, Euler’s angles. Hamiltonian mechanics – The principle of least action, the Legendre transformation, Hamilton’s equations, Poisson’s brackets, canonical transformations, Hamilton-Jacobi equations.

TEXT BOOKS/REFERENCES:

18ED702 NONLINEAR VIBRATIONS 3-0-0-3


TEXT BOOKS/REFERENCES:

18ED703 MODELING, SIMULATION AND ANALYSIS OF ENGINEERING SYSTEMS 3-0-0-3
Introduction to linear systems, principle of super position-Modelling of engineering systems-
mechanical, electrical, fluid, thermal and mixed discipline systems-Free, forced and transient
response of first and second order systems-Solution of differential equation using Laplace
Transforms-Time domain and Frequency domain analysis-State space representation-System
characteristics from state space representation-Solving the state equations-Stability criterion
through the state transition matrix-Control system design in state space-Linear optimal
control.

TEXT BOOKS/REFERENCES:
3. Ashish Tiwari, “Modern Control Design with MATLAB and SIMULINK”, John

18ED704 ADVANCED MECHANISM ANALYSIS AND DESIGN 3-0-0-3

Review of fundamentals of kinematics - Mobility Analysis - Formation of one D.O.F.
multiloop kinematic chains, Network formula - Gross motion concepts- Position Analysis
– Vector loop equations for four bar- slider crank- inverted slider crank- geared five bar and
six bar linkages- Analytical methods for velocity and acceleration Analysis– four bar linkage,
Types of complex mechanisms- velocity-acceleration analysis of complex mechanisms by the
normal acceleration and auxiliary point methods-Goodman’s indirect acceleration analysis-
Fixed and moving centrodes- inflection points and inflection circle-Euler Savary equation,
graphical constructions – cubic of stationary curvature- Type synthesis – Number synthesis –
Associated Linkage Concept- Dimensional synthesis – function generation- path generation-
motion generation- Graphical methods-Pole technique inversion technique-point position
reduction-two- three and four position synthesis of four- bar mechanisms-Analytical methods-
Freudenstein’s Equation-Bloch’s Synthesis- synthesis of coupler curve based mechanisms-
Cognate Linkages-parallel motion Linkages - Kinematics of Robot - Introduction - Topology
arrangements of
robotics arms – Kinematic Analysis of Spatial RSSR mechanism - Direct Kinematic Model –
Mechanical structure and notations, Description of links and joints, Kinematic modeling of
manipulator, Denavit-Hartenberg notation, Kinematic relationship between adjacent links,
Manipulator Transformation Matrix; Inverse Kinematic Model – Manipulator Workspace,
Solvability, Solution techniques, Closed form solution - Study and use of mechanism using
software packages.

TEXT BOOKS/REFERENCES:
18ED705  THEORY OF PLASTICITY  3-0-0-3


TEXT BOOKS/REFERENCES:

18ED706  TRIBOLOGY  3-0-0-3


TEXT BOOKS/REFERENCES:

18ED707 PRODUCT LIFECYCLE MANAGEMENT 3-0-0-3


TEXT BOOKS/ REFERENCES:

18ED708 THEORY OF PLATES AND SHELLS 3-0-0-3

Introduction - Formulation of governing equations and associated boundary conditions by equilibrium and energy methods, Rectangular plates - Solution of equation by double and single series, Circular plates - symmetric and un-symmetric loading cases, Continuous Plates, Plates with various plan forms, Plates with variable flexural rigidity, Plates on elastic foundation. Numerical and approximate methods - finite difference method - finite element method, energy methods and other variational methods. Introduction, Theory of Surfaces - first and second fundamental forms - principal curvatures, Formulation of governing equations in general orthogonal curvilinear coordinates based on classical assumptions - various shell theories, Membrane theory - governing equations - shells of revolution - application to specific geometric shapes - axisymmetric and non-axisymmetric loading cases. General theory of shells - governing equations and associated boundary conditions for specific geometry of
shells (cylindrical, conical and spherical shells) - classical solutions - finite difference and finite element methods applied to shell problems.

TEXT BOOKS/REFERENCES:

18ED709  COMPUTATIONAL FLUID DYNAMICS  3-0-0-3


TEXT BOOKS/REFERENCES:

18ED710  SELECTION OF MATERIALS FOR MECHANICAL DESIGN  3-0-0-3

Overview of materials properties for Design, Overview of design principles,- mechanical, thermal, oxidation, corrosion, wear, creep and fatigue. Classification of materials - metals, ceramics, glasses, polymers, elastomers, composites, foams, advanced materials such as nano

**TEXT BOOKS/REFERENCES:**

**18ED711 MECHANICS OF COMPOSITE MATERIALS 3-0-0-3**


**TEXT BOOKS/REFERENCES:**

**18ED712 RANDOM VIBRATIONS 3-0-0-3**
Concept of probability - Theory of random variables - Probability structure of random variable - Stationary and non-stationary random process - Calculus of random process - Spectral decomposition of random process - Gaussian, Poisson and Markov process - Response of single degree of freedom, multi degree of freedom and continuous systems to random excitation - Failure modes in random vibration-level crossing statistics-First excursion failure-Rice formula - Fatigue failure - Palmgren – Miner cumulative damage law - Application to civil, mechanical and ocean structures - Introduction to non linear random vibration.

TEXT BOOKS/REFERENCES:

18ED713 COMPUTER AIDED PRODUCT DEVELOPMENT 3-0-0-3


TEXT BOOKS/ REFERENCES:
Introduction: An overview of micro-electro-mechanical devices and technologies, and an introduction to design and modelling. Standard microelectronic fabrication technologies; bulk micromachining, surface micromachining, bonding technologies, related fabrication methods, and creating process flows. Mechanical, thermal, electrical, magnetic, optical, and chemical properties of materials. Introduction to lumped modeling of systems and transducers; an overview of system dynamics. MEMS examples, energy methods, the thermal energy domain; modeling dissipative processes, Fluids and Transport.

TEXT BOOKS/REFERENCES:


TEXT BOOKS/REFERENCES:


18ED716 DESIGN OF EXPERIMENTS 3-0-0-3

Introduction to Research, Review of linear estimation, basic designs and Design Principles, Completely Randomized Designs, Treatment Comparisons, Diagnostics and Remedial Measures, Experiments to Study Variances, Random Effects Models. Factorial Designs: General factorial experiments, factorial effects; best estimates and testing the significance of factorial effects; study of 2n and 3r factorial experiments in randomized blocks; complete and partial confounding, construction of symmetrical confounded factorial experiments, fractional replications for symmetrical factorials, split plot and strip-plot experiments. Complete Block Designs: Balanced incomplete block designs, simple lattice designs, Two-associate partially balanced incomplete block designs: association scheme and intra block analysis, group divisible design. Analysis of Covariance including a Measured Covariate Split-Plot Designs, Repeated Measures Designs, missing plot technique: General theory and applications, Analysis of Co-variance for CRD and RBD. Application areas: Response surface experiments; first order designs, and orthogonal designs; clinical trials, treatment-control designs; model variation and use of transformation; Tukey’s test for additivity.

TEXT BOOKS/ REFERENCES:

18ED717 MATERIAL JOINING TECHNIQUES 3-0-0-3

Joining techniques, Welding processes and grouping, welding terms. Plasma, electron emission and ionization potential, arc temperature, influence of magnetic fields on arcs, arc blow, metal transfer, effect of polarity, effect of gases. Power source characteristics, static and dynamic characteristics, CC and CV power source designs, current and voltage relationships, solid state power sources.

TEXT BOOKS/REFERENCES:

18ED718 BEARING AND GEAR DESIGN 3-0-0-3


TEXT BOOKS/REFERENCES:
MECHATRONIC SYSTEM DESIGN

Mechatronic systems, Mechatronic design process, Traditional and Mechatronics designs, Advanced approaches in Mechatronics system, Industrial design and ergonomics.
Real-time interfacing, Elements of data acquisition and control, Overview of I/O process, Analog signals, discrete signals and Frequency signals.
Simulation basics, Probability concepts in simulation, Discrete event simulation, Simulation Methodology, Queuing system model components, Continuous system modelling, Monte Carlo simulation, Analysis of simulation results, Simulation life cycle.
Case studies of design of mechatronic products: Motion control using D.C.Motor & Solenoids, Car engine management systems.
Applications in Mechatronics: Sensors for condition based maintenance, Mechatronic Control in IoT based system, Artificial intelligence in Mechatronics, Machine Learning Applications in Mechatronics.

TEXT BOOKS/ REFERENCES:


DESIGN AUTOMATION WITH IoT


Communication and networking technologies in IoT: Communication models, AdHoc. Industrial & Automotive Networks. Vehicular networks
Sensors and Actuators: Categorization based on complexity, Introduction with applications, IR/Ultrasonic proximity & distance measurement, Accelerometers, Gyroscope, magnetometer, Acoustic Sensors, Multi sensor fusion. Motion control, motor control, relays, solenoid valve, IP based control. Control of Actuators via Internet, Cloud based control.

IoT implementation in Transportation and logistics, Energy and utilities, Automotive Connected supply chain, Plant floor control automation, remote monitoring, Management of critical assets, and proactive maintenance.
Applications HCI and IoT world - Multilingual interactions Robotics and Autonomous Vehicles Sensing and data processing - Simultaneous mapping and localization - Levels of autonomy, Smart factories, Future research challenges.

TEXT BOOKS/ REFERENCES:

18ED721  RELIABILITY ENGINEERING  3-0-0-3


TEXT BOOKS/ REFERENCES:

18ED722  MULTI -BODY DYNAMICS  3-0-0-3


TEXT BOOKS/REFERENCES:

18ED723  BIO-MECHANICS  3-0-0-3


TEXT BOOKS/REFERENCES:

18ED724  PIPING AND PRESSURE VESSEL DESIGN  3-0-0-3

Piping - Introduction to piping Codes and Standards - Flow diagram - Basic Design of Piping Systems (material selection, pressure class, pipe size and thickness) and the components - Head losses due to pipes, valves & fittings – Darcy Weisbach and Hazen Williams equations and its applications - Piping layout and piping stress analysis – Allowable stresses - Flexibility factor and stress intensification factor – Two phase flow – Water hammer – Steam hammer – Piping Vibrations - Types of piping supports and their behavior. Pressure Vessel Design - Classification - Factors influencing the design of vessels - Material selection - Introduction to ASME cods for pressure vessel design, Pressure vessel and related components’ design using ASME codes - Membrane stresses in pressure vessel under internal pressure and its application to shells (cylindrical, conical and spherical) and end closures - Thermal stresses - Buckling phenomenon - Elastic Buckling of circular ring and cylinders under external pressure - collapse of thick walled cylinders or tubes under external pressure - Effect of supports on Elastic Buckling of Cylinders - Design of circumferential stiffeners - Buckling under combined External pressure and axial loading - Design of saddle supports – Allowable nozzle loads and moments - Reinforcement requirements.
TEXT BOOKS/REFERENCES

7. ASME Boiler and Pressure Vessel Code, Section II (Part D) and Section VIII (Division 1 & 2).
9. ASME B36.10M Welded and Seamless Wrought Steel Pipe.

18ED725 NON-LINEAR FINITE ELEMENT METHOD

Sources of nonlinearities in structural problems: material, geometry, loads, boundary conditions; General features of nonlinear response: equilibrium trajectories, path dependencies, critical points; Geometrically nonlinear finite elements: residual and incremental forms. Finite element total Lagrangian and co-rotational formulations, FEM nonlinear equilibrium equations: initial stress, tangent and secant stiffness, geometric stiffness; Solution of nonlinear equations: classification, incremental control techniques, augmented equation methods, incremental and pseudo-force methods, Newton Methods, Secant (quasi-Newton) methods, Acceleration and line search, dynamic relaxation, determination and transversal of critical points. Computer implementation: model definition, element level calculation, equation assembly, nonlinear equation solver, residual evaluation, post-processing, Non-linear constitutive models, Applications to structural stability analysis and bifurcations, nonlinear static analysis and nonlinear transient problems (implicit vs. explicit time integration techniques), Treatment of constraints.

TEXT BOOKS/REFERENCES:

INTRODUCTION TO NONLINEAR DYNAMICS AND CHAOS


TEXT BOOKS/REFERENCES:

FRACTURE MECHANICS


TEXT BOOKS/REFERENCES:

18ED728 EXPERIMENTAL STRESS ANALYSIS


TEXT BOOKS/REFERENCES:

18ED729 DESIGN THINKING

Design process: Traditional design, Design thinking, Existing sample design projects, Study on designs around us, Compositions/structure of a design, Innovative design: Breaking of patterns, Reframe existing design problems, Principles of creativity Empathy: Customer Needs, Insight-leaving from the lives of others/standing on the shoes of others, Observation
Design team-Team formation, Conceptualization: Visual thinking, Drawing/sketching, New concept thinking, Patents and Intellectual Property, Concept Generation Methodologies, Concept Selection, Concept Testing, Opportunity identification

Prototyping: Principles of prototyping, Prototyping technologies, Prototype using simple things, Wooden model, Clay model, 3D printing; Experimenting/testing.

Sustainable product design, Ergonomics, Semantics, Entrepreneurship/business ideas, Branding, Advertising.

Product Data Specification, Establishing target specifications, Setting the final specifications.

Design projects for teams.

TEXT BOOKS/ REFERENCES:

2. Idris Mootee, Design Thinking for Strategic Innovation, 2013, John Wiley & Sons Inc
6. Stuart Pugh, Total Design: Integrated Methods for Successful Product Engineering,
7. Bjarki Hallgrimsson, Prototyping and model making for product design, 2012, Laurence King Publishing Ltd
8. Kevin Henry, Drawing for Product designers, 2012, Laurence King Publishing Ltd