Programme Structure (M.Tech. in Design Engineering)

Total credit requirement for the course completion: minimum **128 credits**
IC: Institute core = **64 credits**, PC:
Program core = **52 credits**,
PE: Program Electives = 12 **credits**

1st semester:

- 6 core courses = 32 credits prescribed program core (4 theory courses with 6 credits each, one core lab with 6 credits + Research Methodology with 2 credits)

2nd semester:

- 2 Core courses (6 credits each) = 12 credits prescribed program core
- 2 Elective courses (6 credits each)
- 1 Core-lab (5 credits)
- Practicum (3 credits)

3rd semester:

- MTech Technical Project work - Phase I (32 credits)

4th semester:

- MTech Technical Project work - Phase II (32 credits)

Semester-II (32 Credit)

Course Name	L-T-P-C	Objective of the course	Category
Advanced Solid Mechanics (ME 607)	3-0-0-6	To introduce a general theory to study the response of solids to applied forces to be used to study simple boundary value problems. All the treatment would be three dimensional. The aim of the course material would be to inculcate in the reader some of the available tools to analyze a structure and to elucidate the simplifying assumptions made to make the structure analyzable.	PC
Finite Element Analysis (ME 643)	3-0-0-6	To introduce students to FEA to allow them to solve practical industry relevant problems.	PC
Dynamics and Control (New)	3-0-0-6	To arm students with the knowledge to tackle problems related to vehicle dynamics, robotics, etc and also enable them to apply popular control algorithms such as PID in a closed loop dynamical system	PC
Engineering Mathematics for Advanced Studies (ME 903)	3-0-0-6	To introduce mathematical methods.	PC
Introduction to Programming and Modeling Laboratory (ME 621)	1.5-0-3-6	To introduce students to programming, analysis tools and software, Operating systems, R and Python programming, etc.	PC
Research Methodology (New)	1-0-0-2	To introduce students to literature review, report preparations and seminar presentation to a large audience as seminar on research topics in Mechanical Engineering	PC

1	**Title of the course** (L-T-P-C)	**Advanced Solid Mechanics** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	--
3	**Course content**	**Module 1: Analysis of Stress:** Concept of traction, Cauchy Stress formula: Traction on arbitrary planes, Equality of cross-shears, Principal stresses and Principal Planes, Stress invariants, State of Stress Referred to Principal Axes – Octahedral stresses, Mohr's Circles for 3D State of Stress, Equations of equilibrium – Cartesian and Cylindrical coordinate systems. **Module 2: Analysis of Strain:** Displacement field, Deformation gradient, Change in length of a linear element and its linearization and physical interpretation, State of Strain at a point, Change in thedirection of a linear element, cubical dilatation, change in the angle between two linear elements – shear strain, Principal axes of strain and Principal strains, Strains in cylindrical coordinate systems, compatibility of linear strains. **Module 3: Stress-strain Relations – Linear Elastic Solids:** Generalized Hooke's Law, Material Symmetry Planes – Monoclinic, Orthotropic and Isotropic, Lames's constants, Bounds on moduli. **Module 4: Formulations, General theorems and Solution Strategies:** Stress formulation – Beltrami-Michell Compatibility relations, Navier-Lame Equations of equilibrium, Strain Energy Concept, Saint Venants principle, Principle of Superposition, Uniqueness theorem; General Solution strategies. **Module 5: Plane elasticity:** Plane stress, Pane strain, 2D stress formulation in Cartesian and Polar Coordinates: Airy stress function. **Module 6: 2D Problems:** Cartesian coordinate Problems: Using Polynomials and Fourier series , Polar coordinate Problems: Axisymmetric problems - Lame, Rotating Disk, curved beams under pure moments, Infinite/Semi-infinite body subjected to concentrated loads – Kelvin and Flamant problems, Stress concentration in an infinite plate with a small hole – Kirsch problem. **Module 7: Extension, Flexure and Torsion of Prismatic bars:** Extension formulation; Torsion formulation: Saint Venants semi-inverse approach, Prandtl's stress function approach, Membrane analogy, Solution using Fourier series, Torsion of thin-walled tubes – Bredt-Batho formula; Flexure formulation without twist.
4	**Texts/References**	**Text-books:** **1.** M.H.Sadd,"Elasticity: Theory, Applications and Numerics",Academic Press, 2013. **2.** J. R. Barber, Elasticty, Springer, 2010. **3.** L.S.Srinath,"Advanced Mechanics of Solids" Tata McGraw Hill, 2007. **References:** **1.** S.P. Timoshenko and J.N. Goodier, "Theory of Elasticity," McGraw-Hill, Third Ed., New York,1970. **2.** Allan F. Bower, Applied mechanics of Solids.. CRC press, 2009. **3.** Adel S. Saada , Elasticity: Theory and Applications, Second Edition, Revised & Updated.. J. Ross Publishing, ,2009. **4.** Robert William Soutas-Little,Elasticity, Courier Corporation, 2012.

1	**Title of the course** (L-T-P-C)	**Finite Element Analysis** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	Mechanics of Materials
3	**Course content**	Approximate solution of differential equations - - Weighted residual techniques. Collocation, Least Squares and Galerkin methods. Piecewise approximations. Basis of Finite Element Method. Formulation of the matrix method -- "stiffness matrix"; transformation and assembly concepts. Example problems in one dimensional structural analysis, heat transfer and fluid flow. Elements of Variational calculus. Minimisation of a functional. Principle of minimum total potential. Piecewise Rayleigh - Ritz method and FEM. Comparison with weighted residual method. Two dimensional finite element formulation. Isoparametry and numerical integration. Algorithms for solution of equations. Convergence criteria, patch test and errors in finite element analysis. Finite element formulation of dynamics. Applications to free vibration problems. Lumped
4	**Texts/References**	**1.** Bathe, K. J., Finite element procedures in Engineering Analysis, Prentice Hall of India, 1990. **2.** Cook, R.D., D. S. Malkus and M. E. Plesha, Concepts and Applications ofFinite element analysis, John Wiley, 1989. **3.** Reddy, J. N., An Introduction to the Finite Element Method, 2nd ed., McGraw Hill, 1993. **4.** Seshu, P. Finite Element Method, Prentice Hall of India, New Delhi, 2003. **5.** Zienkiewicz, O. C., and K. Morgan, Finite elements and approximation, John Wiley, 1983. **6.** Zienkiewicz, O. C., and R. L. Taylor, The

1	**Title of the course** (L-T-P-C)	**Dynamics and Control** **3-0-0-6**
2	**Pre-requisite courses(s)**	--
3	**Course content**	**<u>Kinematics:</u>** ● Mathematical representation of position and orientation of a rigid body in 3D space, Euler angles, quaternions, transformation matrix ● Linear velocity, angular velocity from rotation matrix, acceleration of a rigid body in 3D space ● System of rigid bodies, degrees of freedom, holonomic and non- holonomic constraints, generalized coordinates ● Position, velocity and acceleration of multi body systems. Dynamics: ● Mass, inertia of a rigid body, linear and angular momentum, external forces and moments. ● Free body diagram, Newton-Euler formulation, equations of motion, examples ● Lagrangian formulation for equations of motion, comparison with Newton-Euler formulation, example solution of equations of motion using computer ● Modeling and simulation of multi-body systems using computer tools ● Vibration: 1 DOF oscillations, free/forced/damped responses, MDOF oscillations, natural frequencies, normal modes, time response, frequency response, bode plots **<u>Controls:</u>** ● Linearizing equations of motion, state space formulation, solution of state space equations ● Stability, controllability and observability in SISO systems, examples ● Root locus, bode plots, the relationship of classical and state space methods ● Design of controllers using state space and root locus ● Case studies of control of mechanical systems
4	**Texts/References**	1. A. Ghosal, Robotics: Fundamental Concepts and Analysis, Oxford University Press, 2006 2. “Analytical Dynamics”, Leonard Meirovitch, First Edition, McGraw Hill. 1970 3. Advanced Dynamics, Donald T Greenwood, Cambridge University Press; Reissue edition (2 November 2006) 4. G. F. Franklin, J. D. Powell, and A. Emami-Naeini, Feedback Control of Dynamic Systems, Pearson, 2006/5th edition

1	**Title of the course** (L-T-P-C)	**Engineering Mathematics for Advanced Studies (3-0-0-6)**
2	**Pre-requisite courses(s)**	--
3	**Course content**	**Module-1:** Linear Algebra: Vector Spaces, Matrices, Linear algebraic equations, Eigenvalues and Eigen- vectors of matrices, Singular-value decomposition **Module-2:** Tensor Algebra: Index Notation and Summation Convection, Tensor Algebra **Module-3:** Vector Calculus: Dot and Cross Product, Curves. Arc Length. Curvature. Torsion, Divergence and Curl of a Vector Field, Line Integrals, Green's Theorem, Stokes's Theorem, use of Vector Calculus in various engineering streams **Module-4:** Ordinary Differential Equations: Initial Value Problem, Method to solve first order ODE, Homogeneous, linear, 2nd order ODE, Non-homogeneous, linear, 2nd order ODE, System of 1st order ODE **Module-5:** Laplace and Fourier transformation: First and Second Shifting Theorems, Transforms of Derivatives and Integrals, Fourier Cosine and Sine Transforms, Discrete and Fast Fourier Transforms **Module-6:** Partial Differential Equations: Basic Concepts of PDEs, Modeling: Wave Equation, Heat Equation, Solution by Separating Variables, Solution by Fourier Series, Solution by Fourier Integrals and Transforms **Module-7:** Numerical Methods: Methods for Linear Systems, Least Squares, Householder's Tridiagonalization and QR-Factorization, Methods for Elliptic, Parabolic, Hyperbolic PDEs **Module-8:** Complex Analysis and Potential Theory: The Cauchy-Riemann Equations, Use of Conformal Mapping, Electrostatic Fields, Heat and Fluid Flow Problems, Poisson's Integral Formula for Potentials **Module-9:** Optimization and Linear Programming: Method of Steepest Descent, Linear Programming Fundamental theorem of linear inequalities, Cones, polyhedra. and polytopes, Farkas' lemma, LP-duality, max-flow min-cut, Simplex Method, primal- dual, Fourier-Motzkin elimination, relaxation methods **Module-10:** Probability Theory and Statistics: Experiments, Outcomes, Events, Permutations and Combinations, Probability Distributions, Binomial, Poisson, and Normal Distributions, Distributions of Several Random Variables, Testing Hypotheses, Goodness of Fit, $\chi 2$-Test **Module-11:** Abstract Algebra: Groups, Sub-groups, Cosets and Lagrange's theorem, Group actions, direct and semi-direct products.
4	**Texts/References**	**1.** E. Kreyszig. Advanced Engineering Mathematics, John Wiley & Sons, 2011. **2.** P.V. O'Neil. Advanced Engineering Mathematics, CENGAGE Learning, 2011. **3.** D.G. Zill. Advanced Engineering Mathematics, Jones & Bartlett Learning 2016. **4.** B. Dasgupta. Applied Mathematical Methods, Pearson Education, 2006. **5.** A. Schrijver, Theory of Linear and Integer Programming, 1998. **6.** D.S. Dummit, R.M. Foote, Abstract Algebra, 2004.

1	**Title of the course** (L-T-P-C)	**Introduction to Programming and Modeling Laboratory** **1-0-3-5**
2	**Pre-requisite courses(s)**	--
3	**Course content**	**SESSION A – Programming in C and Python** 1. Elements of programming 2. Compiling - Coding and Machine representation 3. Integrated Development Environments (IDEs) 4. Types of Variables and Arrays 5. Control Loops 6. Functions 7. Introduction to source code version control 8. Best Practices and Documentation **SESSION B – Introduction to Mathematical Toolkits** 1. Basic programming syntax 2. Working with Arrays - Initialization of arrays, extracting intrinsic matrix properties 3. Evaluation of commonly used statistical metrics 4. Plotting for research – data visualization, data conditioning, different types of plots 5. Primer to Data Science **SESSION C – Exposure to 3D modelling and grid generation** 1. Use of software to create basic geometrical shapes 2. Grid generation and mesh quality assessment **SESSION D – Software project** 1. Hands-on implementation to appreciate comprehensive project execution
4	**Texts/References**	2. R. Pratap, Getting Started with MATLAB: A Quick Introduction for Scientists & Engineers, Oxford, (2010). 3. C Programming Language– Brian Kernighan and Dennis Ritchie, Second Edition, Pearson Education India. 4. Technical guides, user manuals, and tutorials for various software packages

1	**Title of the course** (L-T-P-C)	**Research Methodology** 1-0-0-2
2	**Pre-requisite courses(s)**	--
3	**Course content**	**Scientific Literature:** Research articles, resources, types of publications, identifying authentic sources **Reading:** Reading research articles; experimental, numerical, analytical, and review publications. **Writing:** Communicating formally (letters, emails) Styling; Units; Writing research articles; Automations using LaTeX, MS Word, Mendeley, BibTex; Research ethics **Presentations:** Presenting research work, Content and time management. Presentation tools: MS PowerPoint, Beamer, Excel; Plotting tools: Grapher, Origin, Tecplot, Matlab; Figures: quality, scaling, vector vs raster formats. **Oral Communication:** Stage manners, voice modulation **Hybrid Mode Presentations:** Initial setup and the tools required.
4	**Texts/References**	1. A Manual for Writers of Research Papers, Theses, and Dissertations, Kate L Turabian, Ninth Edition, The University of Chicago Press, 2018. 2. Communication Skills for Engineers and Scientists, Sangeeta Sharma and Binod Mishra, Second Edition, PHI Learning, 2009. 3. The elements of style, William Strunk Jr and E White, Fourth Edition, Pearson Education, 1999. 4. A New Approach to Research Ethics Using Guided Dialogue to Strengthen Research Communities, Henriika Mustajoki and Arto Mustajoki, First Edition,Routledge Publications, 2017. References: 1. Wren and Martin “High School English Grammar and Composition”, Regular edition, January 2017.

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Semester II (32 Credit)

Course Name	L-T-P-C	Objective of the course	Category
Experimental Theory & Laboratory **(ME 611)**	1-0-3-5	To introduce students with experimental analysis, data analysis, measurement tools and to introduce basic and advance level experiments in Thermo-Fluids Engineering	PC
Design of Mechanical Transmission Systems **(New)**	3-0-0-6	With a review of fundamentals of a typical design course, the course discusses in detail the aspects related to transmission of power in gears, brake, clutch, belt drives, and bearings	PC
Mechatronics and Robotics (New)	2-0-2-6	This course introduces concepts spanning mechatronics such as sensors/actuators and its use in control of robotic manipulators. Robotics relevant topics such as navigation and vision systems are al;so included to allow students to work on hands-on course projects.	PC
Elective I	3-0-0-6	To give a choice to the student to choose postgraduate level course within Design stream offered electives	PE
Elective II	3-0-0-6	To give a choice to the student to choose postgraduate level course within Design stream offered electives	PE
Practicum	0-0-0-3	Presentation to a large audience at a seminar on research topics in Mechanical Engineering	PC

1	**Title of the course** (L-T-P-C)	**Design of Mechanical Transmission Systems** **3-0-0-6**
2	**Pre-requisite courses(s)**	--
3	**Course content**	**Basics:** Review of Mechanical Engineering Design, Materials, Load and Stress Analysis, Deflection, and Stiffness. **Failure Prevention:** Review of Failures Resulting from Static Loading, Review of Fatigue Failure Resulting from Variable Loading. Design of Mechanical transmission systems: **Shafts:** Design for Stress, Deflection Considerations, Critical Speeds for Shafts, Miscellaneous Shaft Components, Limits and Fits. **Lubrication and Journal Bearings:** Types of Lubrication, Petroff's Equation, Thick-Film Lubrication, Hydrodynamic Theory, Thrust Bearings Design Considerations **Rolling-Contact Bearings:** Types, Bearing Load Life at Rated Reliability, Reliability versus Life—The Weibull Distribution, Relating Load, Life, and Reliability, Combined Radial and Thrust Loading **Gears**: Gears—General, Spur, Helical, Bevel, and Worm gears: The Lewis Bending Equation, Surface Durability, AGMA Stress Equations, AGMA Strength Equations-Geometry Factors, Dynamic Factor, Overload Factor, Surface Condition Factor, Size Factor, Load-Distribution Factor, Hardness-Ratio Factor, Stress-Cycle Factors, Reliability Factor, Temperature Factor, Rim-Thickness Factor, Safety Factors. **Gearbox:** Introduction, Evaluation, and application of Gearbox, Step Ratio, Preferred Numbers, Structural Formula & Rules of optimum Gearbox, Ray diagram construction, Machine Tool Gearbox - Kinematic diagram construction, Centre distance, and teeth calculation **Brake** -Torque requirement for drum brake systems, Torque requirement for disc brake systems, static and dynamic analysis, brake force distribution. Braking efficiency & distance and brake factor. Thermal analysis and braking conditions, braking power absorbed by lining and drum/disc **Clutch:** Types and working method, Torque transmitting capacity – uniform pressure & wear theories. Multiple discs and cone clutches, Centrifugal clutch, Dynamic analysis. **Belt Drives** - Introduction and types, Geometrical relationship for open and crossed belt drives - V and micro-v belts, Selection of V and micro-v belts, V and micro-v pulley design.
4	**Texts/References**	**1.** Richard G. Budynas, J. Keith Nisbett, Shigley's Mechanical Engineering Design, McGraw-Hill Higher Education, 2017 **2.** Stephen P Radzevich , Dudley's Handbook of Practical Gear Design and Manufacture, CRC Press, 2012. **3.** Peter Lynwander, Gear Drive Systems Design and Application, CRC Press, 2019. **4.** Hani M. Tawancy, Anwar Ul-Hamid, Nureddin M. Abbas, Practical Engineering Failure Analysis, CRC Press, 2004.

1	**Title of the course** (L-T-P-C)	**Mechatronics and Robotics** 2-0-2-6
2	**Pre-requisite courses(s)**	--
3	**Course content**	**1.** Mechatronics vs robotics **2.** Modeling friction, DC motor, Lagrange formulation for system dynamics. **3.** Dynamics of 2R manipulator, Simulation using Matlab, Selection of sensors and actuators. **4.** Concept of feedback and closed loop control, mathematical representations of systems, linearization of the system, stability analysis and control design for regulation and tracking **5.** Basics of sampling of a signal, and signal processing **6.** Navigation: environment description, map building, path planning and collision avoidance **7.** Vision systems: 2-D Projective Geometry, camera geometry, point clouds, range image processing, clustering and classification, examples **8.** Dimensionality reduction and sparse representation Hands on project
4	**Texts/References**	**1.** Indri and Oboe, "Mechatronics and Robotics: New Trends and Challenges:, CRC Press, 1st edition, 2020 (ISBN 9780367562045) **2.** Boukas K, Al-Sunni, Fouad M "Mechatronic,Systems Analysis, Design and Implementation," Springer, 2012 **3.** Katsuhiko Ogata, Modern Control Theory, Prentice Hall Ogatta, 1990.

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Semester – III: 32 Credits			**Semester – IV: 32 Credits**		
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M.Tech. Project - I	0-8-16-32	IC	M.Tech. Project - II	0-8-16-32	IC

PC: Program Core

IC: Institute Core

PE: Program Elective