New elective courses

SN	Course Code	Course Title	L-T-P-CH-CR
1.	ME-511	Experimental Stress Analysis for Design	3-0-1-5-4
2.	ME-512	Theory of Plasticity	3-0-0-3-3
3.	ME-513	Introduction to Fracture Mechanics	3-0-0-3-3
4.	ME-521	Robotics	3-1-0-4-4
5.	ME-606	Stability Problem in Applied Mechanics	3-0-0-3-3
6.	ME-607	Soft Computing Technique in Engineering	3-0-0-3-3
7.	ME-608	Mechatronics and Industrial Automation	3-0-0-3-3
8.	ME-609	Design of Internal Combustion Engine	3-0-0-3-3
9.	ME-610	Kinematics and Dynamics of Internal Combustion Engine	3-0-0-3-3
10.	ME624	Design of Internal Combustion Engine Auxiliary System	3-0-0-3-3

Syllabus (New elective courses)

ME-511: Experimental Stress Analysis for Design **L-T-P-CH-CR: 3-0-1-5-4**

Review of Stress and Strain Analysis: Stress-strain relations and general equations of elasticity;

Strain Measuring Devices: Various types of strain gauges, Electrical resistance strain gauges: gauge factor, types, gauge materials, backing materials, adhesives, protective coatings, bonding of strain gauges, lead wires and connections, Semiconductor strain gauges,

Performance of Strain Gauges: Temperature compensation, transverse sensitivity, gauge length, response, excitation level, stability;

Strain gauge circuits, recording instruments for static and dynamic applications, strain gauge rosettes analysis, stress gauge;

Photoelasticity: Theory of photoelasticity, analysis techniques, three dimensional photoelasticity;

Brittle coating methods of strain indication;

Introduction to Moiré fringe technique;

Residual Stress Analysis: Analytical and numerical solution of residual stresses in metal working processes (autofrettage, welding etc.), Experimental methods for assessing residual stresses: Sachs boring, X-ray diffraction, neutron diffraction and hole drilling method, inference of residual stresses from microhardness test.

Textbooks

1. Dove R.C. and Adams P. H. *Experimental Stress Analysis* (McGraw Hill, 1992)
2. Dally J.W. and Riley W.F. *Experimental Stress Analysis* (McGraw-Hill Inc., New York, 1998)
3. Srinath, L.S. and Raghavan M.R. *Experimental Stress Analysis* (Tata McGraw-Hill, 1998).

References

1. Freddi A. Olmi G. and Cristofolini L. *Experimental Stress Analysis for Materials and Structures* (Springer, Switzerland, 2015)
2. Timoshenko S.P. and Goodier J.N. *Theory of elasticit*, (McGraw-Hill International Editions, 1970)
3. Sharpe W.N. *Handbook of Experimental Solid Mechanics* (Springer, 2008)
4. Noyan I.C. and Cohen J.B. *Residual Stress* (Springer, 1987)
5. Kandil F.A., Lord J.D., Fry A.T. and Grant P.V. *A review of residual stress measurement methods—A guide to technique selection* (NPL Report MATC(A)04, February 2001, NPL Materials Centre Queens Road, Teddington, Middlesex, UK)
6. Kamal S.M. Borsaikia A. and Dixit U.S. Experimental assessment of residual stresses induced by the thermal autofrettage of thick-walled cylinders, *Journal of Strain Analysis*, Vol. 51(2), pp. 144−160, 2016.

ME-512: Theory of Plasticity **L-T-P-CH-CR: 3-0-0-3-3**

Stresses and Strain: Stress and strain behavior of materials, plastic and tangent modulus, strain hardening, plastic instability in tensile test, empirical stress-strain equations, effect of pressure, strain-rate and temperature. Analysis of stress tensor, eigenvalues, decomposition of stress tensor into deviatoric and hydrostatic components, octahedral stresses. Analysis of strain and strain-rates. Stress equilibrium and virtual work, objective stress rates.

The criteria of yielding. Isotropic and anisotropic hardening. Rules of plastic flow: Levy-Mises and Prandtl-Reuss equations. Hill's 1948 and 1979 yield criteria for anisotropic yielding. Anisotropic flow rule. Upper bound and lower bound theorems with a few applications.

Axisymmetric elastic-plastic problems: Hydraulic autofrettage, Swage autofrettage and Thermal autofrettage; Expansion of hole in a plate.

Plane stress elastic-plastic problems: Bending of beam.

Indentation problem: by upper bound and cavity method

Dynamics Elasto-plastic problems: Longitudinal stress wave propagation in a rod, Taylor rod problem.

Introduction to Updated Lagrangian and Eulerian formulations.

Textbooks

1. Dixit P.M. and Dixit U.S. *Plasticity: Fundamentals and Applications* (CRC Press, 2015)
2. Chakrabarty J. *Theory of Plasticity* (Elsevier Butterworth-Heinemann, 2006)

References

1. Dixit P.M. and Dixit U.S. *Modeling of Metal Forming and Machining Processes by Finite*

Element and Soft Computing Methods (Springer, 2008)
2. Rees D.W.A. *Basic Engineering Plasticity* (Elsevier Butterworth-Heinemann, 2006)
3. Lal G.K. and Reddy N.V. *Introduction to Engineering Plasticity* (Narosa, 2009)
4. Kamal S.M. and Dixit U.S. Feasibility study of thermal autofrettage of thick-walled cylinders, *ASME Journal of Pressure Vessel and Technology*, Vol. 137(6), pp. 061207-1−061207-18, 2015.

ME513: Introduction to Fracture Mechanics **L-T-P-CH-CR: 3-0-0-3-3**

Fatigue: Mechanisms of fatigue crack initiation and propagation; Notch sensitivity; Factors influencing fatigue strength, Prevention of fatigue failure.
Introduction to fracture: Failure and fracture, Types of fracture, Modes of fracture failure.
Energy of Fracture: Energy balance during crack growth, Griffith's theory, Crack stability, Fracture criterion, Strain energy release rate.
Linear Elastic Fracture Mechanics: Analysis of crack tip stress, Irwin's fracture criterion, Determination of stress intensity factor, Fracture toughness.
Elastic-Plastic Fracture Mechanics: Crack tip opening displacement, J-Integral and its applications;
Computational Fracture Mechanics: Finite element method, Virtual crack extension, Virtual crack closer integral;
Advanced Topics: Fracture in composite, Fracture in nanometer scale.
Case studies on fracture failure.

Textbooks

1. Kumar, P. *Elements of Fracture Mechanics* (Tata McGraw-Hill, New Delhi, 2009)
2. Anderson, T.L. *Fracture Mechanics: Fundamentals and applications* (3rd ed., CRC Press, 2005)

References

1. Sanford R.J. *Principles of Fracture Mechanics* (Prentice Hall, 2003)
2. Bolotin V.V. *Mechanics of Fatigue* (CRC Press, 1999)
3. Broek, D. *Elementary Engineering Fracture Mechanics* (Kluwer Academic Publishers, 1986)
4. Rolfe S.T. and Barsom J.M. *Fracture and Fatigue Control in Structures: Applications of Fracture Mechanics* (Butterworth-Heinemann, 2000)
5. Maiti S.K. *Fracture Mechanics: Fundamental and Applications* (Cambridge University Press, 2015)
6. Kundu T, *Fundamental of Fracture Mechanics* (CRC Press, Taylor & Francis, 2008)
7. Kuna M. *Finite Elements in Fracture Mechanics* (Springer, 2013)
8. Gdoutos E. E. *Fracture of Nano and Engineering Materials and Structures* (Springer, 2006)

ME521: Robotics **L-T-P-CH-CR: 3-1-0-4-4**

Introduction: A brief history; Types of robots; Basic principles in robotics; Notation.

Mathematical Representation of Robots: Position & orientation of a rigid body; Transformation between coordinate systems; Homogeneous transformation and its properties; Representation of joints; Representation of links using Denavit-Hartenberg parameters; Link transformation matrices.

Kinematics of Serial Manipulators: Degrees of freedom; Direct kinematics problem; Inverse kinematics problem; Redundant manipulators.
Velocity Analysis and Statics of Manipulators: Linear and angular velocities of a rigid body; Linear and angular velocities of links in serial manipulators; Jacobian; Singularities of serial manipulators; Statics of serial manipulators; Redundancy resolution.
Elements of Kinematics of Parallel Manipulators: Degrees of freedom; Direct kinematics problem; Inverse kinematic problem; Mobility of parallel manipulators; Jacobian, Statics & Singularity.
Dynamics of Manipulators: Forward and inverse dynamics of manipulators; Newton-Euler and Lagrangian formulations.
Trajectory Planning and Generation: General considerations in path description and generation; Joint space schemes; Cartesian space schemes.
Position and Force Control of Manipulators: Feedback control of a single-link manipulator; PID control of a multi-link manipulator; Non-linear control of manipulators; Partitioning a task for force and position control; Hybrid position/force controller; Stability analysis.
Elements of a Robot: Actuators, Transmission & Sensors.

Textbooks

1. Ghosal A. *Robotics - Fundamental concepts & Analysis* (Oxford university press, 2006)
2. Craig J. J. *Introduction to Robotics - Mechanics & Control* (Addison - Wesley Publishing Company, New York, 1986)

References

1. Asada H. and Slotine J. E. *Robot Analysis & Control* (John Wiley & Sons, New York, 1986)
2. Nakamura Y. *Advanced robotics - Redundancy & Optimization* (Addison - Wesley Publishing Company, New York, 1991)
3. Merlet J.P. *Parallel Robots* (Kluwer Academic Publishers, Netherlands, 2000)

ME606: Stability Problems in Applied Mechanics **L-T-P-CH-CR: 3-1-0-4-4**

***Basic Dynamic Considerations*:**
Introduction; One-Dimensional Flows: Flows on the Line; Parameter Dependent Flows & Bifurcations; Flows on the Circle;
Two Dimensional Dynamic Systems: Phase-plane Description; Linearized Stability Analysis;
Limit cycle and its Stability; Parametric Instability: Floquet Theory.
***Stability of Static Equilibrium*:**
Introduction; Euler's Method: Buckling of Columns; Energy Method: Approximate Solution; Non-adjacent Equilibrium Configuration: Snap Buckling; Asymmetric Deformation, Imperfection Sensitivity; Buckling due to Follower Load: Insufficiency of Static Analysis; Euler Buckling Load Revisited: Dynamic Analysis; Second Revisit of Buckling of Column (Euler Load); Other Examples of Instability.
***Stability Problems in Dynamics*:**
Introduction; Different Notions of Stability; Stability of Equilibrium Configuration; Stability of a Rotating Rigid Body; Parametric Instability of a Linear Continuous System; Periodic Solution of Non-Linear Oscillators and its Stability.
Emergence of Length Scale and Pattern Formation:

Introduction; Stripes of Zebra Skin; Turning Pattern; Rayleigh-Taylor Instability; Staffman-Taylor Instability; Rayleigh-Plateau Instability; Rayleigh Benard Convection; On the Nature of Bifurcation; Faraday Instability; Rotating Couette Flow; Hydraulic Jump.

Textbooks:

1. Mallik, A. K. and Bhattacharjee, J. K. *Stability Problems in Applied Mechanics*, Narosa Publication (2005)

References:

1. Dym, C.L., *Stability Theory & its application to Structural Mechanics*, Noordhoff International Publications, Holland (1974)
2. Baznat, Z.P. and Cedolin, L., *Stability of Structures*, Oxford University Press, NY (1991)
3. Timoshenko, S.P. and Gere, J.M., *Theory of Elastic Stability*, Mc-Graw Hill, New York (1961)
4. Strogatz, S. H., *Nonlinear Dynamics & Chaos*, Addison-Wesley Pub. Co. Reading (1994)
5. Jordan D.W.and Smith, P., *Nonlinear Ordinary Differential Equations*, Clarendon Press, Oxford (1999)

ME-607: Soft Computing Techniques in Engineering **L-T-P-CH-CR: 3-0-0-3-3**

Introduction to soft computing, hard computing, Need for soft computing;
Neurons and neural networks; Basic models of artificial neural networks – single-layer perceptron, multilayer perceptron; Radial basis function networks; SOM; Recurrent neural networks; Training of neural network; Applications of neural networks in mechanical engineering;
Introduction to fuzzy sets, Fuzzy reasoning and clustering;
Optimization tools: Traditional and non-traditional, genetic algorithms, simulated annealing etc.; Combined techniques: Genetic Algorithms–Fuzzy Logic, Genetic Algorithms–Neural Networks, Neural Networks–Fuzzy Logic.
Support Vector Machine (SVM) - introduction, principle and application.

Textbooks:

1. Pratihar D. K. *Soft Computing* (Narosa Publishing House, 2015)
2. Haykin S. *Neural Networks: A Comprehensive Foundation* (Pearson Education, 2nd ed., 2009)
3. Chen G. and Pham T.T. *Introduction to Fuzzy Sets, Fuzzy Logic, and Fuzzy Control Systems* (CRC Press, 2001)

References:

1. Dixit, P. M. and Dixit, U. S., *Modeling of metal forming and machining processes: by finite element and soft computing methods*, (Springer, 1st ed., 2008)
2. Deb K. *Optimization for Engineering Design: Algorithms and Examples* (Prentice Hall, 2006)
3. Aliev R.A. and Aliev R.R. *Soft Computing and its Applications* (World Scientific Publishing, 2001)

ME-608: Mechatronics and Industrial Automation **L-T-P-CH-CR: 3-0-0-3-3**

Introduction to Mechatronics: Introduction, Elements of Mechatronics system, Applications.

Sensors and Actuators: Sensing principle, Electrical actuators, Hydraulic and Pneumatic actuators.

Signal Processing: Signal conditioning devices, Protection, Conversion and pulse width modulation, Data conversion devices.

Microprocessors: Introduction to microprocessors, Introduction to microprocessor programming, Internal architecture of 8085 microprocessor.

Principles of Automation Technology: Automation system components, Discrete manufacturing automation, Continuous process automation.

Programmable Logic Controllers (PLC): Industrial Control, Structure of PLC, Programming languages for PLC, Boolean logic for process control, Timers, Counters and other functions.

Feedback Control: Continuous and Time- Discrete control, On/Off control, PID control, Distributed Control System (DCS)

Man machine communication: Supervisory control and data acquisition (SCADA)
Assignment and mini-project.

Textbooks

1. Bolton W. *Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering* (Pearson education, 2007)
2. Lamb F. *Industrial Automation: Hands-On* (McGraw-Hill Education, 2013)

References

1. Appukuttan K.K. *Introduction to mechatronics* (Oxford University Press, 2007)
2. Stenerson J. *Industrial automation and process control* (Prentice Hall, 2003)

ME-609: Design of Internal Combustion Engine **L-T-P-CH-CR: 3-0-0-3-3**

Prerequisite for engineering design and design conditions of internal combustion engine components, Design of parts working under alternating loads, piston, piston ring and pin, Design of connecting rod small end, big end, shank and bolts, pressure on crank pin and journals, Design of crank web, inline and V engine crankshafts, Design of cylinder block, upper crankcase, liner, cylinder head and studs, Design of cam profile, harmonics of cam, valve gear, valve spring and camshaft, electronic control system for IC engine.

Textbooks

1. Hoag, K. and Dondlinger, K. *Vehicular Engine Design* (Springer, New York, 2016)
2. Smith, J. H. *An Introduction to Modern Vehicle Design* (Butterworth-Heinemann, Oxford, 2002)

References

1. Kolchin, A. and Demidov, V. *Design of Automotive Engine* (Mir Publisher, Moscow, 1984)
2. Fenton, J. *Hand Book of Vehicle Design Analysis* (Mechanical Engineering Publication Limited, London, 2013).

ME-610: Kinematics and Dynamics of Internal Combustion Engine **L-T-P-CH-CR: 3-0-0-3-3**

Fundamentals of kinematics and dynamics, Different components of internal combustion engine, Types of IC Engine (Petrol, Diesel, 4 stroke , 2 strok4), Speed characteristics, Kinematics of crank mechanism comprising of piston stroke, speed and acceleration, Dynamics of crank mechanism comprising of gas pressure forces, masses of crank mechanism, inertial forces, total forces acting in crank mechanism, forces acting on crank pins, forces acting on main journals, crankshaft journals and pin wear, Balancing of diverse types of engines, uniformity of engine torque.

Textbooks

1. Hoag, K. and Dondlinger, K. *Vehicular Engine Design* (Springer, New York, 2016)
2. Smith, J. H. *An Introduction to Modern Vehicle Design* (Butterworth-Heinemann, Oxford, 2002)

References

1. Kolchin, A. and Demidov, V. *Design of Automotive Engine* (Mir Publisher, Moscow, 1984)
2. Fenton, J. *Hand Book of Vehicle Design Analysis* (Mechanical Engineering Publication Limited, London, 2013).