Punyashlok Ahilyadevi Holkar Solapur University, Solapur

पुण्यश्लोक अहिल्यादेवी होळकर
सोलापूर विद्यापीठ
।। विद्यया संपन्नता ।।

NAAC Accredited-2015
'B' Grade (CGPA 2.62)

Name of the Faculty: Science & Technology

CHOICE BASED CREDIT SYSTEM

Syllabus: Mechanical Engineering

Name of the Course: Ph. D. Course Work Paper No. 3

(Syllabus to be implemented from w.e.f. June 2021)

Punyashlok Ahilyadevi Holkar Solapur University, Solapur

Course Work for Ph.D. – Mechanical Engineering

Paper 03: Advanced Knowledge In Core domain of concerned subjects
(Mechanical Engineering)

Note: Students can choose any one subject from 03 subjects as per his specific area of research.

The three options available for students are as follows:

1. Design Engineering
2. Manufacturing Engineering
3. Thermal and Heat Power Engineering

Punyashlok Ahilyadevi Holkar Solapur University, Solapur

Course Work for Ph.D. – Mechanical Engineering

Paper 03: Advanced Knowledge In Core domain of concerned subjects (Mechanical Engineering)

Design Engineering

Teaching Scheme | Examination Scheme
Lecturers: 3 Hrs/ Week | Theory: 100 Marks

Objectives

1. To understand basics required for research
2. To study recent and modern trends in Mechanical Engineering
3. To make research scholar aware about newly added knowledge to broad understanding of Mechanical Engineering

Section – I

Unit-1. Optimization Methods and Design of Experiments (06)

Basic Concepts of Optimization- Convex and Concave Functions, Necessary and sufficient conditions for Stationary Points. Single Variable Optimization: Optimum problem formulation, Optimality Criteria, Bracketing methods, region-Elimination method, Multivariable optimization: Optimality criteria, Unidirectional search, Direct search method- Evolutionary optimization, Simplex search. Multi-Objective Programming, Introduction to Genetic Algorithms, Simulated Annealing and ANN Based Optimization.

One factor at a time model, Fixed effects model, Estimation of the model parameters, Model adequacy checking, The normality assumption, Two-Factor factorial design, The general factorial design. Fractional factorial design. Response surface methodology. Taguchi method.

Unit-2. Solid Mechanics (24 Hr)

Stress analysis: Body force, surface force, stress/traction vector, state of stress at a point, normal and shear components, plane stress, stress transformations, Mohr's circle, principal stresses, principal planes, stress invarients, differential equations of equilibrium in cartesian, cylindrical and spherical polar coordinates

Analysis of Deformations: Small deformation theory, definition of strains, strain at a point, normal and shear strain, plane strain, strain transformations, Mohr's cricle, principal strains, principal axes of strains, compatibility equations, strain gauge rosettes, strain displacement relations in cylindrical and spherical polar coordinates.

Stress Strain Temperature Relations: Idealization/Types of stress strain curves, thermal strains, stress strain temperature relations for linear elastic isotropic body, interpretation of different elastic constants, relations between elastic constants. Stress strain relations for orthotropic and transversely isotropic materials.

Formulation and Solutions to 2D problems: Types of boundary conditions, uniqueness theorem, Airy's stress function, principle of superposition, Saint Venant's principle.

Energy methods: Strain energy, reciprocal theorem, principle of virtual work, Castigliano's theorem, principle of minimum potential energy, Rayleigh-Ritz method for approximate solutions.

Theory of Failures: Maximum normal stress theory, Mises yield criteria, Tresca yield criteria.

Torsion: Torsion of circular straight rods, torsion of shafts with rectangular cross-sections, torsion of hollow shafts, torsion of thin tubes, shafts subjected to combined loads Torsion of shafts with arbitrary cross-sections, Prandtl stress function approach, membrane analogy.
Bending: Stress and deflections in symmetrical elastic beams, symmetrical beams subjected to combined loads, bending of unsymmetrical beams, bending of curved beams.
Asymmetric problem: Thick and thin cylinders subjected to internal pressure, rotating disk problems.
Miscellaneous problems: Non-axisymmetric problems like Flamant problem, stress concentration factor for a hole in a plate subject to uniaxial loading.
Buckling: Equilibrium approach, potential energy approach, eigenvalue problems, beam buckling with various boundary conditions, approximation of buckling loads using potential energy methods.

Section- II

Unit-3 Uncertainty Analysis in Experiments & Finite Element Techniques (6)
Uncertainty Analysis in Experiments (03)
Errors in instruments, Analysis of experimental data and determination of overall uncertainties in experimental investigation, Uncertainties in measurement of parameters like pressure, temperature, flow etc. under various conditions. Estimation of uncertainty by Partial Differentiation Method (PDM), Combining uncertainty components. Student's t-test method.

Finite Element Techniques (03)
Model boundary value problem, finite element discretization, element shapes, sizes and node locations, interpolation functions, derivation of element equations, connectivity, boundary conditions, FEM solution, post-processing, compatibility and completeness requirements, convergence criteria, higher order and isoparametric elements, natural coordinates, Langrange and Hermite polynomials.

Unit-4. Kinematics and Dynamics (24 Hr)
System of particles: Position, velocity, and acceleration analysis; reference frames and their relative motion; constrained motion of connected particles; work, kinetic and potential energy; impulse and momentum (linear and angular).
Motion of Rigid Bodies: Translation and rotation of rigid bodies; centripetal and Coriolis acceleration. Three-dimensional rigid bodies: analysis of motion and energy; gyroscope – precession and nutation; governor mechanism.
Lagrange dynamics: Hamilton's principle; Lagrange's equations; principle of virtual work. Application of Lagrange's equation problems of rigid body dynamics.
Mechanisms: Position, velocity and acceleration analysis of mechanisms; kinematic synthesis – function generation, path generation and rigid body guidance; graphical and analytical techniques of synthesis; dynamic analysis of mechanism - equations of motion, forward and inverse dynamic analysis; systems of interconnected rigid bodies.
Vibrations: Single degree-of-freedom systems: Equations of motion, differential equations and their solution, free and forced response, damping. Multiple degree-of-freedom systems: matrix-vector form of governing equations, the eigenvalue problem and its solution, natural frequencies and mode shapes, orthogonality, generalized coordinates, response to initial conditions and typical excitation forms, proportional and modal damping.
Vibration Control: Introduction, vibration nomograph and vibration criteria, reduction of vibration at the source, balancing of rotating machines, whirling of rotating shafts, balancing of reciprocating engines, control of vibrations, control of natural frequencies, vibration isolation, vibration absorbers.

Vibration measurement and applications: Introduction, transducers, vibration pickups, frequency measuring instruments, vibration exciters, signal analysis, dynamic test of machines and structures, experimental modal analysis, machine condition monitoring and diagnosis.

Reference Books:

1. S. S. Rao, Engineering Optimization Theory and Practice, New Age International.
2. Kalyanmoy Deb, Optimization for Engineering Design, PHI.
3. J.S. Arora, Optimization Techniques, John Wiley.
4. Holman, J.P, Experimental methods for engineers, McGraw-Hill, 1988.
5. Montgomery Douglas C., Design and analysis of experiments, Wiley, 2008
6. Zienkiewicz , The Finite Element Method, Tata McGraw Hill
7. Huebner, The Finite Element Method for Engineers, John Wiley
8. J. N. Reddy, An Introduction to the Finite Element Method, McGraw Hill
9. S.S. Rao, The Finite Element Method in Engineering, Pergamon Press
10. S.S. Rao, Mechanical Vibrations, Pear and on Publication.
11. Thomson, Mechanical Vibration, Printice Hall.
12. Den Hartog, Mechanical Vibration, McGraw-Hill
13. Saad, M. H., Elasticity: Theory, Applications and Numerics
14. Timoshenko, S. P., Theory of Elasticity
15. Srinath, L. S, Advanced Mechanics of Solids
16. Crandal, S, Lardner, T, Dahl, N and Sivakumar, M. S., An Introduction to Mechanics of Solids

Punyashlok Ahilyadevi Holkar Solapur University, Solapur

Course Work for Ph.D. – Mechanical Engineering

Paper 03: Advanced Knowledge In Core domain of concerned subjects
(Mechanical Engineering)

Manufacturing Engineering

Teaching Scheme	Examination Scheme
Lecturers: 3 Hrs/ Week	Theory: 100 Marks

Objectives

1. To understand basics required for research
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Section – I

Unit-1. Optimization Methods and Design of Experiments (06)
Basic Concepts of Optimization- Convex and Concave Functions, Necessary and sufficient conditions for Stationary Points. Single Variable Optimization: Optimum problem formulation, Optimality Criteria, Bracketing methods, region-Elimination method, Multivariable optimization: Optimality criteria, Unidirectional search, Direct search method- Evolutionary optimization, Simplex search. Multi-Objective Programming, Introduction to Genetic Algorithms, Simulated Annealing and ANN Based Optimization.
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Unit-2 Manufacturing-I (24 Hr)
Casting processes: dispensable and permanent mould processes; analysis of melting, pouring and solidification phenomena; design of pattern, core, feeder and gating system; casting defects and inspection.

Joining processes: fusion and solid-state welding; brazing and soldering; weld joint design, cooling rate, and joint properties; welding defects and inspection.

Bulk and Sheet Forming processes: rolling, forging, extrusion and drawing; sheet metal working; forming limit diagram; loads, friction and lubrication; forming defects and inspection.

Powder processing: Powder manufacture, characterization, compaction and sintering; metal injection moulding; hot and cold isostatic pressing.

Advanced processes: Free form fabrication (rapid prototyping), and net shape manufacturing processes.

Polymers & Composites: Definition of composite material, Classification based on matrix and topology, Constituents of composites, Thermoplastics, thermosets, elastomers and composites; related processes; injection mould design; moulding defects and inspection, Interfaces and Interphases, Distribution of constituents, Composites Fabrication, Fracture & Safety of Composite and Introduction to Nanotechnology, Manufacturing and Characterization of Nano-composites.

Section-II

Unit-3 Uncertainty Analysis in Experiments & Finite Element Techniques (6)

Uncertainty Analysis in Experiments (03)

Errors in instruments, Analysis of experimental data and determination of overall uncertainties in experimental investigation, Uncertainties in measurement of parameters like pressure, temperature, flow etc. under various conditions. Estimation of uncertainty by Partial Differentiation Method (PDM), Combining uncertainty components. Student's t-test method.

Finite Element Techniques (03)

Model boundary value problem, finite element discretization, element shapes, sizes and node locations, interpolation functions, derivation of element equations, connectivity, boundary conditions, FEM solution, post-processing, compatibility and completeness requirements, convergence criteria, higher order and isoparametric elements, natural coordinates, Langrange and Hermite polynomials.

Unit-4 Manufacturing-II (24 Hr)

Material Removal Processes (2Hrs)

Mechanics of Machining, tool geometry and materials, chip formation, tool temperature, tool wear, tool life, surface finish, machinability. Optimization of machining processes.

Metrology and Quality Control (6 Hrs)

Error due to Numerical Interpolation, displacement measurement technique, Error types and their evaluation, Image processing and its applications in metrology, Laser trackers, micro and nanometrology, Process capability- Process Capability Index. Advanced dimensional chain and tolerance stacking , Global management or six sigma management, methods of improving accuracy and surface finish. Quality Control, Statistical Quality Control, Quality assurance systems

Tribology (6 Hrs)

Tribo-environment, contact theory of surface, Ergodicity and Stationarity of surface, Contact phenomenon & contact deformation of the surface, Parameters affecting friction and wear, Adhesive, Abrasive, Erosive wear, Dry friction, boundary friction, semi liquid and liquid friction under lubrication, Use of solid lubricants in extrusion and metal cutting, method of testing and Characterization of lubrication.

Advanced Machine Tool Design (4 Hrs)

Design of elements like Bed, Columns, Guide ways, Design of Guides using FEA, Lumped parametric method, Design of spindles based on deformation and rigidity, Reliability based design, static and dynamic rigidity, stability analysis, Vibrational study – Micro-displacement and error analysis Modular Concept in Machine tool structure.

Advanced Machining / Non conventional Machining (6 Hrs)

Theory and Numerical analysis of abrasive jet machine, Abrasive flow machining, Ultrasonic machining, Electrical Discharge Machining(EDM), Electro Chemical Machining, Electro Chemical Discharge Machining(ECDM) ,Vibro ECDM, Dry and Near dry EDM, thermal Energy Methods material pressing, LASER machining, Electron Beam Machining, Plasma arc machining, Physical vapour deposition and chemical vapour deposition, high energy rate forming and Electroforming.

Jigs and fixtures, principles of location and clamping, synthesis of simple jigs and fixtures. Principles of assembly engineering, theory of dimensional chains, fully interchangeable and selective assembly. Introduction to Numerical Control.

Reference Books:

1. S. S. Rao, Engineering Optimization Theory and Practice, New Age International.
2. Kalyanmoy Deb, Optimization for Engineering Design, PHI.
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8. J. N. Reddy, An Introduction to the Finite Element Method, McGraw Hill
9. S.S. Rao, The Finite Element Method in Engineering, Pergamon Press
10. Kaw, Autar K. Mechanics of composite materials. CRC press, 2005.
11. Kumar D. S., Mechanical Measurement & Control, Metropolitan Book Co. Pvt. Ltd. New Delhi, 2007
12. Hume K. J., Engineering Metrology, Macdonald, 1950
13. Beckwith T. G., Marangoni R. D., Lienhard J. H., Mechanical Engineering Measurements, Pearson Prentice Hall, 2007
14. Boothroyd G. and Knight W. A., Fundamentals of Machining and Machine Tools, CRC-Taylor and Francis, 2006
15. V.K. Jain, Advanced Machining Processes, Allied Publishers Pvt Ltd
16. P.C. Pandey and H.S. Shan, Modern Machining Processes. Tata McGraw- Hill

Punyashlok Ahilyadevi Holkar Solapur University, Solapur
Course Work for Ph.D. – Mechanical Engineering

Paper 03: Advanced Knowledge In Core domain of concerned subjects (Mechanical Engineering)

Thermal and Heat Power Engineering

Teaching Scheme	Examination Scheme
Lecturers: 3 Hrs/ Week	Theory: 100 Marks

Objectives

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Section – I

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One factor at a time model, Fixed effects model, Estimation of the model parameters, Model adequacy checking, The normality assumption, Two-Factor factorial design, The general factorial design. Fractional factorial design. Response surface methodology. Taguchi method.

Unit-2. Fluid Dynamics (24 Hr)

Introduction: Review of vector calculus, cartesian tensor notation.

Kinematics of Fluid Flow: Description of fluid motion: Eulerian and Lagrangian approaches; Pathlines, Streaklines, Streamlines; Kinematic decomposition of velocity field.

Fundamental Governing Equations: Conservation equations in Integral and Differential form; Stresses in fluid; Rates of deformation and development of the constitutive equations of Fluid Dynamics (Stokes' relations); The Navier-Stokes (N-S) Equations; Special forms of the N-S equations; Initial and Boundary conditions; Differential form of Thermal and Mechanical energy equations; Introduction to non-dimensionalization and scaling; Non-dimensional numbers of interest in incompressible flow; Classification of incompressible flow on the basis of Reynolds number.

Laminar Flow: Creeping flow (Stokes' solution for flow past a sphere, Hele-Shaw flow); Exact solutions to the incompressible N-S equations (e.g., Couette and Poiseuille flows, Flow between rotating cylinders, Stokes' First and Second problems, Stagnation point flow, Flow over a porous walls, etc.).

Potential Flow: High Reynolds number approximation - inviscid flow; Circulation and Vorticity; Kelvin's theorem; Irrotationality; Simple Potential Flows; Superposition; Technique of images; Introduction to use of complex variables for plane Potential Flows; Introduction to lifting surfaces **Vortex Dynamics:** Helmholtz theorems; Vorticity transport equation; Potential and Rankine vortex; Interaction of vortices.

Laminar Boundary Layers: Concept of a boundary layer in High Reynolds number flow; Scale analysis and development of Prandtl's boundary layer equations; Blasius' solution to flat plate; Boundary layer with pressure gradient (Falkner-Skan solutions); von-Karman-Pohlhausen integral analysis method; Boundary layer separation and control.

Introduction to Turbulent Flow: Introduction to instability and transition; Origin of turbulence - role of vorticity and viscosity; Statistical description; Reynolds' averaging of N-S equations; Reynolds' stresses; Kinetic energy budget in turbulent flow; Wall turbulence: eddy diffusivity, Prandtl's mixing length hypothesis, von-Karman's similarity hypothesis; Universal velocity profile.

Introduction to Compressible Flow: A brief review of concepts from Thermodynamics; Acoustic waves; Normal shock waves; Basic one-dimensional compressible flow in a duct with varying cross-sectional area; One-dimensional compressible flow with friction and heat transfer.

Section-II

Unit-3 Uncertainty Analysis in Experiments & Finite Element Techniques (6)

Uncertainty Analysis in Experiments (03)

Errors in instruments, Analysis of experimental data and determination of overall uncertainties in experimental investigation, Uncertainties in measurement of parameters like pressure, temperature, flow etc. under various conditions. Estimation of uncertainty by Partial Differentiation Method (PDM), Combining uncertainty components. Student's t-test method.

Finite Element Techniques (03)

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Unit-4 Advanced Heat Transfer (24 Hr)

Convective Heat Transfer:

Fully developed flows, exact and similarity solutions, boiling and condensation, special topics Turbulence, Governing equations, Free shear flows, Near wall behavior, Energy spectrum, Turbulence models Boiling and condensation: Bubble dynamics, boiling and condensation enhancement techniques, recent advances in heat pipes.

Conduction and radiation:

Transient heat conduction, Micro scale heat transfer, Radiation shape factor, Radiation from luminous fuel, oil, gas and flames, Radiation network, Radiation from gases and vapors

Advanced Trends in Heat Exchanger:

Heat Exchanger design theory, recent trends in heat exchangers, advanced material in HE, Electronic cooling, Nanomaterial, micro channel heat exchangers.

Advanced Topics in I C Engines: Engine Emissions & Control, Engine Electronics, Modeling Real Engine Flow and Combustion Process, Fuel/Air Mixture Requirements, Premixed and Diffusion flames

Advanced Topics in Refrigeration and Cryogenics

Refrigeration applications in preservation of Food, transport by trucks and containers; Railway cars; Marine Refrigeration; Fans and Blowers, Sound Control. Construction of psychrometric charts, enthalpy deviation curves, advances in cryogenics, absorption system.

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1. S. S. Rao, Engineering Optimization Theory and Practice, New Age International.
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8. J. N. Reddy, An Introduction to the Finite Element Method, McGraw Hill
9. S.S. Rao, The Finite Element Method in Engineering, Pergamon Press
10. W.M Kays and M.E. Crawford, "Convective Heat and Mass Transfer", McGraw Hill Intl. 2. T Cebeci, "Convective Heat Transfer", Springer
11. T Cebeci, "Convective Heat Transfer", Springer
12. Heat And Mass Transfer- Millls, Ganesan
13. P.K.Nag, Heat and Mass Transfer
14. R.K Shah, Heat Exchanger Design methodology
15. Kays and London, Compact Heat Exchanger
16. Sadic and Kakac, Heat Exchanger Design
17. Holand and Frass, Process heat transfer
18. D.Q. Kern, Process Heat Trasnfer
19. ASHRAE HANDBOOKS (i) Fundamentals (ii) Refrigeration
20. Threlkeld J.L., "Thermal Environmental Engineering", Prentice Hall
21. Dossat R.J., Principles of Refrigeration, Pearson Education Asia
22. Handbook of air-conditioning system design, Carrier Incorporation, McGraw Hill Book Co., U.S.A.
23. Hainer R.W. 'Control Systems for Heating, Ventilation and Air – Conditioning', Van Nastrand Reinhold Co., New York, 1984.
24. K V Wong, Thermodynamics for Engineers, First Indian Edition, 2010, CRC Press.
25. Frank P Incropera & David P De witt, Fundamentals of Heat & Mass Transfer, Fifth Edition, John Wiley & Sons
26. Barron, R., Cryogenic Systems, McGraw-Hill, 1966.
27. Timmerhaus, K. D. and Flynn, T. M., Cryogenic Process Engineering, Plenum Press, 1989.
28. Scott, R. B., Cryogenic Engineering, D'Van-Nostrand, 1962.
29. Vance, R. W. and Duke, W. M., Applied Cryogenic Engineering, John Wiley, 1962.
30. Sitting, M. Cryogenic, D' Van-Nostrand, 1963.