UNIVERSITY OF PUNE, PUNE

Structure and Syllabus

FOR

M. E. (Mechanical) (Design Engineering)
2013-Course

UNDER FACULTY OF ENGINEERING

EFFECTIVE FROM JULY 2013

M.E. Mechanical Engineering (Design Engineering) - 2013 Course

SEMESTER I

CODE	SUBJECT	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
		Lect./ Pr	Paper		TW	Oral/ Presentation	Total	
			In Semester Assessment	End Semester Assessment				
507201	Advanced Mathematics	4	50	50	-	-	100	4
502202	Material Science and Mechanical Behavior of Materials	4	50	50	-	-	100	4
502203	Advanced Stress Analysis	4	50	50	-	-	100	4
502204	Research Methodology	4	50	50	-	-	100	4
502205	Elective I**	5	50	50	-	-	100	5
502206	Lab Practice I	4			50	50	100	4
Total		25	250	250	50	50	600	25

SEMESTER II

CODE	SUBJECT	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
		Lect./ Pr	Paper		TW	Oral/ Presentation	Total	
			In Semester Assessment	End Semester Assessment				
502207	Analysis and Synthesis of Mechanisms	4	50	50	-	-	100	4
502208	Advanced Mechanical Vibrations	4	50	50	-	-	100	4
502209	Finite Element Method	4	50	50	-	-	100	4
502210	Elective II	5	50	50	-	-	100	5
502211	Lab Practice II	4	-	-	50	50	100	4
502212	Seminar I	4	-	-	50	50	100	4
Total		25	200	200	100	100	600	25

Note:
Elective I: Common to All M.E. Mechanical Programmes**

SEMESTER III

CODE	SUBJECT	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
		Lect./ Pr	Paper		TW	Oral/ Presentation	Total	
			In Semester Assessment	End Semester Assessment				
602213	Optimization Techniques	4	50	50	-	-	100	4
602214	Mechanical Measurements and Controls	4	50	50	-	-	100	4
602215	Elective III	5	50	50	-	-	100	5
602216	Seminar II	4	-	-	50	50	100	4
602217	Project Stage I	08	-	-	50	50	100	8
Total		25	150	150	100	100	500	25

SEMESTER IV

CODE	SUBJECT	TEACHING SCHEME	EXAMINATION SCHEME				CREDITS
		Lect./ Pr	Paper	TW	Oral/ presentation	Total	
602218	Seminar III	5	-	50	50	100	5
602219	Project Work Stage II	20	-	150	50	200	20
Total		25	-	200	100	300	25

Lab Practice I & II:
The laboratory work will be based on completion of assignments confined to the courses of that semester.

SEMINAR:
The student shall deliver the seminar on a topic approved by authorities.

Seminar I : shall be on state of the art topic of student's own choice approved by authority. The student shall submit the seminar report in standard format, duly certified for satisfactory completion of the work by the concerned Guide and head of the department/institute.

Seminar II : shall be on the topic relevant to latest trends in the field of concerned branch, preferably on the topic of specialization based on the electives selected by him/her approved by authority. The student shall submit the seminar report in standard format, duly certified for satisfactory completion of the work by the concerned Guide and head of the department/institute.

Seminar III: shall be extension of **seminar II.** The student shall submit the seminar report in standard format, duly certified for satisfactory completion of the work by the concerned Guide and head of the department/institute.

PROJECT WORK:
The project work shall be based on the knowledge acquired by the student during the coursework and preferably it should meet and contribute towards the needs of the society. The project aims to provide an opportunity of designing and building complete system or subsystems based on area where the student likes to acquire specialized skills.

Project Work Stage – I
Project work Stage – I is the integral part of the project Work. In this, the student shall complete the partial work of the Project that will consist of problem statement, literature review, project overview, scheme of implementation (UML/ERD/block diagram/ PERT chart, etc.) and Layout & Design of the Set-up. The candidate shall deliver a presentation as a part of the progress report of Project work Stage-I, on the advancement in Technology pertaining to the selected dissertation topic.
The student shall submit the progress report of Project Work Stage-I in standard format duly certified for satisfactory completion of the work by the concerned guide and head of the department/Institute.

Project Work Stage - II
In Project Work Stage – II, the student shall complete the balance part of the Project that will consist of fabrication of set up required for the project, conducting experiments and taking results, analysis & validation of results and conclusions.

The student shall prepare the final report of Project work in standard format duly certified for satisfactory completion of the work by the concerned guide and head of the department/Institute.

Note: Institute must submit the list of candidates, guide and project details (title, area, problem definition, and abstract - clearly indicating objectives and scope, sponsorship details, if any) to the university within month of commencement of third semester. The guide must be approved/qualified teacher of the institute. A guide can guide at the most 8 students per year.

Semester - I
Advanced Mathematics [507201]

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		In Semester Assessment	End Semester Assessment				
507201	4	50	50	-	-	100	4

1. Inner Product Spaces, Orthogonality

Inner products, Cauchy-Schwartz inequality, Orthogonal projections, Gram-Schmidt orthogonalization, Matrix representation of inner product, Least square solutions

2. Complex Analysis

Complex variables, Complex differentiation, Harmonic functions, conformal mapping, Complex integration, Cauchy's integral formulae and Calculus of residues

3. Transforms

Concept of transforms, Fourier transforms, Applications to partial differential equations, Discrete Fourier transform, Laplace transforms and its inverse, Laplace transform of special functions: Unit step, Unit impulse, Periodic and Error. Applications to initial value problem and wave equation using transform techniques.

4. Differential Equation

Series Solution of differential equations, Bessel's and Legendre's differential equations, Mass spring systems of multi degree freedom, Matrix formulation for differential equations in vibration theory, Normal mode solution, Numerical computation of Eigen value.

5. Numerical Analysis

Finite difference analysis, Explicit and Implicit finite difference scheme, Stability of finite difference method, Applications of finite difference analysis in boundary value problems, one dimensional diffusion equation, Wave equation, Laplace equation.

6. Calculus of Variation

Introduction, Functional, Euler's equation, Isoperimetric Problem, Functional involving higher order derivative, Approximate solution of boundary value problem, Rayleigh –Ritz method , Galerkin's method, Lagrange's principal.

References –

1. Advanced Engineering Mathematics, Erwin Kreyszig, Wiley India
2. Higher Engineering Mathematics, B. S. Grewal, Khanna Publishers Delhi
3. Linear Algebra, Jin Ho Kwak and Sungpyo Hong, Springer international edition
4. Mechanical Vibration, Singiresu S. Rao, Pearson Education, Inc
5. Applied Numerical Analysis, Curtis F.Gerald and Patrick O. Wheatley, Pearson Education, Inc
6. Essential Mathematical Methods for Physicists, Hans J. Weber and G. B. Arfken, Academic Press

Semester - I
Material Science and Mechanical Behavior of Materials [502202]

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		In Semester Assessment	End Semester Assessment				
502202	4	50	50	-	-	100	4

1. Structures of Metals and Ceramics
Atomic structure and inter-atomic bonding, structures of metals and ceramics, crystal structures, crystallographic directions and planes, crystalline and non-crystalline materials, polymer structure, Imperfections in solids, point defects, linear defects, interfacial defects, volume defects, diffusion mechanisms, diffusion in ionic and polymeric materials

2. Response of metals and alloys to applied load
Stress, strain, transformations, Mohr's circle, isotropic elasticity, anisotropic elasticity, anisotropic thermal expansion, octahedral shear stress, yield criteria, yield surface, yield curve

3. Material Testing under Complex Loading
Tensile testing – uni-axial and biaxial tension test, full range stress-strain curves, true stress-strain curve, Bridgman correction, temperature rise, Bauschinger effect, torsion test, bend test, elastic recovery

4. Plastic Behavior
Experimental studies of plastic deformations under simple and complex loading, strain hardening, power law approximations, isotropic, kinematic and combined hardening models, theory of plastic flow, strain-rate and temperature dependence of flow stress, deformation theory of plasticity, thermo-plasticity, behavior of metals with initial deformations

5. Elastic-Plastic Equilibrium
Equations of Elastic-Plastic Equilibrium, residual stresses and strains, plastic-rigid body, elastic-plastic bending and torsion, elastic-plastic bodies under variable loading, shakedown theorems

6. Elasto-Visco-Plasticity
Visco-elasticity, rheological models, Maxwell model, Voigt model, Voigt–Maxwell model, damping, natural decay, dependence of damping and elastic modulus on frequency, thermo-elastic effect, low temperature and high temperature visco-plastic deformation models, rubber elasticity, damping, yielding, effect of strain rate, crazing

References –

1. Fundamentals of Materials Science and Engineering, William D. Callister, Jr., John Wiley & Sons, Inc.
2. Mechanical Metallurgy, George E. Dieter, McGraw Hill Book Company, 1988
3. Theory of Plasticity, J. Chakrabarty, Elsevier, 2006
4. Foundations of Theory of Plasticity, L.M. Kachanov, Dover Publications, 2004
5. Mechanical Behaviour of Materials, Dominique Francois, Andre Pineau, Andre Zaoui, Springer, 2012
6. Mechanical Behaviour of Materials, W. F. Hosford, Cambridge University Press, 2005

Semester - I
Advanced Stress Analysis [502203]

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		In Semester Assessment	End Semester Assessment				
502203	4	50	50	-	-	100	4

1. Theory of Elasticity
Elasticity problems in two dimensions - stress strain relationship for brittle materials, ductile materials. Compatibility equations in two and three dimensions, free body diagram of complicated structures and stress calculations, stress functions in rectangular and cylindrical coordinate systems, evaluation of stresses in flat rectangular plates with different clamp and load conditions evaluation of the stresses in the flat and circular plate with center hole/holes using stress function

2. Theory of Plasticity
Different criterions for three dimensional stress analysis using plasticity, evaluation of stress concentration factors in different geometries using plasticity theorem, practical problems on stress analysis for plasticity-stress in the sharp groove of the shaft, stress in the L shaped bracket under cantilever load, strain rate effects on highly deformable materials and stress calculations.

3. Stress Analysis of Engineering Plastics and Composites
Types of engineering plastics (Nylon, ABS, PP) failure modes, failure phenomenon in two and three dimensional stress analysis, wear and tear of plastics, impact properties of plastics, types of composites (fiber reinforced plastics), evaluation of elastic properties of composites, stress analysis of composite circular tubes (internal and external pressure), flat plate fixed at the edges and concentrated load, uniformly distributed load

4. Plate bending
Bending of plate to cylindrical surface, bending of a long uniformly loaded rectangular plate, pure bending in two perpendicular directions, bending of circular plates loaded symmetrically w.r.t. center, bending of circular plates of variable thickness, circular plate with circular hole at center symmetrically loaded and load distributed along inner and outer edges

5. Contact stresses
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, gear contacts, contacts between cam and follower, ball bearing contacts

6. Experimental stress analysis
Dimensional analysis, analysis techniques, strain gauges, types of strain gauges, materials, configuration, instrumentation, characteristics of strain gauge measurement, theory of photoelasticity, elements of polariscope, simple and circular polariscope, fringes in dark and white field, isoclinic and isochromatic fringe patterns, evaluation of stresses from these fringe patterns

References
1. Advanced Mechanics of Materials – Cook and Young, Prentice Hall
2. Advanced Strength and Applied Stress Analysis – Richard G. Budynas, McGraw Hill
3. Advanced Mechanics of Materials – Boresi, Schmidt, Sidebottom, Willey
4. Theory of Elasticity – Timoshenko and Goodier, Mc Graw Hill
5. Advanced Strength of Materials, Vol. 1, 2 – Timoshenko, CBS
6. Advanced Strength of Materials – Den Harteg
7. Experimental Stress Analysis – Dally & Riley
8. Theory of Plates and Shells – Timoshenko Mc Graw Hill
9. The Mathematical Theory of Plasticity - R. Hill, Oxford University Press, 1998

Semester – I
Research Methodology [502204]

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		In Semester Assessment	End Semester Assessment				
502204	4	50	50	-	-	100	4

1. Research Problem
Meaning of research problem, Sources of research problem, Criteria / Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem

2. Basic instrumentation
Instrumentation schemes, Static and dynamic characteristics of instruments used in experimental set up, Performance under flow or motion conditions, Data collection using a digital computer system, Linear scaling for receiver and fidelity of instrument, Role of DSP is collected data contains noise.

3. Applied statistics
Regression analysis, Parameter estimation, Multivariate statistics, Principal component analysis, Moments and response curve methods, State vector machines and uncertainty analysis, Probable errors in the research, Error analysis

4. Modelling and prediction of performance
Setting up a computing model to predict performance of experimental system, Multi-scale modelling and verifying performance of process system, Nonlinear analysis of system and asymptotic analysis, Verifying if assumptions hold true for a given apparatus setup, Plotting family of performance curves to study trends and tendencies, Sensitivity theory and applications.

5. Developing a Research Proposal
Format of research proposal, Individual research proposal, Institutional proposal, Proposal of a student – a presentation and assessment by a review committee consisting of Guide and external expert only, Other faculty members may attend and give suggestions relevant to topic of research.

In semester assessment is to be carried out by two internal tests and five assignments one on each unit.

Reference Books:
1. 'Research methodology: an introduction for science & engineering students', by Stuart Melville and Wayne Goddard
2. 'Research Methodology: An Introduction' by Wayne Goddard and Stuart Melville
3. 'Research Methodology: A Step by Step Guide for Beginners', by Ranjit Kumar, 2nd Edition
4. 'Research Methodology: Methods and Trends', by Dr. C. R. Kothari
5. 'Operational Research' by Dr. S.D. Sharma, Kedar Nath Ram Nath & co.
6. Software Engineering by Pressman

Semester – I
Elective – I [502205]

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		In Semester Assessment	End Semester Assessment				
502205	5	50	50	-	-	100	5

Modules of 2 Credits (Select any Two)			
Code No.	**Title**	**Code No.**	**Title**
ME2I – M1	Energy Audit and Management	**ME2I – M6**	Operation Management
ME2I – M2	Financial Management	**ME2I – M7**	Engineering Economics
ME2I – M3	Financial Costing	**ME2I – M8**	Technology Forecasting
ME2I – M4	Project Management	**ME2I – M9**	Technology Transfer
ME2I – M5	Energy Efficient Technologies in Electrical Systems	**ME2I – M10**	Human Rights
Modules of 1 Credit (Select any One)			
Code No.	**Title**	**Code No.**	**Title**
ME1I – M11	Environmental Pollution and Control	**ME1I – M12**	Intellectual property Rights

Note: For e.g., ME2I-M1 indicates
ME – Common to all M.E. Mechanical Course, 2 – 2 Credits, I – Elective I, M1 – Module 1

ME2I – M1 Energy Audit and Management
Definition, Energy audit- need, Types of energy audit, Energy management (audit) approach-understanding energy costs, Bench marking, Energy performance, Matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution, Energy audit instruments
Ref. Books: Guide Books, Bureau of Energy Efficiency

ME2I – M2 Financial Management
Investment-need, Appraisal and criteria, Financial analysis techniques- Simple payback period, Return on investment, Net present value, Internal rate of return, Cash flows, Risk and sensitivity analysis, Financing options, Energy performance contracting and role of Energy Service Companies (ESCOS).
Ref. Books: Guide Books, Bureau of Energy Efficiency

ME2I – M3 Financial Costing
Significance, Traditional absorption costing, Marginal costing, Contract costing, Activity based costing, Process costing
Ref. Books: Cost Accounting, N K Prasad, Book Syndicate Pvt. Ltd.

ME2I – M4 Project Management
Definition and scope of project, Technical design, Financing, Contracting, Implementation and performance monitoring, Implementation plan for top management, Planning Budget, Procurement Procedures, Construction, Measurement and Verification
Ref. Books: Guide Books, Bureau of Energy Efficiency

ME2I – M5 Energy Efficient Technologies in Electrical Systems
Maximum demand controllers, Automatic power factor controllers, Energy efficient motors, Soft starters with energy saver, Variable speed drives, Energy efficient transformers, Electronic ballast, Occupancy sensors, Energy efficient lighting controls.
Ref. Books: Guide Books, Bureau of Energy Efficiency

ME2I – M6 Operation Management

Introduction, Importance, Operating systems models, key decisions, Planning and controlling, Strategic approach, Processes and systems, supply chain or network approach, Technology and knowledge management, Quality Management, Operations - Challenges, Opportunities, Excellence, risk management and sustainability, Case studies

Ref. Books:1) Operations Management - An Integrated Approach, Danny Samson and Prakash J. Singh, :Cambridge University Press, 2) Modern production/Operations Management, 8th Edition, E.S. Buffa and R. K. Sarin, John Wiley & Sons.

ME2I – M7 Engineering Economics

Fundamentals, Markets and Government in a Modern economy, Basic Elements of Supply and Demand, Demand and Consumer Behaviour, Analysis of Perfectly Competitive Markets, Unemployment, Inflation and Economic policy

Ref. Books: Economics, Samuelson Nordhaus, Tata McGraw Hill

ME2I – M8 Technology Forecasting

Approaches, Technology Performance Parameters, Use of Experts in Technology Forecasting, Planning, Technology Progress, Morphological Analysis of a Technology System.

Ref. Books: 1) Gerard H. Gaynor, Hand Book of Technology Management, Mc Graw Hill.

ME2I – M9 Technology Transfer

Definition, Source of Technology Transfer [TT], Model of TT with Public and Private Enterprises, Success and Failure Factors in Technology Transfer, The concepts of Invention and Innovation, Definition and classifications of Research and Development, New Product Development, Challenges in Commercializing Research Results.

Ref. Books: 1) Gerard H. Gaynor, Hand Book of Technology Management, Mc Graw Hill.

ME2I – M10 Human Rights

Human Rights – Concept, Development, Evolution, Philosophical, Sociological and Political debates, Benchmarks of Human Rights Movement. Human Rights and the Indian Constitution Human Rights & State Mechanisms, Police & Human Rights, Judiciary & Human Rights, Prisons & Human Rights, National and State Human Rights Commissions, Human Rights of the Different Sections and contemporary issues, Citizens' Role and Civil Society, Human Rights and the international scene Primary Information with reference to Engineering Industry

Ref. Books:1)Study material on UNESCO,UNICEF web site, 2)HUMAN RIGHTS IN INDIA A MAPPING,Usha Ramanathan, 3)Introduction to International Humanitarian Law by Curtis F. J. Doebbler - CD Publishing , 2005 .This book is an introductory text on international humanitarian law (the laws of war) that provides the basics of law, including excerpts from some of the leading treaty texts. Perfect for a short course in the law -- one to five weeks, 4) Freedom of Information by Toby Mendel - UNESCO , *2008*

ME1I – M8 Environmental and Pollution control

Pollution and Environmental Ethics, Air pollution, Water pollution, Soil pollution, Marine pollution, Noise pollution, Thermal pollution, Nuclear hazards Environmental impact and economic aspects, Emission standards and regulations for Automobiles.

Ref. Books: 1) Environmental Pollution and Control, J. Jeffrey Peirce, P Aarne Vesilind, Ruth Weiner, Butterworth-Heinemann, 2) Environmental Pollution Control Engineering, C.S. Rao, New Age International

ME1I – M12 Intellectual property Rights

Patentable and non-patentable inventions, statutory exceptions, Persons entitled to apply for patents.

Ref. Books: 1) Satyawrat Ponkshe, The Management of Intellectual Property, by, Ponkshe & Bhate Publications, Pune.

Semester - I
Lab Practice – I [502206]

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		In Semester Assessment	End Semester Assessment				
502206	4	-	-	50	50	100	4

Lab practice file shall consist of following assignments/experiments

1. Computer program to find Eigen values using numerical method
2. Computer program of Fourier and Laplace transform for an engineering application
3. Measurement of strain in cantilever beam using strain gauges
4. Contact stress analysis using FEM software
5. Elasto-plastic analysis of a tensile test specimen using FEM software
6. Determination of full range stress strain curve for mild steel and aluminium specimen as per ASTM -E8M
7. Assignment on instrumentation and data collection
8. Assignment on research proposal

Lab. work or Assignments have to be carried out at respective labs as mentioned in the syllabus of respective. It is to be submitted as term work at the end of semester after continuous assessment of each by respective teacher. Assessment of term work has to be carried out as per R-1.4 and R-1.5 of PG Rules and Regulations of Credit System.

Semester - II
Analysis and Synthesis of Mechanisms [502207]

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		In Semester Assessment	End Semester Assessment				
502207	4	50	50	-	-	100	4

1. Complex Mechanisms
Types of complex mechanisms, velocity-acceleration analysis of complex mechanisms by the normal acceleration and auxiliary point methods, Goodman's indirect acceleration analysis

2. Planar Mechanisms Dynamic Analysis
Inertia forces in linkages, principle of super position, analysis of elastic mechanisms, beam element, displacement fields for beam element, element mass and stiffness matrices, system matrices, elastic linkage model, equations of motion.

3. Curvature theory
Fixed and moving centrodes, inflection circle, Euler- Savy equation, Bobillier constructions, cubic of stationary curvature, Ball's point, applications in dwell mechanisms

4. Synthesis of Planar Mechanisms
Types, number and dimensional synthesis, function generation, path generation and rigid body guidance problems, accuracy (precision) points, Chebychev spacing, types of errors, graphical synthesis for function generation and rigid body guidance with two, three and four accuracy points using pole method, center point and circle point curves, Bermester points, synthesis for five accuracy points, branch and order defects, synthesis for path generation.

5. Analytical synthesis of Planar Mechanisms
Freudenstein's equation, synthesis for four accuracy points, compatibility condition, synthesis of four-bar for prescribed angular velocities and accelerations using complex numbers, complex numbers method of synthesis, the dyad, center point and circle point circles, ground pivot specifications, three accuracy point synthesis using dyad method, Robert Chebychev theorem, cognates

6. Kinematics of Spatial Mechanisms
Transformations describing planar finite displacements, planar finite transformations, identity transformation, rigid-body transformations, spatial transformations Denavit-Hartenberg parameters, matrix method of analysis of spatial mechanisms

References:
1. Theory of Machines and Mechanisms, A. Ghosh and A.K.Mallik, Affiliated East-West Press.
2. Kinematic Synthesis of Linkages, R. S. Hartenberg and J. Denavit, McGraw-Hill.
3. Mechanism Design - Analysis and Synthesis (Vol.1 and 2), A. G. Erdman and G. N. Sandor, Prentice Hall
4. Theory of Machines and Mechanisms, J. E. Shigley and J. J. Uicker, 2nd Ed. McGraw-Hill.
5. Design of Machinery: An Introduction to the Synthesis and Analysis of Mechanisms and Machines, Robert L. Norton, Tata McGraw-Hill, 3rd Edition.
6. Kinematics and Linkage Design, A. S. Hall, Prentice Hall of India.

Semester – II
Advanced Mechanical Vibrations [502208]

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		In Semester Assessment	End Semester Assessment				
502208	4	50	50	-	-	100	4

1. Multi Degree Freedom System
Free vibration equation of motion, influence coefficient i) stiffness coefficient (ii) flexibility coefficient generalized coordinates, coordinate couplings, Lagrange's equations matrix method Eigen values Eigen vector problems, modal analysis, forced vibrations of undamped system and modal analysis, numerical methods - (i) Rayleigh's Method, (ii) Rayleigh-Ritz Method (iii) Holzer's Method (iv) Methods of Matrix iterations (v) Transfer Matrix Method, impulse response and frequency response functions.

2. Continuous System
Vibrations of String, Bars, Shafts and beams, free and forced vibration of continuous systems

3. Transient vibrations
Response of a single degree of freedom system to step and any arbitrary excitation, convolution (Duhamel's) integral, impulse response functions

4. Vibration Control
Balancing of rotating machine, in-situ balancing of rotors, control of natural frequency introduction of damping, vibration isolation and vibration absorbers

5. Vibration Measurement
FFT analyzer, vibration exciters, signal analysis, time domain and frequency domain analysis of signals, experimental modal analysis, machine conditioning and monitoring, fault diagnosis

6. Random Vibrations
Auto and cross correlation function, spectral density, response of linear systems, and analysis of narrow band systems

References:

1. Theory of Vibrations with Applications, W. T. Thomson, CBS Publishers, Delhi

2. Mechanical Vibrations, S. S. Rao, Addison-Wesley Publishing Co

3. Fundamentals of Vibration, Leonard Meirovitch, McGraw Hill International Edison

4. Principles of Vibration Control: Ashok Kumar Mallik, Affiliated East-West Press

5. Mechanical Vibrations, A H Church, John Wiley & Sons Inc

6. Mechanical Vibrations, J P Den Hartog, McGraw Hill

7. Mechanical Vibration Analysis, Srinivasan, McGraw Hill

8. Mechanical Vibrations, G K Groover

Semester - II
Finite Element Method [502209]

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		In Semester Assessment	End Semester Assessment				
502209	4	50	50	-	-	100	4

1. Introduction – Finite element method, brief history, basic steps, advantages and disadvantages, weak formulation, variational methods of approximation – Rayleigh-Ritz methods, Methods of Weighted Residuals (Galerkin, Least-squares & Collocation methods), Variational formulation of 1D bar and beam elements (Euler Bernoulli and Timoshenko beam) – governing equation, domain discretization, elemental equations, assembly and element connectivity, application of boundary condition, solution of equations, postprocessing of the results.

2. Isoparametric Elements and Formulation of Plane Elasticity Problems
Introduction, shape functions – linear & quadratic, displacement function – criteria for the choice of the displacement function, polynomial displacement functions, displacement function in terms of nodal parameters, strain-nodal parameter relationship, stress-strain relationship, element stiffness matrix, convergence of isoparametric elements, numerical integration – Trapezoidal rule, Simpson's 1/3 rule, Newton-Cotes Formula, Gauss Quadrature formula, Gauss Quadrature in two and three dimensions

3. Plate Bending Problems – Plate and Shell Elements
Introduction, thin and thick plates – Kirchoff theory, Mindlin plate element, triangular and rectangular, conforming and nonconforming elements, degenerated shell elements, reduced and selective integration, shear locking and hour glass phenomenon

4. Nonlinear Problems – Geometric, Material and Contact Problems
Introduction to non-linear analysis, formulation for geometrical, material and contact nonlinear problems, Nonlinear equation solving procedure - direct iteration, Newton-Raphson method, modified Newton-Raphson method, incremental techniques

5. Dynamic Problems – Eigen value and Time Dependent Problems
Formulation of dynamic problems, consistent and lumped mass matrices
Solution of eigenvalue problems – transformation methods, Jacobi method, Vector Iteration methods, subspace iteration method
Forced vibration – steady state and transient vibration analysis, modeling of damping, the mode superposition scheme, direct integration methods – implicit and explicit numerical integration

6. Special Topics
Linear buckling analysis, adaptive finite element technique, error estimation, h & p refinements, symmetry – mirror/plane, axial, cyclic & repetitive, submodelling and substructuing

References

1. Seshu P., "Text book of Finite Element Analysis", PHI Learning Private Ltd., New Delhi, 2010.
2. Mukhopadhyay M and Sheikh A. H., "Matrix and Finite Element Analyses of Structures", Ane Books Pvt. Ltd., 2009.
3. Bathe K. J., "Finite Element Procedures", Prentice-Hall of India (P) Ltd., New Delhi.
4. Cook R. D., "Finite Element Modeling for Stress Analysis", John Wiley and Sons Inc, 1995
5. Chandrupatla T. R. and Belegunda A. D., "Introduction to Finite Elements in Engineering", Prentice Hall India.
6. Liu G. R. and Quek S. S. "The Finite Element Method – A Practical Course", Butterworth-Heinemann, 2003.
7. Reddy, J. N., "An Introduction to The Finite Element Method", Tata McGraw Hill, 2003.

Semester – II
Elective II [502210]

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		In Semester Assessment	End Semester Assessment				
502210	5	50	50	-	-	100	5

Modules of 2 Credits (Select any Two)			
Code No.	**Title**	**Code No.**	**Title**
DE2II-M1	Vehicle Dynamics – I	**DE2II-M5**	Mechanics of Composites
DE2II-M2	Vehicle Dynamics – II	**DE2II-M6**	Design of Composite Structure
DE2II-M3	Design of Material Handling Equipment – I	**DE2II-M7**	Acoustics and Noise Control - I
DE2II-M4	Design of Material Handling Equipment – II	**DE2II-M8**	Acoustics and Noise Control – II
Modules of 1 Credit (Select any One)			
Code No.	**Title**	**Code No.**	**Title**
DE1II-M9	Design of Piping System	**DE1II-M11**	Dynamics of Structures
DE1II-M10	Process Equipment Design	**DE1II-M12**	Robotics

Note: For e.g., DE2II-M1 indicates
DE – Design Engineering, 2 – 2 Credits, II – Elective II, M1 – Module 1
For e.g., DE1II-M12 indicates
DE – Design Engineering, 1 – 1 Credit, II – Elective II, M12 – Module 12

DE2II-M1 Vehicle Dynamics - I

Tire Characteristics - Tire – types, axis system, mechanics of pneumatic tires - tire forces and moments, rolling resistance of tires, tractive (braking) effort and longitudinal slip (skid), cornering properties of tires, slip angle and cornering force, slip angle and aligning torque, camber and camber thrust, characterization of cornering behaviour of tires, performance of tires on wet surfaces, ride properties of tires

Performance characteristics of road vehicles - Equation of motion and maximum tractive effort, aerodynamic forces and moments, vehicle power plant and transmission characteristics, acceleration time and distance, gradability, engine and transmission matching, Electronic Stability Control (ESC), Braking characteristics of a two-axle vehicle, braking efficiency and stopping distance, antilock brake systems, traction control systems, Electronic Brakeforce Distribution (EBD), Electronic Brake assist System (EBS)

Suspension Kinematics - Terminology, definitions – reference frame, toe-in, toe-out, wheel camber, caster and kingpin angle, steering offset, types of dependent and independent suspensions, equivalent mechanisms (front view / side view), anti-dive and squat geometry, roll center analysis, steering geometry, error, steering force and moments

Ref. Books: 1) Road Vehicle Dynamics – Problems & Solutions, Rao & Dukkipati, SAE, 2) Theory of Ground Vehicles, J.Y. Wong, John Wiley & Sons, 3) Fundamentals of Vehicle Dynamics, T.D. Gillespie, SAE

DE2II-M2 Vehicle Dynamics - II

Handling characteristics of vehicle - Steady-state handling characteristics of a two-axle vehicle, steady-state response to steering input, testing of handling characteristics, transient response characteristics, directional stability, steering of tracked vehicles

Vehicle ride characteristics - Calculation of spectral densities, RMS values, relation to ride comfort, vehicle ride models - two-degree-of-freedom vehicle model for sprung and un-sprung mass, numerical methods for determining the response of a quarter-car model to irregular surface profile excitation, two-degree-of-freedom vehicle model for pitch and bounce, active and semi-active suspension

Road and Suspension modeling - Road – modeling aspects, deterministic profile, random profile, auto-correlation function, spectral density, relation between input and output spectral densities, effect of wheelbase, modeling of springs, anti-roll bars, torsion bar, air springs, dampers, bump stop

Ref. Books: 1) Road Vehicle Dynamics – Problems & Solutions, Rao & Dukkipati, SAE, 2) Theory of Ground Vehicles, J.Y. Wong, John Wiley & Sons, 3) Fundamentals of Vehicle Dynamics, T.D. Gillespie, SAE

DE2II-M3 Design of Material Handling Equipment - I

Material handling system - principles and features of material handling system, importance, terminology, objectives and benefits of better material handling, classification of material handling equipment

Selection of material handling equipment - choice of material handling equipment, factors affecting for selection, general analysis procedures, basic analytical techniques, the unit load concept

Design of cranes - hand-propelled and traveling mechanisms of cantilever and monorail cranes, design considerations for structures of rotary cranes with fixed radius, fixed post and overhead traveling cranes, stability of stationary rotary and traveling rotary cranes, electric overhead travelling crane - essential parts, design parameters, structural considerations, end carriages, long and cross travel mechanisms, brakes, motor selection, safety arrangements, electrical control system

Ref. Books 1) N. Rudenko, 'Material Handling Equipment', Peace Publishers 2) James M. Apple, 'Material Handling System Design', John-Wiley and Sons 3) John R. Immer, 'Material Handling' McGraw Hill 4) Colin Hardi, 'Material Handling in Machine Shops'. Machinery Publication Co. Ltd., 5) M .P. Nexandrn, 'Material Handling Equipment', MIR Publication, 6) C. R. Cock and J. Mason, 'Bulk Solid Handling', Leonard Hill Publication Co. Ltd., 7) Spivakovsy, A.O. and Dyachkov, V.K., 'Conveying Machines', Volumes I and II, MIR Publishers, 8) Kulwiac R. A., 'Material Handling Hand Book', John Wiley Publication

DE2II-M4 Design of Material Handling Equipment - II

Load lifting attachments - load chains and types of ropes used in material handling system, forged, standard and Ramshorn hooks, crane grabs and clamps; grab buckets; electromagnet; design consideration for conveyor belts; drums, sheaves, sprockets

Study of bulk material handling systems - objectives of storage; bulk material handling; gravity flow of solids through slides and chutes; storage in bins and hoppers; screw conveyor, vibratory conveyor, pneumatic & hydraulic conveyor (classification, types, principles of operation)

Automation in material handling - control of hoisting & conveying machinery, material handling in direct-line production and automated lines, safety and design; safety regulations and discipline

Ref. Books 1) N. Rudenko, 'Material Handling Equipment', Peace Publishers 2) James M. Apple, 'Material Handling System Design', John-Wiley and Sons 3) John R. Immer, 'Material Handling' McGraw Hill 4) Colin Hardi, 'Material Handling in Machine Shops'. Machinery Publication Co. Ltd., 5) M .P. Nexandrn, 'Material Handling Equipment', MIR Publication, 6) C. R. Cock and J. Mason, 'Bulk Solid Handling', Leonard Hill Publication Co. Ltd., 7) Spivakovsy, A.O. and Dyachkov, V.K., 'Conveying Machines', Volumes I and II, MIR Publishers, 8) Kulwiac R. A., 'Material Handling Hand Book', John Wiley Publication

DE2II-M5 Mechanics of Composites

Introduction to Composite Materials - Introduction, types – fibrous, laminate, particulate, combination, polymer matrix composites, metal matrix composites, mechanical behaviour of composite material, applications – military, civil, space and automotive.

Mechanical Behaviour of Lamina - Anisotropy, orthotropy, stiffness, engineering constants, uniaxial and biaxial strength of lamina, failure theories – maximum stress, maximum strain, Tsai-Hill, Hoffman, Tsai-Wu, computational procedure, applicability, mechanics approach to stiffness and strength

Mechanical Behaviour of Laminate - Classical laminate theory, stress-strain variation in laminate, resultant laminate forces and moments, laminate configurations, laminate stiffness, strength of laminates, interlaminar stresses

Ref. Books 1) Mechanics of Composite Materials, Robert M. Jones, Taylor & Francis 2) Engineering Mechanics of Composite Materials, Isaac M. Daniel and Ori Ishai, Oxford University Press 3) Mechanics of Composite Materials, Autar K. Kaw, CRC Press 4) Mechanics and Analysis of Composite Materials, Valery V. Vasiliev and Evgeny V. Morozov, Elsevier

DE2II-M6 Design of Composite Structure

Bending, Buckling and Vibration of Laminated Plates - Governing equations, simply supported laminated plates – deflection under distributed transverse load, buckling under in-plane load, vibration

Testing of Composite Materials - Characterization of constituent materials, physical characterization of composite material, determination of tensile, compressive and shear properties, determination of inter-laminar fracture toughness, bi-axial testing, characterization of composites with stress concentration

Design of Composite Structures - Structural design procedure, configuration selection, joints, design requirements, failure criteria, design analysis, optimization

Ref. Books 1) Mechanics of Composite Materials, Robert M. Jones, Taylor & Francis 2) Engineering Mechanics of Composite Materials, Isaac M. Daniel and Ori Ishai, Oxford University Press 3) Mechanics of Composite Materials, Autar K. Kaw, CRC Press 4) Mechanics and Analysis of Composite Materials, Valery V. Vasiliev and Evgeny V. Morozov, Elsevier

DE2II-M7 Acoustics and Noise Control - I

Basics of acoustics - speed of sound, wavelength, frequency, and wave number, acoustic pressure and particle velocity, acoustic intensity and acoustic energy density, spherical wave, directivity factor and directivity index, levels and the decibel, combination of sound sources, octave bands, weighted sound levels. A**coustic measurement -** sound level meters, intensity level meters, octave band filters, acoustic analysers, dosimeter, measurement of sound power, sound power measurement in a reverberant room, sound power measurement in an anechoic, sound power survey measurements, measurement of the directivity factor, noise measurement procedures

Transmission of sound - the wave equation, complex number notation, wave equation solution, solution for spherical waves, changes in media with normal incidence, changes in media with oblique incidence, sound transmission through a wall, transmission loss for walls - stiffness-controlled region- mass-controlled region - damping-controlled region, method for estimating the transmission loss, transmission loss for composite walls, sound transmission class, absorption of sound, attenuation coefficient

Acoustic criteria - the human ear, hearing loss, industrial noise criteria, speech interference level, noise criteria for interior spaces

Ref. Books: 1) Vibration and Noise for Engineers, Kewal Pujara, Dhanpat Rai and Co. 2) Industrial Noise Control Fundamentals and applications, Lewis H. Bell, Douglas H. Bell, Marcel Dekker, Inc. 3) Fundamentals of Noise & Vibration analysis for Engineers: M. P. Norton, D. G. Karczub, Cambridge University Press 4) Engineering Noise Control, Bies D. A. and Hansen C. H, Spon 5) Fundamentals of Acoustics, Kinsler L. E. et al , Wiley Mechanical Vibrations, S. S. Rao, Addison-Wesley Publishing Co.

DE2II-M8 Acoustics and Noise Control - II

Room acoustics - surface absorption coefficients, steady-state sound level in a room, reverberation time, effect of energy absorption in the air, noise from an adjacent room, acoustic enclosures, acoustic barriers

Noise control - noise sources, vibration isolation for noise control- un-damped single-degree-of-freedom (sdof) system - damped single-degree-of-freedom (sdof) system, damping factors, forced vibration, mechanical impedance and mobility, transmissibility, rotating unbalance, displacement excitation, dynamic vibration isolator, vibration isolation materials.

Silencer design - silencer design requirements, lumped parameter analysis, Helmholtz resonator, side branch mufflers, expansion chamber mufflers, dissipative mufflers, evaluation of the attenuation coefficient, commercial silencers

Ref. Books: 1) Vibration and Noise for Engineers, Kewal Pujara, Dhanpat Rai and Co. 2) Industrial Noise Control Fundamentals and applications, Lewis H. Bell, Douglas H. Bell, Marcel Dekker, Inc. 3) Fundamentals of Noise & Vibration analysis for Engineers: M. P. Norton, D. G. Karczub, Cambridge University Press 4) Engineering Noise Control, Bies D. A. and Hansen C. H, Spon 5) Fundamentals of Acoustics, Kinsler L. E. et al , Wiley Mechanical Vibrations, S. S. Rao, Addison-Wesley Publishing Co.

DE1II-M9 Design of Piping System

Piping design and procedure for process plant, design of piping support, valves and fittings, standards, stress analysis, operation and maintenance aspects in piping design, safety consideration, use of computer software for piping design

Ref. Books: 1) Design of Piping Systems, M. W. Kellogg Company 2) Pipe Stress Engineering, Liang-Chuan Peng and Tsen-Loong Peng, ASME Press 3) Introduction to Pipe Stress Analysis, Sam Kannappan , ABI Enterprise

DE1II-M10 Process Equipment Design

Basic concepts in process design, block diagrams for flow of processes, material flow balance, design pressures and temperatures, design stresses, factory of safety, minimum shell thickness and corrosion allowance, weld joint efficiency, design loading, stress concentration and thermal stresses, failure criteria, optimization technique such as Lagrange's multiplier and golden section method, cost and profitability estimation, introduction to design codes like IS-2825, ASME-SECT, EIGHT-DIV-II TEMA.API-650, BS-1500 & 1515

Ref. Books: 1) Process Equipment Design, Lloyd E. Brownell and Edwin H. Young, Wiley-Interscience 2) Process Equipment Design, M.V. Joshi, Mc-Millan

DE1II-M11 Dynamics of Structures

Single degree of freedom system, multi degree of freedom system, numerical evaluation of dynamic response – linear and nonlinear, time stepping methods, methods based on interpolation of excitation, central difference method, Newmark's method, stability and computational error, free vibration, modal analysis, modal response contribution

Ref. Books: 1) Mechanical Vibrations and Structural Dynamics - Analytical, Numerical and Experimental Methods, Waller, Heinz, Lenzen, Amin, Springer 2) Mechanical Vibrations: Theory and Applications to Structural Dynamics, M. Géradin, Wiley

DE1II-M12 Robotics

Manipulator Kinematics

Matrix algebra, inverse of matrices, rotational groups, matrix representations of coordinate, transformation, transformation about reference frame and moving frame, forward and inverse kinematics

Robotics Dynamics

Velocity kinematics, acceleration of rigid body, mass distribution Newton's equation, Euler's equation, iterative newton – Euler's dynamic formulation, closed dynamic, Lagrangian formulation of manipulator dynamics, dynamic simulation, and computational consideration

Trajectory planning

Introduction, general considerations in path description and generation, joint space schemes, cartesian space schemes, path generation in runtime, planning path using dynamic model, point to point and continuous trajectory

Ref. Book: 1) Robotics Technology and Flexible Automation, S. R. Deb, Tata McGraw Hill 2) Industrial Robotics (Technology ,Programming and application s), M. P. Groover, M. Weiss R.N. Nagel, N.G. Odrey, McGraw, Hill 3)Robotics : Control , sensors vision and in intelligence, K. S. Fu, R. C. Gonzalez and C. S. G. Lee, McGraw-Hill.

Semester – II
Lab Practice – II [502211]

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		In Semester Assessment	End Semester Assessment				
502211	4	-	-	50	50	100	4

Lab practice file shall consist of following assignments/experiments

1. Analysis of inertia forces in slider crank mechanism using computer software
2. Coupler curve synthesis for a mechanism using computer software
3. Determination of natural frequencies & modal analysis of a machine component using FFT Analyzer
4. Stress and deflection analysis of short and long beams with different end conditions and cross-sections subjected to different loading conditions (i.e., point load – force & moment, distributed load etc) using FEA software
5. Stress and deflection analysis of thin and thick rectangular and circular plates/shells with different end conditions subjected to different loading conditions (i.e., point load – force & moment, distributed load etc) using FEA software
6. Stress analysis of rotating disc (solid and hollow discs) using FEA software
7. Buckling mode analysis of a thin shell cylinder using FEA software
8. Direct/Modal frequency response analysis of a beam/plate under a single-point cyclic load/base excitation with and without damping using FEA software

Lab. work or Assignments have to be carried out at respective labs as mentioned in the syllabus of respective. It is to be submitted as term work at the end of semester after continuous assessment of each by respective teacher. Assessment of term work has to be carried out as per R-1.4 and R-1.5 of PG Rules and Regulations of Credit System.

Seminar – I, II and III [502212, 602216, 602218]

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Pr /Week	Paper		TW	Oral/ Presentation	Total	
		In Semester Assessment	End Semester Assessment				
502212	4	-	-	50	50	100	4
602216	4	-	-	50	50	100	4
602218	5	-	-	50	50	100	5

Assessment of Seminar has to be carried out as per R-1.4 and R-1.5 of PG Rules and Regulations of Credit System.

INSTRUCTIONS FOR SEMINAR REPORT WRITING

It is important that the procedures listed below be carefully followed by all the students of M.E. (Mechanical Engineering).

1. Prepare 3 **COPIES** of your manuscript.
2. Limit your project report to preferably
   a) 15-20 manuscript pages for Seminar I
   b) 20-25 manuscript pages for Seminar II
   c) 25-30 manuscript pages for Seminar III
3. The footer must include the following:
   Institute Name, M. E. (Mechanical) (Design Engineering) Times New Roman 10 pt. and centrally aligned.
4. Page number as second line of footer, Times New Roman 10 Pt, centrally aligned.
5. Print the manuscript using
   a) Letter quality computer printing.
   b) The main part of manuscript should be Times New Roman 12 pt. and justified**.**
   c) Use 1.5 line spacing.
   d) Entire report shall be one chapter. No chapters for Seminar I, II and III.
   e) Seminar I shall not have last section as Conclusions, it will be summary only.
6. Use the paper size **8.5'' × 11''** or **A4 (210 × 197 mm).** Please follow the margins given below.

Margin Location	Paper 8.5'' × 11''	Paper A4 (210 × 197 mm)
Top	1''	25.4 mm
Left	1.5''	37 mm
Bottom	1.25''	32 mm
Right	1''	25.4 mm

7. All paragraphs will be 1.5 line spaced with a one blank line between each paragraph. Each paragraph will begin without any indentation.
8. Section titles should be bold with 14 pt typed in all capital letters and should be left aligned.

9. Sub-Section headings should be aligning at the left with 12 pt, bold and Title Case (the first letter of each word is to be capitalized).
10. Illustrations (charts, drawings, photographs, figures) are to be in the text. Use only illustrations really pertinent to the text. Illustrations must be sharp, clear, **black and white. Illustrations downloaded from internet are not acceptable.**
    a) Illustrations should not be more than **two** per page. One could be ideal
    b) Figure No. and Title at bottom with **12 pt**
    c) Legends below the title in **10 pt**
    d) Leave proper margin in all sides
    e) Illustrations as far as possible should not be Xeroxed.

11. **Photographs** if any should be of glossy prints
12. Please use **SI** system of units. If students would like to add the equivalent in inch-pound (British) units, they must be stated in parenthesis after the **SI** units. In case the final result comes out in any other units (say due to empirical formula etc.) covert the unit to **SI** unit.
13. Please **number the pages** on the front side, centrally below the footer
14. **References** should be either in order as they appear in the thesis or in alphabetical order by last name of first author
15. **Symbols** and **notations** if any should be included in nomenclature section only
16. Following will be the order of report
    i. **Cover page** and **Front page** as per the specimen on separate sheet
    ii. **Certificate** from the Institute as per the specimen on separate sheet
    iii. **Acknowledgement**
    iv. **List of Figures**
    v. **List of Tables**
    vi. **Nomenclature**
    vii. **Contents**
    viii. **Abstract** (A brief abstract of the report not more than **150 words**. The heading of abstract i.e. word "Abstract" should be **bold, Times New Roman, 12 pt** and should be typed at the **centre.** The contents of abstract should be typed on new line without space between heading and contents. Try to include one or two sentences each on **motive, method, key-results** and **conclusions** in the Abstract)
    ix. Section: Introduction
    x. References
17. All section headings and subheadings should be numbered. For sections use numbers **1, 2, 3, ….** and for subheadings **1.1**, **1.2**, **….** etc and section subheadings **2.1.1**, **2.1.2, ….** etc.
18. **References** should be given in the body of the text and well spread. No verbatim copy or excessive text from only one or two references. If **figures** and **tables** are taken from any reference then indicate source of it. Please follow the following procedure for references

    Reference Books

    Collier, G. J. and Thome, J. R., Convective boiling and condensation, 3rd ed., Oxford University Press, UK, 1996, pp. 110 – 112.

    Papers from Journal or Transactions

    Jung, D. S. and Radermacher, R., Transport properties and surface tension of pure and mixed refrigerants, *ASHRAE Trans*, 1991, 97 (1), pp. 90 – 98.

Bansal, P. K., Rupasinghe, A. S. and Jain, A. S., An empirical correction for sizing capillary tubes, *Int. Journal of Refrigeration*, 1996, 19 (8), pp.497 – 505.

Papers from Conference Proceedings

Colbourne, D. and Ritter, T. J., *Quantitative assessment of flammable refrigerants in room air conditioners*, Proc. of the Sixteenth International Compressor Engineering Conference and Ninth International Refrigeration and Air Conditioning Conference, Purdue University, West Lafayette, Indiana, USA, 2002, pp. 34 – 40.

Reports, Handbooks etc.

United Nations Environmental Programme, Report of the Refrigeration, Air Conditioning and Heat Pumps, Technical Option Committee, 2002, Assessment - 2002.

ASHRAE Handbook: Refrigeration, 1994 (Chapter 44)

Patent

Patent no, Country (in parenthesis), date of application, title, year.

Internet

www.(Site) [Give full length URL]

Format for front page and Certificate

A Seminar I / II / III on (TNR, 16pt, centrally aligned)

Title (TNR, 27pt, Bold, Centrally Aligned, Title Case)

By (TNR, 16pt, Centrally Aligned)

Mr. Student's Name (TNR, 16pt, Centrally Aligned)

Guide (TNR, 16pt, Centrally Aligned)

Guide's Name (TNR, 16pt, Centrally Aligned)

Institute

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Department of Mechanical Engineering

Name of the Institute

[2011-12](TNR, 22pt, Title Case Centrally Aligned)

Name of the Institute

Institute

Logo

C E R T I F I C A T E

This is to certify that *Mr. Lele M. M.*, has successfully completed the seminar-I/II/III entitled "Performance analysis of……." under my supervision, in the partial fulfilment of Master of Engineering (Mechanical) (Design Engineering) of University of Pune.

Date :

Place :

Guide's Name
Guide

_____
Head
Department and
Institute Name

External Examiner

Seal

_____
Principal,
Institute Name

Semester – III
Optimization Techniques [602213]

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		In Semester Assessment	End Semester Assessment				
602213	4	50	50	-	-	100	4

1. Classical Optimization Techniques
Engineering applications of optimization, statement of optimization problem, classification of optimization problem, single variable optimization, multi variable optimization with no constraint, equality constraint, in-equality constraint

2. Linear Programming
Simplex algorithm, two phases of the simplex method, applications

3. Non-Linear Programming
One-dimensional minimization - exhaustive search, golden section method, quasi-newton method, random search methods, Powell's method

4. Modern Methods of Optimization
Genetic algorithms, simulated annealing, fuzzy optimization, neural-network-based methods

5. Topology Optimization
Problem formulation and parameterization of design, solution methods, topology optimization as a design tool, combining topology and shape design, buckling problems, stress constraints

6. Evolutionary Structural Optimization (ESO) Methods
ESO Based on Stress Level, evolutionary methods, two-bar frame, Michell type structure, ESO for stiffness or displacement optimization, Bi-directional Evolutionary Structural Optimization (BESO) method, BESO Based on von Mises Stress, topology optimization for natural frequency

References

1. Structural Optimization, Raphael T. Haftka and Zafer Gurdal, Kluwer Academic Publishers
2. Practical Optimization Methods with Mathematical Applications, M. Asghar Bhatti, Springer
3. Topology Optimization – Theory, Methods and Applications, M. P. Bendse, Q. Sigmund
4. Evolutionary Topology Optimization of Continuum Structures, Methods and Applications, X. Huang, Y.M. Xie, Wiley, 2010
5. Engineering Optimization: Theory and Practice, Singiresu S. Rao, John Wiley & Sons

Semester – III
Mechanical Measurements and Controls [602214]

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		In Semester Assessment	End Semester Assessment				
602214	4	50	50	-	-	100	4

1. Instrument types and performance characteristics
Active and Passive instruments, Null type and deflection type instruments, Analogue and digital instruments, Indicating instruments and instruments with signal output, smart and non smart instruments. Static and Dynamic characteristics of instruments, Necessity of calibration

2. Measurement Uncertainty
Sources of Systematic Error, System Disturbance due to Measurement, Errors due to Environmental Inputs, Wear in Instrument Components, Accumulation of Accepted Error, Improper Functioning of Instruments, Dual Sensitivity Errors, Other Sources of Error, Minimizing Experimental Error, Statistical Analysis of Measurements subject to Random Errors, Aggregation of Measurement System Errors, Reduction of Systematic Errors, Quantification of Systematic Errors, Sources and Treatment of Random Errors, parameter estimation, regression analysis, correlations, analysis of data

3. Measurement of field quantities
Temperature, heat flux measurement, heat transfer coefficient, measurement of force, pressure, flow rate, velocity, humidity, noise, vibration

4. Measurement of derived quantities
Force, Acceleration, Torque, power, thermo physical properties, radiation and surface properties, Miscellaneous Measurements - Time, Frequency, and Phase-Angle Measurement, Liquid Level, Chemical Composition, Current and Power Measurement

5. Control in Time Domain
Introduction to open loop and closed loop control, Modelling of system using state space approach (only second order mechanical, electro-mechanical, thermal and hydraulic system), Poles and Zeros of System, Stability of system using Lyapunov's criterion, Controllability of system, Full state feedback control of system using pole placement technique, Pole placement using Ackerman's formula

6. Control in Frequency Domain
Modelling of system using transfer function (only second order mechanical, electro-mechanical, thermal and hydraulic system), Transient response of system based on location of poles, Transient response specifications for second order system, Stability of system based on Routh Hurwitz criterion, Analysis of second order system using Bode Plots, Closed loop control of system using Proportional Integral Derivative Control

Reference Books:

1. Measurement Systems-Application and Design, Doebelin E.O, McGraw Hill Publication
2. Measurement and Instrumentation – Theory and Application, Alan Morris, Reza Langari, Elsevier
3. Instrumentation for Engineering Measurements, James Dally, William riley and Kenneth McConnell, Wiley.
4. Mechanical Measurements, S.P. Venkateshan, Ane Books Pvt. Ltd.
5. Control System Engineering, Norman Nise, 6th Edition, John Wiley and Sons
6. Mechanical Measurements, S.P. Venkateshan, Ane Books Pvt. Ltd

Semester – III
Elective – III [602215]

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		In Semester Assessment	End Semester Assessment				
602215	5	50	50	-	-	100	5

Modules of 2 Credits (Select any Two)			
Code No.	**Title**	**Code No.**	**Title**
DE2III-M1	Fatigue	**DE2III-M5**	Condition Monitoring – I
DE2III-M2	Fracture Mechanics	**DE2III-M6**	Condition Monitoring – II
DE2III-M3	CAE – I	**DE2III-M7**	Industrial Tribology – I
DE2III-M4	CAE – II	**DE2III-M8**	Industrial Tribology – II
Modules of 1 Credit (Select any One)			
Code No.	**Title**	**Code No.**	**Title**
DE1III-M9	Reliability Engineering	**DE1III-M11**	Fatigue Analysis using FEM
DE1III-M10	Design for X	**DE1III-M12**	Product Life Cycle Management

DE2III-M1 Fatigue

Fatigue Mechanics

Time varying uniaxial, biaxial and multiaxial loading of components, load spectra, cycle counting, fatigue damage theories of crack initiation, stress based and strain based approach

Fatigue Testing

Data acquisition and instrumentation, classical methods of fatigue testing, ASTM standards - specimen preparation, procedure

Advanced Topics in Fatigue

Fatigue analysis in frequency domain, vibration fatigue, fatigue of welded structure, corrosion fatigue, high temperature and low temperature fatigue

Ref. Books: 1) Metal Fatigue Analysis Handbook, YUNG-LI LEE, Elsevier 2) Design & Analysis of Fatigue Resistant Welded Structure, Dieter Radaj, Woodhead Publishing 3) Fatigue of Structures and Materials, Japp Schijve, Kluwer Academic 4) Fatigue Testing and Analysis – Theory and Practice, YUNG-LI LEE, Elsevier 5) Metal Fatigue in Engineering, Ali Fatemi, Wiley-Interscience

DE2III-M2 Fracture Mechanics

Linear Elastic Fracture Mechanics

Mechanisms of fracture, initiation of fracture and crack propagation, stress and energy criteria and fracture - effects of geometry, Inglis theory of stress, energy concept – Griffith theory of fracture, energy balance during crack growth, modes of loading, calculation of stress intensity – center crack, single edge crack, double edge crack, round hole with crack, superposition of stress intensity factors, leak before break criterion, experimental determination of stress intensity factor – strain gauge method, optical method of photo elasticity

Elastic – Plastic Fracture Mechanics

introduction, crack tip stress state, Irwin's approximation, Dugdale's approximation, crack opening displacement, shape of the plastic zone – von Mises and Tresca yielding criteria, plastic constraint factor

Energy Principle

Energy release rate, criteria for crack growth, linear compliance, path independent integrals, J – integral, application of J-integral to cracks and notches, J – integral fracture criterion, experimental determination of the J – integral - single specimen and multiple specimen method

Ref. Books: 1) Fracture Mechanics Anderson T.L., CRC Press 2) Fracture Mechanics, Nestor Perez, , Kluwer Academic Publishers 3) Fracture Mechanics – An Introduction, Gdoutos E. E., , Springer 4) Nonlinear Fracture Mechanics for Engineers, Ashok Saxena, , CRC Press 5) Elements of Fracture Mechanics, Prashant Kumar, Mc Graw Hill Education 6) Deformation and Fracture Mechanics of Engineering Materials, Hertzberg, R. W., John Wiley & Sons, Inc. 7) Mechanical Metallurgy, George E Dieter and David Bacon, Mc Graw Hill Book Co.

DE2III-M3 CAE - I

CAE Driven Design Process

Analysis types, geometry clean-up, meshing techniques, 1-D, 2-D and 3-D mesh, element selection, special elements, solution convergence, element quality checks, material information, boundary conditions and loads.

Static Analysis

Externally applied forces and pressures, steady-state inertial forces (such as gravity or rotational velocity), imposed (nonzero) displacements, temperatures (for thermal strain), non-linear structural analysis, model verification

Normal Modes and Buckling analysis

Real eigenvalue analysis, governing equations, methods of computations, normal modes analysis, Block Lanczos and QR damped methods of modes extraction, linear buckling analysis

Ref. Books: 1) Strukturdynamik, R. Gasch, K. Knothe, Springer 2) Dynamics of Structures, W. C. Hurty and M. F. Rubinstein, Prentice-Hall 3) Dynamics of Structures, R. W. Clough and J. Penzien, McGraw-Hill 4) S. Timoshenko, D. H. Young, and W. Weaver, Jr., Vibration Problems in Engineering, John Wiley & Sons 5) K. J. Bathe and E. L. Wilson, Numerical Methods in Finite Element Analysis, Prentice-Hall 6) Theory of Matrix Structural Analysis, J. S. Przemieniecki, McGraw-Hill 7) Structural Dynamics: An Introduction to Computer Methods, R. R. Craig, , John Wiley & Sons

DE2III-M4 CAE - II

Harmonic Response Analysis

Definition, applications, methods – full, reduced and mode superposition, pre-stressed harmonic response analysis

Transient dynamic analysis

Dynamic modeling input, normal mode analysis, reduction in dynamic analysis, rigid body modes, damping, transient response analysis, frequency response analysis, direct matrix input, dynamic equations of motion, residual vector methods, enforced motion, shock and response spectrum analysis, random response analysis, complex eigenvalue analysis

Advanced topics in FEA

Complex eigenvalue analysis, normal mode analysis using parts super-element, transfer functions, normal modes of preloaded structures, dynamic design optimization, test-analysis correlation

Ref. Books: 1) Strukturdynamik, R. Gasch, K. Knothe, Springer 2) Dynamics of Structures, W. C. Hurty and M. F. Rubinstein, Prentice-Hall 3) Dynamics of Structures, R. W. Clough and J. Penzien, McGraw-Hill 4) S. Timoshenko, D. H. Young, and W. Weaver, Jr., Vibration Problems in Engineering, John Wiley & Sons 5) K. J. Bathe and E. L. Wilson, Numerical Methods in Finite Element Analysis, Prentice-Hall 6) Theory of Matrix Structural Analysis, J. S. Przemieniecki, McGraw-Hill 7) Structural Dynamics: An Introduction to Computer Methods, R. R. Craig, , John Wiley & Sons

DE2III-M5 Condition Monitoring – I

Vibrations

System response to vibration, nature of vibration, harmonics, limits and standards of vibration

Predictive maintenance techniques

Predictive maintenance basics, maintenance philosophies, evolution of maintenance philosophies, plant machinery classification and recommendations, principles of predictive maintenance, predictive maintenance techniques, and vibration analysis – a key to predictive maintenance

Data acquisition

Introduction, collection of vibration signal – vibration transducers, characteristics and mountings, conversion of vibrations to electrical signal

Ref. Books: 1) Theory of Vibration with Applications, Thomson, W. T., CBS Publishers and Distributors, New Delhi 2) Introductory Course on Theory and Practice of Mechanical Vibrations, Gupta K., New Age International Ltd. 3) Vibratory Condition Monitoring of Machines, J. S. Rao, Narosa Publishing House, New Delhi 3) Shock and Vibration Handbook, Cyril M. Harris, Allan G. Piersol, McGraw-Hill Publishing Co., 4) Practical Machinery Vibration Analysis and Predictive Maintenance, C. Scheffer, Paresh Girdhar, Elsevier

DE2III-M6 Condition Monitoring – II

Signal processing - applications and representation

The Fast Fourier transform (FFT) analysis, time waveform analysis, phase signal analysis, spectral signal processes.

Machinery fault diagnosis using vibration analysis

Commonly witnessed machinery faults diagnosed by vibration analysis, correcting faults that cause vibration, balancing, alignment, resonance vibration control with dynamic absorbers

Oil and particle analysis

Condition-based maintenance and oil analysis, setting up an oil analysis program, oil analysis – sampling methods, oil analysis – lubricant properties, oil analysis – contaminants in lubricants, particle analysis techniques, alarm limits for various machines

Ref. Books: 1) Theory of Vibration with Applications, Thomson, W. T., CBS Publishers and Distributors, New Delhi 2) Introductory Course on Theory and Practice of Mechanical Vibrations, Gupta K., New Age International Ltd. 3) Vibratory Condition Monitoring of Machines, J. S. Rao, Narosa Publishing House, New Delhi 3) Shock and Vibration Handbook, Cyril M. Harris, Allan G. Piersol, McGraw-Hill Publishing Co., 4) Practical Machinery Vibration Analysis and Predictive Maintenance, C. Scheffer, Paresh Girdhar, Elsevier

DE2III-M7 Industrial Tribology – I

Friction and wear

Friction control and wear prevention, boundary lubrication, tribological properties of bearing materials and lubricants, theories of friction and wear, instabilities and stick-slip motion

Lubrication of bearings

Mechanics of fluid flow, Reynold's equation and its limitations, idealized bearings, infinitely long plane pivoted and fixed show sliders, infinitely long and infinitely short (narrow) journal bearings, lightly loaded infinitely long journal bearing (Petroff's solution), finite bearings - hydrostatic, hydrodynamic and thrust oil bearings, heat in bearings

Hydrostatic squeeze film

Circular and rectangular flat plates, variable and alternating loads, piston pin lubrications, application to journal bearings

Ref. Books: 1) Principles of Lubrication, Camaron, Longman's Green Co. Ltd. 2) Fundamental of Friction and Wear of Metals – ASM 3) The Design of Aerostatic Bearings – J. W. Powell 4) Gas Bearings – Grassam and Powell 5) Theory Hydrodynamic Lubrication, Pinkush and Sterrolicht 6) Tribology in Machine Design, T. A. Stolarski

DE2III-M8 Industrial Tribology – II

Elasto-hydrodynamic lubrication

Pressure-viscosity term in Reynold's equation, hertz theory, Ertel-Grubin equation, lubrication of spheres

Air lubricated bearings

Tilting pad bearings, hydrostatic, hydrodynamic and thrust bearings with air lubrication

Tribological aspects of rolling motion

Mechanics of tire-road interaction, road grip and rolling resistance, tribological aspects of wheel on rail contact, tribological aspects of metal rolling, drawing and extrusion

Ref. Books: 1) Principles of Lubrication, Camaron, Longman's Green Co. Ltd. 2) Fundamental of Friction and Wear of Metals – ASM 3) The Design of Aerostatic Bearings – J. W. Powell 4) Gas Bearings – Grassam and Powell 5) Theory Hydrodynamic Lubrication, Pinkush and Sterrolicht 6) Tribology in Machine Design, T. A. Stolarski

DE1III-M9 Reliability Engineering

Analysis of variance (ANOVA), factorial design and regression analysis, reliability theory, design for reliability, hazard analysis, fault tree analysis, gear design - involute gears, helical gears, tooth thickness, interference, undercutting, rack-shift, profile modification, spring design - vibration and surging of helical springs, helical springs for, maximum space efficiency, analysis of Belleville springs, ring spring, volute spring and rubber springs, design for spring suspension

Ref. Books: 1) Concepts of Reliability Engineering, L.S. Srinath, Affiliated East-West Press (P) Ltd. 2) Reliability Engineering, A.K. Govil, Tata McGraw-Hill Publishing Co. Ltd. 3) Reliability Engineering, E. Balagurusmy, Tata McGraw-Hill Publishing Co. Ltd.

DE1III-M10 Design for X

Design for assembly, disassembly, ease of use, maintenance, manufacture, quality, reliability, reuse, cost, environment, quality function deployment

Ref. Books: 1) Design for X: Concurrent engineering imperatives, Charles M. Eastman, Springer

DE1III-M11 Fatigue Analysis using FEM

Different approaches for fatigue analysis, stress life approach – S-N curve, mean stress correction, Haigh diagram, factors affecting fatigue, multi-axial fatigue, spot weld fatigue, arc weld fatigue analysis, vibration fatigue, fatigue life estimation based on measured strain data, fatigue testing techniques, result interpretation and correlation of results

Ref. Books: 1) Biaxial/Multiaxial Fatigue and Fracture, Andrea Carpinteri, Elsevier 2) Design & Analysis of Fatigue Resistant Welded Structure, Dieter Radaj, Woodhead Publishing 3) ***Finite Element Learning Modules for Fatigue Analysis, Joshua A. Coffman, Proquest, Umi Dissertation Publishing***

DE1III-M12 Product Life Cycle Management

background, overview, need, benefits, and concept of product life cycle, components/elements of PLM, emergence of PLM, significance of PLM, customer involvement, product data and product workflow, the link between product data and product workflow, different phases of product life cycle and corresponding technologies

Ref. Books: 1) Product Lifecycle Management, Antti Saaksvuori and Anselmi Immonen, Springer 2) ***Product Lifecycle Management: 21st Century Paradigm for Product Realisation, John Stark, Springer***

Project Stage – I and II [602217, 602219]

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect/Week	Paper		TW	Oral/ Presentation	Total	
		In Semester Assessment	End Semester Assessment				
602217	8	-	-	50	50	100	8
602219	20	-	-	150	50	200	20

Assessment of Project stage-I has to be carried out as per R-1.4 and R-1.5 of PG Rules and Regulations of Credit System.

INSTRUCTIONS FOR DISSERTATION WRITING

It is important that the procedures listed below be carefully followed by all the students of M.E. (Mechanical Engineering).

1. Prepare **Three Hard Bound Copies** of your manuscript.
2. Limit your Dissertation report to 80 – 120 pages (preferably)
3. The footer must include the following:
   Institute Name, M.E. (Mechanical) (Design Engineering) Times New Roman 10 pt. and centrally aligned.
4. Page number as second line of footer, Times New Roman 10 Pt, centrally aligned.
5. Print the manuscript using
   a. Letter quality computer printing.
   b. The main part of manuscript should be Times New Roman 12 pt. with alignment - justified**.**
   c. Use 1.5 line spacing.
   d. Entire report shall be of 5- 7 chapters.
6. Use the paper size **8.5'' × 11''** or **A4 (210 × 197 mm).** Please follow the margins given below.

Margin Location	Paper 8.5'' × 11''	Paper A4 (210 × 197 mm)
Top	1''	25.4 mm
Left	1.5''	37 mm
Bottom	1.25''	32 mm
Right	1''	25.4 mm

7. All paragraphs will be 1.5 line spaced with a one blank line between each paragraph. Each paragraph will begin with without any indentation.
8. Section titles should be bold with 14 pt typed in all capital letters and should be left aligned.
9. Sub-Section headings should be aligning at the left with 12 pt, bold and Title Case (the first letter of each word is to be capitalized).
10. Illustrations (charts, drawings, photographs, figures) are to be in the text. Use only illustrations really pertinent to the text. Illustrations must be sharp, clear, **black and white. Illustrations downloaded from internet are not acceptable.**
    a. Illustrations should not be more than **two** per page. One could be ideal
    b. Figure No. and Title at bottom with **12 pt**

c. Legends below the title in **10 pt**
d. Leave proper margin in all sides
e. Illustrations as far as possible should not be photo copied.

11. **Photographs** if any should of glossy prints
12. Please use **SI** system of units only.
13. Please **number the pages** on the front side, centrally below the footer
14. **References** should be either in order as they appear in the thesis or in alphabetical order by last name of first author
15. **Symbols** and **notations** if any should be included in nomenclature section only
16. Following will be the order of report
    i. **Cover page** and **Front page** as per the specimen on separate sheet
    ii. **Certificate** from the Institute as per the specimen on separate sheet
    iii. **Acknowledgements**
    iv. **List of Figures**
    v. **List of Tables**
    vi. **Nomenclature**
    vii. **Contents**
    viii. **Abstract** (A brief abstract of the report not more than **150 words**. The heading of abstract i.e. word "Abstract" should be **bold, Times New Roman, 12 pt** and should be typed at the **centre.** The contents of abstract should be typed on new line without space between heading and contents. Try to include one or two sentences each on **motive, method, key-results** and **conclusions** in Abstract

1 Introduction (2-3 pages) (TNR – 14 Bold)
1.1 Problem statement (TNR – 12)
1.2 Objectives
1.3 Scope
1.4 Methodology
1.5 Organization of Dissertation

2 Literature Review (20-30 pages)
Discuss the work done so far by researchers in the domain area and their significant conclusions. No derivations, figures, tables, graphs are expected.

3 This chapter shall be based on your own simulation work (Analytical/ Numerical/FEM/CFD) (15- 20 pages)

4 Experimental Validation - This chapter shall be based on your own experimental work (15-20 pages)

5 Concluding Remarks and Scope for the Future Work (2-3 pages)

References

ANNEXURE (if any)
(Put all mathematical derivations, Simulation program as Annexure)

17. All section headings and subheadings should be numbered. For sections use numbers **1, 2, 3, ….** and for subheadings **1.1**, **1.2**, **….** etc and section subheadings **2.1.1**, **2.1.2, ….** etc.
18. **References** should be given in the body of the text and well spread. No verbatim copy or excessive text from only one or two references. If **figures** and **tables** are taken from any reference then indicate source of it. Please follow the following procedure for references

Reference Books

Collier, G. J. and Thome, J. R., Convective boiling and condensation, 3rd ed., Oxford University Press, UK, 1996, pp. 110 – 112.

Papers from Journal or Transactions

Jung, D. S. and Radermacher, R., Transport properties and surface tension of pure and mixed refrigerants, *ASHRAE Trans*, 1991, 97 (1), pp. 90 – 98.

Bansal, P. K., Rupasinghe, A. S. and Jain, A. S., An empirical correction for sizing capillary tubes, *Int. Journal of Refrigeration*, 1996, 19 (8), pp.497 – 505.

Papers from Conference Proceedings

Colbourne, D. and Ritter, T. J., *Quantitative assessment of flammable refrigerants in room air conditioners*, Proc. of the Sixteenth International Compressor Engineering Conference and Ninth International Refrigeration and Air Conditioning Conference, Purdue University, West Lafayette, Indiana, USA, 2002, pp. 34 – 40.

Reports, Handbooks etc.

United Nations Environmental Programme, Report of the Refrigeration, Air Conditioning and Heat Pumps, Technical Option Committee, 2002, Assessment - 2002.

ASHRAE Handbook: Refrigeration, 1994 (Chapter 44)

Patent

Patent no, Country (in parenthesis), date of application, title, year.

Internet

www.(Site) [Give full length URL]

A Project Stage-I Report on (TNR, 16pt, centrally aligned)

Title (TNR, 27pt, Bold, Centrally Aligned, Title Case)

By (TNR, 16pt, Centrally Aligned)

Mr. Student's Name(TNR, 16pt, Centrally Aligned)

Guide

Guide's Name (TNR, 16pt, Centrally Aligned)

Institute

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Department of Mechanical Engineering

Name of the Institute

[2011-12](TNR, 22pt, Title Case Centrally Aligned)

Name of the Institute

Institute

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C E R T I F I C A T E

This is to certify that *Mr. Lele M.M.*, has successfully completed the Project Stage-I entitled "Performance analysis of……." under my supervision, in the partial fulfilment of Master of Engineering (Mechanical) (Design Engineering) of University of Pune.

Date :

Place :

Guide's Name
Guide

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Head
Department and
Institute Name

External Examiner

Seal

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Principal,
Institute Name

A Dissertation on (TNR, 16pt, centrally aligned)

Title (TNR, 27pt, Bold, Centrally Aligned, Title Case)

By (TNR, 16pt, Centrally Aligned)

Mr. Student's Name (TNR, 16pt, Centrally Aligned)

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Institute

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Department of Mechanical Engineering

Name of the Institute

[2011-12](TNR, 22pt, Title Case Centrally Aligned)

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Institute Name

External Examiner

Seal

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Principal,
Institute Name