Department of Mechanical Engineering

National Institute of Technology Raipur

Master of Technology in Machine Design

Scheme and Syllabus

2016

Content

Vision:

"To produce innovative, entrepreneurial and successful engineers and technologists of high caliber for the nation, to serve as a valuable resource for industry, academia and society"

Mission:

1. *To provide the students and the faculty with opportunities to create, interpret, and apply the knowledge in the field of Mechanical Engineering.*
2. *Provide technological service to local, national, and international communities.*

Programme Educational Objectives (PEOs)

Under the Post-graduate Mechanical Engineering Programme in Machine Design, the objectives aim to produce qualified Mechanical Engineering Post-graduates who will:

I. *Possess advanced knowledge and understanding thus enabling them to tackle practical design problems in industrial fields, as well as pursue further academic achievements through research.*
II. *Possess communication, analytical, decision-making, motivational, leadership, problem solving and human relations skills.*
III. *Conduct themselves in a responsible, professional and ethical manner.*
IV. *Inculcate an attitude for life-long learning process.*

Program Outcomes:

a. *Possess knowledge of modern technological concepts and apply specialized expertise practically.*
b. *Conduct simulations and experiments; analyze data, and present results.*
c. *Work on multi-disciplinary group projects to enhance interpersonal and leadership skills.*
d. *Make effective oral presentations of ideas on engineering design solutions and prepare technical documents effectively.*
e. *Develop professional and ethical attitude and become socially responsible citizens.*
f. *Ability to understand global issues and conduct independent research in the emerging areas.*

PO	a	b	c	d	e	f
PEO						
I	y	y	y	y		y
II		y	y	y		
III		y	y		y	
IV	y	y			y	y

National Institute of Technology , Raipur (C.G.)													
M. Tech. in Mechanical Engineering with specialization in Machine Design													
Course of Study & Scheme of Examination							M. Tech. 1st Semester					Branch: Mechanical	
S. No.	Board of Studies	*Sub. Code*	*Subject Name*	*Periods / week*			*Examination Scheme*					*Total Marks*	*Credits*
				L	T	P	TA	FE	SE	ESE	Pract. ESE		
1	Mechanical	ME42111ME	Advanced Numerical Techniques	3	1	-	20	15	15	100	-	150	4
2	Mechanical	ME42112ME	Optimization Techniques	3	1	-	20	15	15	100	-	150	4
3	Mechanical	ME42113ME	Stress and Deformation analysis	3	1	-	20	15	15	100	-	150	4
4	Mechanical	ME42131ME	Elective-I	3	1	-	20	15	15	100	-	150	4
5	Mechanical	ME42132ME	Elective-II	3	1	-	20	15	15	100	-	150	4
6	Mechanical	ME42121ME	Experimental Lab-I	-	-	3	75	-	-	-	50	125	2
7	Mechanical	ME42122ME	Computational Lab-I	-	-	3	75	-	-	-	50	125	2
			Total	15	5	6	250	75	75	500	100	1000	24

List of Electives offered in First Semester of the Specialization:

Elective-I AND II

ME42131ME	Advanced Finite Element Method
ME42132ME	Engineering Tribology
ME42133ME	Experimental Methods for Engineers
ME42134ME	Advanced Mechanism Design
ME42135ME	Product Design
ME42136ME	Computer Aided Design
ME42137ME	Rotor Dynamics

National Institute of Technology , Raipur (C.G.)													
M. Tech. in Mechanical Engineering with specialization in Machine Design													
Course of Study & Scheme of Examination								M. Tech. 2nd Semester				Branch: Mechanical	
S. No.	Board of Studies	*Sub. Code*	*Subject Name*	*Periods / week*			*Examination Scheme*					*Total Marks*	*Credits*
				L	T	P	TA	FE	SE	ESE	Pract . ESE		
1	Mechanical	ME42211ME	Advanced Dynamics	3	1	-	20	15	15	100	-	150	4
2	Mechanical	ME42212ME	Advanced Machine Design	3	1	-	20	15	15	100	-	150	4
3	Mechanical	ME42213ME	Composite Mechanics	3	1	-	20	15	15	100	-	150	4
4	Mechanical	ME42231ME	Elective III	3	1	-	20	15	15	100	-	150	4
5	Mechanical	ME42232ME	Elective-IV	3	1	-	20	15	15	100	-	150	4
6	Mechanical	ME42221ME	Experimental Lab-II	-	-	3	75	-	-	-	50	125	2
7	Mechanical	ME42222ME	Computational Lab-II	-	-	3	75	-	-	-	50	125	2
			Total	15	5	6	250	75	75	500	100	1000	24

List of Electives offered in Second Semester of the Specialization:

Elective-III AND IV

ME42231ME	Industrial Robotics
ME42232ME	Experimental Stress Analysis
ME42233ME	Biomechanics
ME42234ME	Fault Diagnosis and Condition Monitoring
ME42235ME	Pressure Vessel Design
ME42236ME	Design for Manufacturing
ME42237ME	Advanced Material

National Institute of Technology , Raipur (C.G.)													
M. Tech. in Mechanical Engineering with specialization in Machine Design													
Course of Study & Scheme of Examination							M. Tech. 3rd Semester					Branch: Mechanical	
S. No.	Board of Studies	*Sub. Code*	*Subject Name*	*Periods / week*			*Examination Scheme*					*Total Marks*	*Credits*
				L	T	P	TA	FE	SE	ESE	Pract. ESE		
1	Mechanical	ME42321ME	Preliminary Dissertation Work	-	-	24	100	-	-	-	200	300	12
2	Mechanical	ME42322ME	Comprehensive Examination	-	-	-	-	-	-	-	200	200	4
			Total	-	-	24	100	-	-	-	400	500	16

National Institute of Technology , Raipur (C.G.)													
M. Tech. in Mechanical Engineering with specialization in Machine Design													
Course of Study & Scheme of Examination							M. Tech. 4th Semester					Branch: Mechanical	
S. No.	Board of Studies	*Sub. Code*	*Subject Name*	*Periods / week*			*Examination Scheme*					*Total Marks*	*Credits*
				L	T	P	TA	FE	SE	ESE	Pract. ESE		
1	Mechanical	ME42421ME	Dissertation + Seminar	-	-	32	200	-	-	-	300	500	16
			Total	0	0	32	200	-	-	-	300	500	16

राष्ट्रीय प्रौद्योगिकी संस्थान रायपुर
NATIONAL INSTITUTE OF TECHNOLOGY RAIPUR
(Institute of National Importance)
G.E. Road, Raipur – 492010 (CG)

Phone: (0771) 225 42 00
Fax: (0771) 225 46 00
Email: director.nitrr@rediffmail.com
Website: www.nitrr.ac.in

DEPARTMENT OF MECHANICAL ENGINEERING
SYLLABUS (M. Tech. Machine Design)

Name of the Subject	Advanced Numerical Techniques	Subject Code	ME42111ME
Semester	I	Board of Studies	Mechanical Engg.
Maximum Marks	100	Minimum Marks	40
Lecture Periods/Week	Tutorial Periods/Week	Practical Periods/Week	Credits
3	1	0	4

Course Outcomes: At the end of this course the students are expected to be able to:

1. Apply the methods for solving algebraic, transcendental and linear equations.
2. Apply the methods for solving single variable optimization problems.
3. Apply the methods for curve fitting using regression and interpolation techniques.
4. Apply the methods to solve differentiation and integration numerical.
5. Apply the methods for solving ordinary and partial differential equations.
6. Design and develop computer programs for the various numerical methods to solve engineering problems.

Syllabus:

Transcendental & Algebraic Equations: Bracketing & open Methods- Bisection, False Position, Newton-Raphson Method, Secant Method. Gauss Elimination, Gauss Jordon applications, Gauss Seidal, LU decomposition, Matrix Inversion.

Single variable optimization: Optimality Criterion, Bracketing methods - Exhaustive Search Method, Bounding Phase Method, Region Elimination Method - Interval Halving Method, Fibonacci Search Method, Golden Section Search Method, Point Estimation Method - Successive quadratic estimation method, Gradient based methods:- Newton-Raphson Method, Bisection Method, Secant Method, Cubic Search Method, Root Finding Method using Optimsation Technique.

Regression Analysis-Least Square Method, Linear Regression, Polynomial Regression, Fourier Regression, & Nonlinear Regression. Interpolation- Newton's Forward and backward Interpolation, Newton's Divided Difference Interpolation, Lagrange's Interpolation, Gauss's Central Difference Interpolation.

Newton Cotes Integration formulas- Trapezoidal, Simpson, Romberg, Gaussian Quadrature, Numerical Differentiation-Finite Difference Method.

Types of Differential equations, Picard's Series Method, Taylor Series Method, Euler's Method, Modified Euler's Method, Runge-Kutta Method, Predictor Corrector Method, Milnes Method, and Application to Initial & Boundary value Problems.

Introduction to PDE Elliptic, Parabolic & Hyperbolic Equation. Finite Difference Schemes, Forward, Backward, Central Difference, Application to Laplace & Poisson's Equation, Iterative & Relaxation Techniques, Laplacian Operator in Cartesian, polar and other coordinate systems. Solution of Parabolic Equations, Implicit & Explicit Schemes, Crank Nicholson, ADI scheme. Solution of Hyperbolic Equations.

Note: Computer Programs for the above methods are to be practiced using any high level language.

Recommended Text Book:

1. Numerical Methods, B. S. Grewal, Khanna Publishers Ltd.
2. Optimization for Engineering Design - Algorithms and Examples, Kalyanmoy Deb, PHI Pvt. Ltd

Recommended Reference Book:

1. Numerical Methods by Engineers by Steven C Chapra and Raymond P Canale, TMH Publications.
2. Numerical Mathematical analysis, James B. Scarborough, Oxford and IBH Publishing Ltd.

राष्ट्रीय प्रौद्योगिकी संस्थान रायपुर
NATIONAL INSTITUTE OF TECHNOLOGY RAIPUR
(Institute of National Importance)
G.E. Road, Raipur – 492010 (CG)

Phone: (0771) 225 42 00
Fax: (0771) 225 46 00
Email: director.nitrr@rediffmail.com
Website: www.nitrr.ac.in

DEPARTMENT OF MECHANICAL ENGINEERING
SYLLABUS (M. Tech., Machine Design)

Name of the Subject	Optimization Techniques	Subject Code	ME42112ME
Semester	I	Board of Studies	Mechanical Engg.
Maximum Marks	100	Minimum Marks	40
Lecture Periods/Week	Tutorial Periods/Week	Practical Periods/Week	Credits
3	1	0	4

Course Outcomes: Upon completing the subject, the student will be able to:

1. Acquire knowledge and develop basic understanding of the concepts of optimization and mathematical modeling.
2. Acquire knowledge for basic modeling techniques to formulate a real life problem into a mathematical model.
3. Employ some optimization methods and techniques and apply them to some practical problems.
4. Use different direct and gradient based optimization method to solve single and multivariable un-constrained or constrained nonlinear function for minimization or maximization.
5. Use non-traditional optimization methods such as Genetic Algorithms, Simulated Annealing, and Global Optimization.
6. Learn software related to optimization and also develop the computer programs for different optimization algorithms.
7. Get aware to Goal Programming, Advanced Optimization Techniques and Dynamic Programming.

Syllabus:

Introduction, Optimal Problem Formulation, Optimal Design of Various Engineering Problems, Direct & Gradient Based Methods of Single Variable Optimization.

Multivariable Optimization Techniques, Unidirectional Search Methods, Direct Search Methods (Evolutionary Optimization Method, Simplex Search Method, Hooke-Jeeves Pattern Search Method, Powell's Conjugate Direction Method), Gradient Based Methods (Cauchy's Steepest Descent Method, Newton's Method, Marquardt's Method, Conjugate Gradient Method, Variable –Metric Method).

Constrained Optimization Algorithms Transformation Methods (Penalty Function Method, Method of Multipliers), Direct Search (Variable Elimination Method, Complex Search Method, Random Search Method), Linearized Search (Frank-Wolfe Method, Cutting Plane Method), Feasible Direction Methods, Reduced Gradient Methods, Gradient Projection Methods.

Introduction to Genetic Algorithms, Working Principles, Coding, Fitness Function, GA operators, Difference and Similarities Between GAs and Traditional Method, GAs for Non-Linear Single and Multivariable Unconstrained and constrained Optimization, Real Coded-GAs, Multi-Objective GAs.

Linear Programming, Non Traditional Optimization Algorithms, Simulated Annealing, Specialized Algorithms for Integer and Geometric Programming, Global Optimization using Traditional and Non-Traditional Optimization Algorithms, Software related to Optimization.

Recommended Text Book:

1. S. S. Rao, Optimization: Theory and Applications.
2. Kalyanmoy Deb, Optimization for Engineering Design.
3. Mohan C Joshi & K. M. Moudgalya, Optimization: Theory and Practice.

राष्ट्रीय प्रौद्योगिकी संस्थान रायपुर
NATIONAL INSTITUTE OF TECHNOLOGY RAIPUR
(Institute of National Importance)
G.E. Road, Raipur – 492010 (CG)

Phone: (0771) 225 42 00
Fax: (0771) 225 46 00
Email: director.nitrr@rediffmail.com
Website: www.nitrr.ac.in

DEPARTMENT OF MECHANICAL ENGINEERING
SYLLABUS (M. Tech., Machine Design)

Name of the Subject	Stress and Deformation Analysis	Subject Code	ME42113ME
Semester	I	Board of Studies	Mechanical Engg.
Maximum Marks	100	Minimum Marks	40
Lecture Periods/Week	Tutorial Periods/Week	Practical Periods/Week	Credits
3	1	0	4

Course Outcomes- At the end of this course, the students are expected to be able to:
1. Develop understanding of elasticity and plasticity theories.
2. Develop understanding of the Lagrangian and Eulerian formulation of elasticity problems and their ranges of application.
3. Understand and apply the concepts of stresses and strains and generalized Hooke's Law to classical problems of elasticity and plasticity.
4. Analyze and evaluate problems relating to torsion using displacement and stress formulation approaches.
5. Understand and apply the various energy methods in calculating deflections and slopes in beams appearing in engineering applications.
6. Understand and analyse Euler-Bernoulli beam theory, bending of curved beams and unsymmetrical bending and shear centre and apply the concepts in various practical situations.
7. Understand and analyse axisymmetric problems and apply Lame's equation to problems such as thick walled cylinders, rotating shafts and cylinders, etc.

Syllabus:
Analysis of Stress: The state of stress at a point; Normal and shear stress components; Principal stresses; Stress Invariants; Mohr's circle for three-dimensional state of stress; Cauchy's stress tensor; First and Second Piola-Kirchhoff stress tensors; Plane state of stress; state of pure shear; octahedral state of stress; Deviatoric stresses; Differential equations of equilibrium; Cauchy's stress quadric; Lame's ellipsoid; Equations of equilibrium in cylindrical and spherical co-ordinates; Boundary conditions; Airy's stress function.
Analysis of Strain: Lagrangian and Eulerian descriptions of a system; Deformation and Displacement gradients; Analysis of deformation, State of strain at a point; Principal axes of strain and principal strains; Compatibility conditions(Saint-Venant, Beltrami-Michel and Cauchy-Navier);Green-Lagrange strain tensor ; Euler-Almansi strain tensor; Plane state of strain; Strain deviator and its invariants.
Stress Strain Relations for linearly Elastic Solids: Generalized Hooke's law; Young's modulus; Modulus of rigidity; Bulk modulus; Displacement equations of equilibrium.
Axisymmetric Problems: Thick walled cylinders subjected to internal and external pressures-Lame's theory; Shrink fits; Rotating shafts and cylinders; Rotating disks of uniform and variable thickness.
Anti-plane Problems: Torsion of Non-circular cross-section prismatic bars
Energy Methods: Principle of superposition; Elastic strain energy; Energy of distortion and dilatation; Maxwell-Betti-Rayleigh reciprocal theorem; generalized forces and displacements; Kirchhoff's theorem; Castigliano's theorems; Theorem of virtual work; complimentary energy.
Bending of Beams: Euler-Bernoulli beam theory; Straight beams and asymmetrical bending; Shear stresses in thin walled open sections; Bending of curved beams; Deflections of thick curved bars, Unsymmetrical Bending and Shear Center.

Recommended Books:
1. Theory of Elasticity, Timoshenko & Goodier, Tata McGraw Hill Publishing Co.
2. Elements of Continuum Mechanics and Thermodynamics, Wegner & Haddow, CUP, 2009.

Phone: (0771) 225 42 00
Fax: (0771) 225 46 00
Email:
director.nitrr@rediffmail.com
Website: www.nitrr.ac.in

3. Continuum Mechanics for Engineers, Mase & Mase, CRC Press, 1999.
4. Advanced Mechanics of Solids, Srinath, Tata McGraw Hill, 2008.
5. Advanced Mechanics of Solids, Seely & Smith, Prentice hall, Inc.
6. Computational Methods for Plasticity-Theory and Applications, Neto, Peric & Owen, John Wiley & Sons, 2008.
7. Plasticity: Theory and Applications, Mendelson, MacMillan Co., NewYork.
8. Plasticity Theory, Lubliner, Pearson Education, 1990.

राष्ट्रीय प्रौद्योगिकी संस्थान रायपुर
NATIONAL INSTITUTE OF TECHNOLOGY RAIPUR
(Institute of National Importance)
G.E. Road, Raipur – 492010 (CG)
Phone: (0771) 225 42 00
Fax: (0771) 225 46 00
Email: director.nitrr@rediffmail.com
Website: www.nitrr.ac.in

DEPARTMENT OF MECHANICAL ENGINEERING
SYLLABUS (M. Tech., Machine Design)

Name of the Subject	Advanced Finite Element Method	Subject Code	ME42114ME
Semester	I	Board of Studies	Mechanical Engg.
Maximum Marks	100	Minimum Marks	40
Lecture Periods/Week	Tutorial Periods/Week	Practical Periods/Week	Credits
3	1	0	4

Course Outcomes: The objective is to teach the fundamentals of finite element analysis of solids, structures, and fluids. Upon completion of the course students should be able to:
1. Correlate a differential equation and its equivalent integral form and solve ordinary and partial differential equations using the residual methods and weak formulation.
2. Develop the finite element equations to model engineering problems governed by ordinary and partial differential equations.
3. Understand parametric interpolation and parametric geometry and utilize numerical integration in 1-, 2-, and 3-dimensions.
4. Assemble finite element matrices to the global matrices, enforce essential boundary conditions and post process a solution to find its gradient and its integral.
5. Apply source codes and software to stress analysis, thermal analysis, and vibrations.

Syllabus:
Introduction, Weighted Residual Methods, weak form of WR statement, Principle of stationary total potential (PSTP), Rayleigh – Ritz Method, concept of discretization. General form of total potential and finite element equations, Linear bar element, Quadratic bar element, Cubic bar element, Higher order elements, Beam and plate element, Frame elements, Applications of one dimensional elements, Natural co-ordinates and Co-ordinate transformation, Numerical integration.
Two Dimensional Finite Element Analysis: Introduction, Simple three nodded triangular element, four noded rectangular element, six noded triangular element, serendipity and higher order 2-D elements, Iso-parametric element. Axisymmetric elements. Structural mechanics applications of 2-D and axisymmetric elements, Solution of static Equilibrium Equations. Heat transfer and fluid applications in 2-D.
Introduction to dynamic analysis, Equations of motion based on weak form and using Lagrange approach, Consistent and lumped mass matrix, Solution of Eigen value problems, transient vibration analysis.

Recommended Text Book:
1. Textbook of Finite Element Analysis, P Sheshu, PHI, 2004.
2. Finite Element Methods for Engineers, U S Dixit, Cengage Learning, 2011.

Recommended Reference Book:
1. Concepts and Application of Finite Elements Analysis, Cook, Malkus and Plesha, Wiley.
2. An Introduction to Finite Element Method, J N Reddy, McGraw Hill International Edition.
3. Finite Element Procedures, K J Bathe.

राष्ट्रीय प्रौद्योगिकी संस्थान रायपुर
NATIONAL INSTITUTE OF TECHNOLOGY RAIPUR
(Institute of National Importance)
G.E. Road, Raipur – 492010 (CG)
Phone: (0771) 225 42 00
Fax: (0771) 225 46 00
Email: director.nitrr@rediffmail.com
Website: www.nitrr.ac.in

DEPARTMENT OF MECHANICAL ENGINEERING
SYLLABUS (M. Tech., Machine Design)

Name of the Subject	Engineering Tribology	Subject Code	ME42131ME
Semester	I	Board of Studies	Mechanical Engg.
Maximum Marks	100	Minimum Marks	40
Lecture Periods/Week	Tutorial Periods/Week	Practical Periods/Week	Credits
3	1	0	4

Pre-requisites:
Engineering Mathematics, Engineering Mechanics, Material Science, Strength of Materials, Fluid Mechanics, Dynamics of Machines, Machine Design.

Course Objectives / Outcome: After successful completion of this course, students will be able to:
1. Differentiate between the types of lubricants and its respective application area.
2. Understand and explain different laws of friction and topology of surfaces.
3. Appreciate the various modes of wear and the wear-mechanism maps.
4. Understand behaviour of bearing in different lubrication regimes and able to develop mathematical model.
5. Select the type of bearing for any given required engineering use and determine the load carrying capacity and other related parameters.
6. Decide on the condition monitoring techniques based on performance of tribological components.

Syllabus:

UNIT-I

Tribology, Historical background, practical importance and subsequent use in the field.

Lubricants: Types and specific field of applications. Requisite properties of lubricants. Viscosity, its measurement, effect of temperature and pressure on viscosity, standard grades of lubricants, selection of lubricants.

Lubricant Rheology, Lubrication Types, Basic equation of lubrication.

UNIT – II

Friction: Origin, Friction Theories, measurement methods, friction of metals and non-metals.

Wear: Classification and Mechanisms of Wear, Delamination theory, Debris analysis, testing methods and standards, wear mechanism maps and approach to wear reduction.

Related Case Studies.

UNIT – III

Surface Roughness: Standardization, measurement with contacting and non-contacting instruments, Statistical analysis of surface, characteristics of the surface, tribological behaviour of asperities contact.

Behaviour of Tribological components:

Plain & Antifriction Bearings: selection, effect of frictional torque, factors affecting performance, failure modes, bearing lubrication.

Gears: friction & stresses, wear, lubrication & failure. Failure Case Studies.

UNIT – IV

Hydrodynamic Bearings: Mechanism of pressure development, classification, Idealized Journal Bearing, oil film thickness, pressure distribution, load carrying capacity. Failure Case Studies.

Elastohydrodynamic Lubrication: Theoretical considerations, line and point contacts, film thickness equations, different regimes in EHL contact.

UNIT – V

Antifriction Bearings: Ball and roller bearings, geometry of ball bearings, radial load distribution, stresses and deformations, lubrication of ball bearings. Failure Case Studies.

Phone: (0771) 225 42 00
Fax: (0771) 225 46 00
Email:
director.nitrr@rediffmail.com
Website: www.nitrr.ac.in

Monitoring of Equipment's Condition: Condition monitoring techniques, lubricant, corrosion, temperature & surface roughness monitoring. Failure Case Studies.
Nano/Micro Tribology, Green Tribology.

Recommended Text Book:

1. Engineering Tribology– Prasanta Sahoo – Prentice Hall of India Pvt. Ltd., New Delhi, 2005.
2. Fundamentals of Tribology – S.K. Basu, S.N. Sengupta, B.B. Ahuja – PHI Learning Pvt. Ltd., 2010.
3. Tribology in Industries – S.K. Shrivastava – S. Chand & Company Ltd., New Delhi, 2001
4. Bearing Design in Machinery, Engineering Tribology and Lubrication - A. Harnoy- Marcel Dekker Inc., 2003

Recommended Reference Books:

1. Engineering Tribology – G.W. Stachowiak, A.W. Batchelor – Elsevier India Pvt. Ltd., New Delhi.
2. Introduction to Tribology of Bearings – B.C. Majumdar – S. Chand & Company Ltd., New Delhi.
3. Rolling Bearing Analysis – T.A. Harris – John Wiley & Sons, Inc., New York
4. Engineering Tribology – J. Williams - Cambridge University Press, 2004.

राष्ट्रीय प्रौद्योगिकी संस्थान रायपुर
NATIONAL INSTITUTE OF TECHNOLOGY RAIPUR
(Institute of National Importance)
G.E. Road, Raipur – 492010 (CG)
Phone: (0771) 225 42 00
Fax: (0771) 225 46 00
Email: director.nitrr@rediffmail.com
Website: www.nitrr.ac.in

DEPARTMENT OF MECHANICAL ENGINEERING
SYLLABUS (M. Tech. Machine Design)

Name of the Subject	Experimental Lab I	Subject Code	ME42121ME
Semester	I	Board of Studies	Mechanical Engg.
Maximum Marks	50	Minimum Marks	25
Lecture Periods/Week	Tutorial Periods/Week	Practical Periods/Week	Credits
0	0	3	2

Lab Outcomes: At the end of this Lab, the students are expected to be able to

1. Demonstrate a knowledge and understanding of mechanical and optical comparator.
2. Demonstrate knowledge of machining theory and principles using CNC Lathe Slant bed trainer CLT100 machine.
3. Employ theory of combined stresses to find maximum tensile, compressive, and shear stresses in an element in design of machine components and structures.
4. Analyze and determine Gyroscopic Couple in Motorized Gyroscope.
5. Demonstrate a knowledge and understanding of different types of hardness.

List of Experiments:

1. To determine the major diameter, minor diameter, pitch and semi-angle of a screw using an optical comparator.
2. To perform different types of operations (i.e. drilling, turning , grooving) on a job using CNC lathe slant bed trainer CLT100 with the help of standard G-code and M-code programming .
3. To perform tensile test on the given mild steel specimen using Universal Testing Machine and determine its Young Modulus, ultimate stress yield stress, and percentage elongation by plotting stress – strain graph.
4. To determine the compressive strength of a wood specimen along the grain and across the grain by performing compression test on the Universal Testing Machine .
5. To determine the gyroscopic couple in motorized gyroscope .
6. To determine the Rockwell hardness of the given material .
7. To determine the Brinell hardness of the given material .

राष्ट्रीय प्रौद्योगिकी संस्थान रायपुर
NATIONAL INSTITUTE OF TECHNOLOGY RAIPUR
(Institute of National Importance)
G.E. Road, Raipur – 492010 (CG)

Phone: (0771) 225 42 00
Fax: (0771) 225 46 00
Email: director.nitrr@rediffmail.com
Website: www.nitrr.ac.in

DEPARTMENT OF MECHANICAL ENGINEERING
SYLLABUS (M. Tech. Machine Design)

Name of the Subject	Computational Lab I	Subject Code	ME42122ME
Semester	I	Board of Studies	Mechanical Engg.
Maximum Marks	50	Minimum Marks	25
Lecture Periods/Week	Tutorial Periods/Week	Practical Periods/Week	Credits
0	0	3	2

Lab Outcomes: At the end of the course the students are expected to be able to

1. Gain knowledge and experience of MATLAB/C++/PYTHON, and programming as a tool to solve engineering problems.
2. Explain and perform code development for complex engineering problems and interpret data and conclude results of computational analysis.
3. Prepare CAD models of mechanical components and conduct computer aided design and simulation of mechanisms and machine components using CAD and Simulation software.
4. Prepare, communicate and report the findings of design and analysis effectively.

List of Experiments:

Code Development: Prepare codes to execute the following:

1. Root finding of non-linear equations.
2. Solution of BVPs using RK method and MWR.
3. Numerical integration based on Trapezoidal rule and Simpson's rule.
4. Solution of system of linear equations using GE, GS and GJ iterative schemes.
5. Shape function evaluations and representations.

Computer Aided Design: Using CATIA/ SOLIDWORKS/ FREECAD perform the following:

1. Part creation and solid modelling of mechanical components.
2. Assembly of parts.

Simulation: Using ANSYS/ CAELinux/ ELMER Multi-physics, perform the following:

1. FEA of structures.
2. FEA of mechanical parts subject to thermo/mechanical loads.
3. Flow simulation; simple cases.

References:

1. MATLAB help manual.
2. Excel Guide.
3. CATIA Help Manual/ SOLIDWORKS/ FREECAD help manual.
4. ANSYS Help Manual/ CAELinux/ Elmer MP help manual.

राष्ट्रीय प्रौद्योगिकी संस्थान रायपुर
NATIONAL INSTITUTE OF TECHNOLOGY RAIPUR
(Institute of National Importance)
G.E. Road, Raipur – 492010 (CG)
Phone: (0771) 225 42 00
Fax: (0771) 225 46 00
Email: director.nitrr@rediffmail.com
Website: www.nitrr.ac.in

DEPARTMENT OF MECHANICAL ENGINEERING
SYLLABUS (M. Tech., Machine Design)

Name of the Subject	Advanced Dynamics	Subject Code	ME42211ME
Semester	II	Board of Studies	Mechanical Engg.
Maximum Marks	100	Minimum Marks	40
Lecture Periods/Week	Tutorial Periods/Week	Practical Periods/Week	Credits
3	1	0	4

Course Outcomes: At the end of the course the students are expected to be able to

1. Determine the natural frequencies of a vibrating system and interpret their significance while modelling a mechanical system.
2. Identify various methods of vibration reduction and apply the same for design of engineering structures
3. Understand the governing equations of dynamics and be able to apply them to dynamical systems.
4. Understand the integral and differential forms of the energy equations of dynamics and apply the concept for the analysis of dynamical systems.

Syllabus:

Review of Dynamics, Generalized Coordinates, Scleronomic system, Rheonomic systems, types of coordinate systems, Newton's formulation of Dynamics, Euler's Equation of motion, Hamilton's Variational formulation, Extended Hamilton s principle, Rayleigh's Dissipation function, Systems with Holonomic Constraints, Conservation Laws.

Single degree of freedom (SDOF) system, free and forced vibrations, Harmonic oscillator, SDOF with non-linearity, Damping and damping Models (Coulomb damping, Viscous damping, quadratic damping), Energy dissipation analysis, Energetics, Response of a system to periodic forcing, general forcing, Base excitation, rotating imbalance, Single cylinder Engine vibration analysis. Multi-degree of freedom (MDOF) system, properties of Eigen values and Eigen vectors, Orthogonality, Modal analysis, whirling of shafts, Undamped Vibration absorber, Damped vibration absorber, Approximate methods for finding Natural frequency of MDOF system, Rayleigh quotient.

D'Alembert's principle and Lagrange's equations; Hamilton's equations and their differential form; Integrals of the motion; Dissipative and gyroscopic forces; Maggi's equation; The Boltzmann–Hamel equation; The general dynamical equation; The fundamental equation of dynamics; Volterra's equation;

The Gibbs–Appell equation; Constraints and energy rates; Principle of least constraint; Applications of the energy equations; Integral form of Hamilton's principle; Trans-positional relations; The Boltzmann–Hamel equation-trans-positional form; The central equation and its relation with The Boltzmann–Hamel equation.

Text Books:

1. Principles of Dynamics-Ginsberg-Cambridge University Press.
2. Advanced Dynamics-Ginsberg- Cambridge University Press.
3. Elements of Mechanical Vibration, Leonard Meirovitch, McGraw hill Education, London.

Reference Books:

1. Advanced Dynamics-Shuh-Jing Ying.
2. Advanced Engineering Dynamics-Harrison and Nettleton.
3. Mechanical Vibrations, Singiresu. S Rao, 5th Edition, Prentice Hall

राष्ट्रीय प्रौद्योगिकी संस्थान रायपुर
NATIONAL INSTITUTE OF TECHNOLOGY RAIPUR
(Institute of National Importance)
G.E. Road, Raipur – 492010 (CG)
Phone: (0771) 225 42 00
Fax: (0771) 225 46 00
Email: director.nitrr@rediffmail.com
Website: www.nitrr.ac.in

DEPARTMENT OF MECHANICAL ENGINEERING

SYLLABUS (M. Tech., Machine Design)

Name of the Subject	Advanced Machine Design	Subject Code	ME42212ME
Semester	II	Board of Studies	Mechanical Engg.
Maximum Marks	100	Minimum Marks	40
Lecture Periods/Week	Tutorial Periods/Week	Practical Periods/Week	Credits
3	1	0	4

Pre-requisites: Engineering Mathematics, Engineering Mechanics, Material Science, Strength of Materials, Machine Design, Basic Tribology.

Course Objectives: After successful completion of this course, students will be able to

1. Know different Design Methods, calculate Weight & Metal Content and improve Rigidity & Strengthening of Mechanical Members and Structures.
2. Learn how to analyze products and be able to improve their manufacturability and lower costs.
3. Design machine components which are subjected to fluctuating loads.
4. Distinguish different design criterions and their procedure to carry out the required design steps for designing mechanical components.
5. Explain the contact stresses and implementation of Hertz contact phenomenon to the real field problem.
6. To be able to carry out complete mechanical system design of various mechanisms.

Syllabus:

UNIT I

Design Methods, Weight & Metal Content, Rigidity & Strengthening of Structures. Design for fluctuating loads: Failure theories, Statistical nature of fatigue, S-N curve, low cycle fatigue, strain life equations, structural feature of fatigue, fatigue crack propagation, effect of stress concentration, size, surface properties, metallurgical variables on fatigue. ***Related Design & Failure Case Studies.***

Design Projects: Line Diagram & Force Analysis of: Double ended Fit Spanner, Adjustable Spanner, Combination Pliers, Monkey Pliers, Pipe Wrench, Hacksaw Blade Frame, etc.

UNIT II

General Principles followed when designing Units & parts.

Hydrostatic and Hydrodynamic Lubrication: Newton's Law of viscous forces, Flow through stationary parallel plates. Hagen's poiseuille's theory, Concept of lightly loaded bearings, Petroff's equation.

Hydrodynamic Bearings: Pressure development mechanism. Converging and diverging films and pressure induced flow. Reynolds's 2D equation with assumptions. Expression for load carrying capacity. ***Related Design &Failure Case Studies.***

Design Projects: Line Diagram of Mechanism & Force Analysis of: Simple Speed Reducer, Simple Swivel Window Latch, Hand Drill Machine, Hand Vice, Hand Grinding Machine, Simple Scissor, etc.

UNIT III

Manufacturing Process and Design Considerations: Introduction, Primary, secondary and tertiary processes. Convenience in Maintenance and Operation.

Design of Cast Members, Design of Welded Joints, Design for Forming, Design for Machining.

Design Projects: Line Diagram of Mechanism & Force Analysis of: Bicycle Brake Lever, Hand Operated Crimping Tool, Automobile Scissors Jack, Center-Pull Bicycle Brake Arm Assembly, Hand Screw Press, Machinists Clamp, etc.

UNIT IV

Contact stress: Introductions, Hertz contact theory, contact phenomena, examples. Introduction, problem of determining contact stresses, expressions for principal stresses, Methods of computing contact stresses, Deflection of bodies in point contact, Stresses for two bodies in contact over narrow rectangular area (Line contact), Loads normal to area, Stresses for two bodies in line contact. Normal and Tangent to contact area. Lock / Snap Rings.

Design Projects: Line Diagram of Mechanism & Force Analysis of: Bearing Puller, Universal Joint with Connecting Cross, Water Hand Pump, Air Foot Pump, Air Hand Pump, Electric Wire Stripper, etc.

Phone: (0771) 225 42 00
Fax: (0771) 225 46 00
Email:
director.nitrr@rediffmail.com
Website: www.nitrr.ac.in

UNIT V

Surface fatigue, dynamic contact stresses, surface fatigue failures, surface fatigue strength. Application in Rolling Element bearing, spur, helical and bevel gears. Mechanical System design. ***Related Design &Failure Case Studies. Design Projects: Line Diagram of Mechanism & Force Analysis of:*** Water Tank Automatic Feeder, Hydraulic Door Closer, Tile Cutting Machine, Hand Grinding Machine, Rotary Hammer Machine, Spiral Binding Machine, etc.

Recommended Text Books:

1. Machine Design - An Integrated Approach - Robert L. Norton, Prentice-Hall.
2. Fundamentals of Machine Elements - Hamrock, Schmid and Jacobian, 2nd edition, CRC Press.

Recommended Reference Book:

1. Mechanical Engineering Design - J.E. Shigley and L.D. Mitchell, McGraw Hill International.
2. Fundamentals of Machine Component Design - Robert C Juvinall, Kurt M Marshek, John Wiley & Sons.
3. Fundamentals of Machine Design – Part I to IV - P. Orlov – MIR Publishers, Moscow.

राष्ट्रीय प्रौद्योगिकी संस्थान रायपुर
NATIONAL INSTITUTE OF TECHNOLOGY RAIPUR
(Institute of National Importance)
G.E. Road, Raipur – 492010 (CG)
Phone: (0771) 225 42 00
Fax: (0771) 225 46 00
Email: director.nitrr@rediffmail.com
Website: www.nitrr.ac.in

DEPARTMENT OF MECHANICAL ENGINEERING
SYLLABUS (M. Tech., Machine Design)

Name of the Subject	Composite Mechanics	Subject Code	ME42213ME
Semester	I	Board of Studies	Mechanical Engg.
Maximum Marks	100	Minimum Marks	40
Lecture Periods/Week	Tutorial Periods/Week	Practical Periods/Week	Credits
3	1	0	4

Course Outcomes: At the end of the course the students are expected to be able to
1. Distinguish and categorize the types of composite materials.
2. Apply the concepts of tensors and estimate the engineering constants of composite materials.
3. Identify and apply the concepts of plate theory in solving composite structural problems.
4. Interpret the cause of failure of the composite structures.
5. Apply Micromechanics principles in estimating the properties of fibrous composites

Syllabus:
Introduction to composites, Historical Development, The constituents of Composite material, Classification of composites, Classification based on Reinforcement types, Classification based on matrix, Common Categories of composite materials based on fiber strength, Examples of composite materials, role and selection of fiber, role of matrix materials, Advantages and limitations of composite materials, comparison with metals, fabrication process and application of composites.
Concept of tensor, Deformation of a body, Stress, equilibrium equations, constitutive equations, Principles of work and energy, Stress symmetry, Strain Symmetry, Strain energy density function, Material symmetry, Symmetry with respect to plane, symmetry with respect to two orthogonal planes, transverse isotropy, Isotropic bodies, engineering constants, constitutive equations for an orthotropic material, constraints on engineering constants, stress and strain transformation, stiffness transformation, compliance transformation, thermal effects, lamina constitutive relations.
Introduction to classical plate theory, Equilibrium equations for analysis of composite plates, Displacement fields, Strain displacement relations, in-plane resultant forces, resultant moments, laminate constitutive relations, classification of laminates, cross-ply laminates, specially orthotropic laminates, laminate engineering constants, in-plane laminate engineering constants, flexural engineering constants of laminates, laminate theory with thermal effects, laminate theory with hygral effects and governing equations for classical laminate theory, Virtual work approaches, application of Galerkin's method for composite plate, Energy Methods, geometric non-linearity in composite plates, buckling and geometric non linearity, buckling of plates,
Damage mechanics of Unidirectional composites, Defects in composites, damage mechanics of fibrous composites, micro level damage mechanics, matrix level damage mechanics, macro level failure mechanisms, coupled micro-macro level failure mechanisms macroscopic failure theories, Tsai-hill theory, Hoffman theory, Tensor polynomial failure theory.
Micromechanics, Strength of materials approach, concept of equivalent homogeneity, concept of energy equivalence, standard mechanics approach, Hill concentration factor approach, homogenization, Background of concentric cylinder assemblage model, self-consistent Mori-Tanaka and Halpin-Tsai Model, Background of Mechanical testing, Effect of anisotropy of composites in mechanical testing, samples and specimens for mechanical testing, Design consideration of composites

Recommended Text Book:

1. Analysis and Performance of Fiber Composites, Agarwal, B.D. and Broutman, L. J., John Wiley & Sons.
2. Mechanics of Composite Materials, Jones, R. M., Mc-Graw Hill.

Phone: (0771) 225 42 00
Fax: (0771) 225 46 00
Email:
director.nitrr@rediffmail.com
Website: www.nitrr.ac.in

3. Engineering Mechanics of Composite Materials, Daniel, I. M. and Ishai, O., Oxford University Press.

Recommended Reference Books

1. Mechanics of Composite Materials, Autar K. Kaw, CRC.
2. Advanced Mechanics of Composite Materials, Vasiliev and Morozov, Elsevier.

राष्ट्रीय प्रौद्योगिकी संस्थान रायपुर
NATIONAL INSTITUTE OF TECHNOLOGY RAIPUR
(Institute of National Importance)
G.E. Road, Raipur – 492010 (CG)
Phone: (0771) 225 42 00
Fax: (0771) 225 46 00
Email: director.nitrr@rediffmail.com
Website: www.nitrr.ac.in

DEPARTMENT OF MECHANICAL ENGINEERING
SYLLABUS (M. Tech., Machine Design)

Name of the Subject	Advanced Materials	Subject Code	ME42214ME
Semester	I	Board of Studies	Mechanical Engg.
Maximum Marks	100	Minimum Marks	40
Lecture Periods/Week	Tutorial Periods/Week	Practical Periods/Week	Credits
3	1	0	4

Course outcomes:
1. Explain how the micro-structure and processing route for steels and non-ferrous alloys influence the resulting mechanical properties
2. Identify and apply methodologies for the selection of specific materials (steels, stainless steels, polymers and composites) for different applications
3. Explain the use of different types of light metal and their alloys with metallurgical aspects.
4. Describe properties and applications of smart and Nano materials.

Syllabus:

Special Steel and their alloys

Metallurgical aspects, Composition, Properties and applications of: different types of Stainless steels, Dual phase steels, TRIP steels, Maraging steels, High speed steels, Free cutting steels, Ausformed steels, Tool Steels, manganese steels, chrome steels, electrical steels, bearing steels, spring steels, heat resistant steels, creep steels, HSLA steels etc.,

Light metals and their alloys

Need of alloying, Aluminium, magnesium and titanium alloys: Metallurgical aspects, Properties and applications.

Nano and Smart materials

Definition, Types, Properties and applications, Carbon nano tubes, Methods of production, Shape memory alloys, Piezoelectric materials, Electro active Polymers, Electro-rheological fluid, Functionally gradient material (FGM), biomaterials, micro-electro mechanical systems (MEMS).

Miscellaneous Advanced Materials

Magnetic materials, ceramics, composites and polymers, surface metal matrix composites, aerospace materials, and cryogenic materials, semi conducting and superconducting materials.

Processing and Characterization of Advance Materials

Processing of Metal Matrix Composites, Polymer Matrix Composites, Ceramic Matrix Composites
Properties and applications: Strength, stiffness, creep, fatigue and fracture; thermal, damping and tribological properties.

Recommended Text Books:
1. The Science and Engineering of Materials, D. R. Askeland and P. P. Phule, Thomson Publication
2. Advances in Material Science, R. K. Dogra and A. K. Sharma
3. Material science, Van Black
4. Engineering Materials and Applications, R. A. Flinn and P. K. Trojan
5. Light Alloys: Metallurgy of Light Metals, I. J. Polmear
6. Engineering Materials: Properties and applications of Metals and alloys, CP Sharma, PHI
7. Engineering Materials: Polymers, ceramics and composites, AK Bhargava, PHI
8. Nano Technology, AK Bandyopadhyay, New age international publishers

Recommended Reference Books:
1. Gandhi, M.V., Thompson, B.S., Smart Materials and Structures, Chapman and Hall
2. Ray, A.K. (ed), Advanced Materials, Allied publishers.
3. Rama Rao, P. (ed), Advances in Materials and their applications, Wiley Eastern Ltd.
4. Bhushan, B., Nano Technology (ed), Springer, International Edition.

राष्ट्रीय प्रौद्योगिकी संस्थान रायपुर
NATIONAL INSTITUTE OF TECHNOLOGY RAIPUR
(Institute of National Importance)
G.E. Road, Raipur – 492010 (CG)
Phone: (0771) 225 42 00
Fax: (0771) 225 46 00
Email: director.nitrr@rediffmail.com
Website: www.nitrr.ac.in

DEPARTMENT OF MECHANICAL ENGINEERING
SYLLABUS (M. Tech., Machine Design)

Name of the Subject	Industrial Robotics	Subject Code	ME42231ME
Semester	II	Board of Studies	Mechanical Engg.
Maximum Marks	100	Minimum Marks	40
Lecture Periods/Week	Tutorial Periods/Week	Practical Periods/Week	Credits
3	1	0	4

Course Outcomes: At the end of the course the students are expected to be able to
1. Be familiar with serial robotic manipulators.
2. Apply various transformations using D-H scheme for kinematic modeling of serial robotic manipulator.
3. Develop forward and inverse kinematic models of serial robotic manipulators.
4. Understand use of various sensors used in robotic manipulators.
5. Solve basic path planning and control problems related to serial robotic manipulator.
6. Understand vision system related to robotic manipulators.

Syllabus:

Automation-fixed and flexible, need and scope of industrial robots , evolution of robots and robotics Laws of robotics, robot anatomy, arm configurations and work volume, human arm characteristics , end effectors – vacuum, magnetic and air operated grippers, actuator – hydraulic , pneumatic and electrical drives.

Coordinate frames, transformation of vectors, rotation matrix, composite transformation, inverting a homogeneous transforms, Denavit and Hartenberg notations, manipulator transformation matrix, direct and inverse kinematics, direct kinematics models of PUMA, SCARA, Stanford and other robotics manipulators, inverse kinematic solutions of robotic manipulators, differential motion.

Robot trajectories, trajectory planning of robotic manipulators, joint space trajectory planning, polynomial trajectories, parabolic blending, Cartesian space trajectory planning.

Transducers and sensors , sensor characteristics , internal and external sensors , position, velocity and acceleration sensors , force sensors, tactile sensors , proximity and range sensors, sensing joint forces, strain gauges and strain rosettes, control of robots, open and close loop control.

Robotic vision system, image representation, image grabbing, image processing and analysis, edge enhancement, contrast stretching, band rationing, image segmentation, pattern recognition.

Text Books

1. Robotics and Control, R K Mittal and I J Nagrath, TMH, New Delhi.

Reference Books

1. Robotics- K.S.Fu, R.C. Gonzalez and C.S.G. Lee, McGraw Hill
2. Introduction of Robotics – Mechanics and control by J.J. Craig, Addision-Wesley.
3. Robot Engineering: An Integrated Approach, R.D. Klafter, T.A. Chmielewski and M. Negin, Prentice Hall India.
4. Introduction to Robotics Analysis, system Application, saeed B. Niku, Pearson Education.
5. Kinematics synthesis of linkages, Hardenberg and Denavit.
6. Introduction to Robotics, S.K. Saha, Mcgraw Hill.

राष्ट्रीय प्रौद्योगिकी संस्थान रायपुर
NATIONAL INSTITUTE OF TECHNOLOGY RAIPUR
(Institute of National Importance)
G.E. Road, Raipur – 492010 (CG)

Phone: (0771) 225 42 00
Fax: (0771) 225 46 00
Email: director.nitrr@rediffmail.com
Website: www.nitrr.ac.in

DEPARTMENT OF MECHANICAL ENGINEERING
SYLLABUS (M. Tech. Machine Design)

Name of the Subject	Experimental Lab II	Subject Code	ME42221ME
Semester	I	Board of Studies	Mechanical Engg.
Maximum Marks	50	Minimum Marks	25
Lecture Periods/Week	Tutorial Periods/Week	Practical Periods/Week	Credits
0	0	3	2

Course Outcomes: At the end of this Lab, the students are expected to be able to

1. Demonstrate a knowledge and understanding of different mechanical properties
2. Demonstrate knowledge of machining theory and principles using CNC Lathe Slant bed trainer CLT100 machine.
3. Employ theory of combined stresses to find maximum tensile, compressive, and shear stresses in an element in design of machine components and structures.
4. Analyze and determine forming limit diagram by performing a cupping test.
5. Demonstrate a knowledge and understanding of structural behavior of the materials

List of Experiments

1. To perform tensile test on the given mild steel specimen using Universal Testing Machine and determine the toughness, resilience and strain rate by fitting a polynomial curve for stress-strain.
2. To perform compression test of a wood specimen using compression testing machine and Universal Testing Machine and compare the performance characteristic of both machines.
3. To prepare a job using CNC lathe slant bed trainer CLT-100 machine and cut viewer turn software .
4. To study the various characteristic i.e. sensitivity, linearity , range , response time , and resolution of an infrared detection sensor .
5. To determine the formability of a given specimen by performing a cupping test .
6. To observe a specimen using X-ray diffraction technique.
7. To observe a specimen using Scanning Electron Microscope .
8. To perform a mini-project on the assigned topic .

Phone: (0771) 225 42 00
Fax: (0771) 225 46 00
Email: director.nitrr@rediffmail.com
Website: www.nitrr.ac.in

DEPARTMENT OF MECHANICAL ENGINEERING
SYLLABUS (M. Tech. Machine Design)

Name of the Subject	Computational Lab II	Subject Code	ME42222ME
Semester	II	Board of Studies	Mechanical Engg.
Maximum Marks	50	Minimum Marks	25
Lecture Periods/Week	Tutorial Periods/Week	Practical Periods/Week	Credits
0	0	3	2

Lab Outcomes: At the end of the course the students are expected to be able to

1. Further advance the knowledge and experience of MATLAB/C++/PYTHON, and programming as a tool to solve engineering problems.
2. Explain and perform code development for complex engineering problems and interpret data and conclude results of computational analysis.
3. Prepare CAD models of mechanical assemblies and conduct computer aided design and simulation of complex engineering phenomenon using CAD and Simulation software.
4. Further advance the ability to prepare, communicate and report the findings of design and analysis effectively.

List of Experiments:

Code Development: Prepare codes to execute the following:

1. Solution of non-linear ODE using B-Spline collocation technique.
2. Solution of PDE using FD methods.
3. Numerical integration based on GLQ in 1, 2 and 3 dimensions.
4. Optimization of single/ multivariable unconstrained/ constrained objective functions.

Computer Aided Design: Using CATIA/ SOLIDWORKS/ FREECAD perform the following:

1. Assembly of complex mechanisms and machines and piping and routing assembly.
2. Motion analysis of mechanisms.

Simulation: Using ANSYS/ CAELinux/ ELMER Multi-physics, perform simulations on the following:

1. Contact analysis.
2. Geometry and material non-linearity.
3. Coupled field problems; thermo-mechanical and fluid structure interaction.
4. Acoustics.

References:

1. MATLAB help manual.
2. Excel Guide.
3. CATIA Help Manual/ SOLIDWORKS/ FREECAD help manual.
4. ANSYS Help Manual/ CAELinux/ Elmer MP help manual.