NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

DEPARTMENT OF MECHANICAL ENGINEERING

Revised Curriculum and Syllabi

Program Name
Master of Technology in Machine Design
Effective from the Academic Year: 2021-2022

Recommended by DPAC	: 06.08.2021
Recommended in PGAC	: 16.08.2021
Approved by the Senate	: 22.08.2021

CURRICULUM

Sl. No.	Subject Code	Name of the Subject	L	T	S	C	H
Semester I							
1.	ME 1001	Machine Dynamics and Control	3	0	2	4	5
2.	ME 1002	Advanced Mechanics of Solids	3	0	2	4	5
3.	ME 1003	Analysis and Synthesis of Mechanisms	3	0	2	4	5
4.	ME 90XX	Elective-I	3	0	0	3	3
5.	ME 1051	Computational Laboratory	1	0	4	3	5
					Total Credit	**18**	**23**
Semester II							
1.	ME 2001	Machine Design	3	0	2	4	5
2.	ME 2002	Mechanical Vibrations	3	0	2	4	5
3.	ME 90XX	Elective-II	3	0	0	3	3
4.	ME 90XX	Elective-III	3	0	0	3	3
5.	ME 90XX	Elective-IV	3	0	0	3	3
6.	ME 2051	Machine Design Laboratory	0	0	3	1.5	3
7.	ME 2052	Computer Aided Design Laboratory	0	0	3	1.5	3
8.	ME 2053	Mini Project with Seminar	0	0	4	2	4
					Total Credit	**22**	**29**
Semester III							
1.	ME907X	Audit Lectures / Workshops/ Special Topics in Machine Design	1	0	0	0	1
2.	ME 3051	Dissertation - I	0	0	24	12	24
3.	ME 3052	Seminar - Non-Project / Evaluation of Summer Training	0	0	4	2	4
					Total Credit	**14**	**30**
Semester IV							
1.	ME 4051	Dissertation - II / Industrial Project	0	0	24	12	24
2.	ME 4052	Project Seminar	0	0	4	2	4
					Total Credit	**14**	**28**
TOTAL CREDIT POINT : 68, TOTAL CONTACT HOURS: 110							

LIST OF SUBJECTS FOR ELECTIVE I AND II

Sl. No.	Subject Code	Name of the Subject
1.	ME 9011	Applied Computational Methods
2.	ME 9014	Operations Research
3.	ME 9016	Mechatronics
4.	ME 9018	Finite Element Methods
5.	ME 9019	Robotics
6.	ME 9022	Modern Manufacturing Processes
7.	ME 9023	Computer Aided Design
8.	ME 9026	Tribology
9.	ME 9028	Material Handling Equipments
10.	ME 9029	Optimization in Engineering Design
11.	ME 9030	Design of Machine Tools
12.	ME 9044	Fluid Power Systems and Control

LIST OF SUBJECTS FOR ELECTIVE III AND IV

Sl. No.	Subject Code	Name of the Subject
1.	ME 9012	Introduction to Non-linear Dynamic Systems and Control
2.	ME 9013	Theory of Plates and Shells
3.	ME 9015	Theory of Elasticity and Plasticity
4.	ME 9017	Microsystem Design
5.	ME 9020	Knowledge Based Systems
6.	ME 9024	Mechanics of Composite and Functionally Graded Material
7.	ME 9025	Modelling and Simulation of Mechanical Systems
8.	ME 9050	Mathematical Methods in Engineering
9.	ME9063	Lubrication Engineering

SYLLABUS

<table>
<tr><td colspan="8">Department of Mechanical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ME1001</td><td>Machine Dynamics and Control</td><td>PCR</td><td>3</td><td>0</td><td>2</td><td>5</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Fundamental knowledge of Mechanics and Theory of Machines in B.Tech/BE(Mech)</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Students will be able to formulate the procedure for modeling various types of Machines and/ or its components
CO2: Students will learn to study the performance of various systems with respect to time and the procedure to improve.
CO3: Students will learn to identify various types of coordinate frames required for describing the behavior of different mechanisms.
CO4: Students will be able to formulate and evaluate behavior of linear time continuous control systems.
CO5: Students will be able to identify and critically evaluate current developments and emerging trends within the field of control systems.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Topics — Hours
Generalized Forces and Coordinates, Lagrange’s Equations — 8
Cam dynamics — 6
Balancing of rotors, Field balancing — 6
Rotor dynamics, Gyroscope: action and applications — 8
System Modeling, Block diagrams, Transfer functions — 4
Dynamic response of systems — 4
Structure of Control systems and Control Laws — 4
PID control - principle and design — 4
Stability criteria – Frequency response plot — 4
Root locus plot analysis — 4
State-space representations — 4</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Theory of Mechanisms and Machines, Ghosh, Mallik
2. Modern Control Engineering, Ogata

Reference Books
1. Theory of Machines and Mechanisms, Shigley, Uicker
2. Automatic Control System, Kuo</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ME1002</td><td>Advanced Mechanics of Solids</td><td>PEL</td><td>3</td><td>0</td><td>2</td><td>5</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Solid Mechanics Course in B. Tech level</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">CO1: Student will learn about 3-D state of stress and strain
CO2: Student will learn to derive governing equations related to solid mechanics.
CO3: Student will be able to sole various critical engineering problems related to solid mechanics like beam on elastic foundation, curved beam, plate bending and stability problem</td></tr>
<tr><td>Topics Covered</td><td colspan="6">Topics — Hours
Introduction — 4
Stress and Strains in 3-D – Cauchy formula, Principal Stress, hydrostatic stress, deviatoric stress, Mohr circle, octahedral stresses, principal strain, plane state of stress, plane state of strain etc. — 14
Theories of failure — 6
Beam on elastic foundations — 5
Bending of curved beams – Crane Hooks & Chains — 5
Bending of thin plates (Equation for thin rectangular and circular plates, Navier's and Levy's solution for rectangular plates) — 8
Elastic stability, Euler's buckling load, Beam column for various load — 6
Unsymmetrical bending, shear centre — 8</td></tr>
<tr><td rowspan="2">Text Books, and/or reference material</td><td colspan="6">Text Books:
1. Advanced Mechanics of Solids, L. S. Srinath
2. Advanced Strength of Materials, J. P. Denhartog
3. Advance Mechanics of Materials, A. P. Boresi & R. J. Schmidt</td></tr>
<tr><td colspan="6">Reference Books:
1. Advanced Mechanics of Solids, Otto T. Bruhns
2. Solid Mechanics, Clive L. Dym, Irving H. Shames
3. Solid Mechanics, Kazimi</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ME1003</td><td>Analysis and Synthesis of Mechanisms</td><td>PCR</td><td>3</td><td>0</td><td>2</td><td>5</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Engineering Mechanics, Theory of Machine</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Students will be able to understand the need of multi-body mechanics
CO2: Students will be able to formulate and evaluate kinematic behavior of different mechanisms
CO3: Students will be able to synthesize and analyse the multi-body systems involving different types of mechanisms.</td></tr>
<tr><td rowspan="2">Topics Covered</td><td colspan="6">Topics</td><td>Hours</td></tr>
<tr><td colspan="6">Introduction to rigid-link mechanisms: Kinematic pairs, kinematic chains, planar mechanisms, spatial mechanisms, equivalent mechanism, kinematic inversion, mobility, transmission angle, deviation angle etc.

Kinematic analysis of rigid-link mechanisms: displacement, velocity and acceleration analysis of planar mechanisms and spatial mechanisms.

Synthesis of rigid-link mechanisms: Type synthesis, number synthesis, dimensional synthesis, Chebyshev polynomials, Freudenstein’s displacement equation, Dimensional synthesis methods e.g. algebraic methods, complex numbers method, Bloch’s method etc., Coupler-curve synthesis and cognate linkages, Introduction to dimensional synthesis of spatial mechanisms.

Analysis and synthesis of Cams

Introduction to compliant mechanisms: Historical background, Advantages and Challenges of compliant mechanisms, Analysis of compliant mechanisms

Introduction to micro mechanisms: Science of miniaturism, Scaling laws in micromechanisms, Advantages and current trends.</td><td>3

14

16

10

7

6</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Kinematic Analysis and Synthesis by Mallik, Ghosh, Dittrich
2. Kinematic Synthesis of Linkages, Hartenberg, Denavit
3. Compliant Mechanisms, Howell</td></tr>
<tr><td></td><td colspan="7">Reference Books:
1. Theory of Machines and Mechanisms, Uicker, Pennock, Shigley
2. Advanced Mechanism Design: Analysis & Synthesis, Sandor, Erdman</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ME1051</td><td>Computational Laboratory</td><td>PEL</td><td>1</td><td>0</td><td>4</td><td>5</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Applied Computational Methods</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Students will get idea of different programming languages
CO2: Students will learn to develop algorithm for different problems
CO3: Students will learn to write computer program to solve different engineering problems using various numerical methods</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction to programming using high level language (C/C++/Fortran/MATLAB)
Computer programming for solving linear simultaneous equations, non-linear equations
Numerical differentiation and integration
Solution of ordinary differential equations and solution of partial differential equations
Eigen value problems, Boundary value, Initial value problems
Problems as assigned by the respective teachers</td></tr>
<tr><td rowspan="2">Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Getting started with Mat lab By Rudra Pratap
2. Mat Lab Programming for Engineers By S. J. Chapman
3. Computer Programming in Fortran 90 and 95 by Rajaraman</td></tr>
<tr><td colspan="7">Reference Books:
1. Numerical Methods By B. S. Grewal
2. Numerical Recipes in Fortran By W. H. Press, S. A. Teukolsky, W. T. Vetterling and B. P. Flannery</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ME2001</td><td>Machine Design</td><td>PCR</td><td>3</td><td>0</td><td>2</td><td>5</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Advanced Mechanics of Solids</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Students will be able to identify the significant loads on various Machine Components
CO2: Students will learn types of Lubrication methods and various design aspects of sliding contact bearings.
CO3: Students will learn to visualize the stress in machine components having complicated shape.
CO4: Students will be able to design machine components for given lifespan and also predict damage that can occur during its.
CO5: Students will be able to understand the functioning of gears and the concept of maximum load that can appear on such gears and methods to be adopted for improving the life of gears.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Topics — Hours
Hydrodynamic Lubrication of Sliders and Bearings, Long and Short Bearings, Pressure distribution, Oil film thickness, Load carrying capacity, Friction and heating of journal bearing. — 14
Torsion of noncircular shafts. — 8
Press fitted assemblies and rotating discs. — 13
Fatigue strength, Fluctuating loads, Cumulative fatigue damage. — 9
Contact stresses. — 6
Dynamic load on gears — 6</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1.Introduction to Tribology , B. C. Majumder
2. Advanced Strength of Materials, Seely, Smith

Reference Books
1. Analytical Mechanics for Gear, E. Buckingham
2. Analysis of Mechanical Design, A. Burr</td></tr>
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Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ME2002	**Mechanical Vibrations**	PCR	**3**	**0**	**2**	**5**	**4**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Theory of Machines		CT+EA					
Course Outcomes	CO1: Understanding the fundamental material for a modern treatment of vibrations. CO2: Application of Lagrange equations for lumped and continuous systems CO3: Understanding fundamentals of beam theory; extensional, torsional, and flexural vibrations of beams. CO4: Understanding Self-excited vibration, nonlinear vibration etc.						
Topics Covered	Topics						Hours
	Review of relevant mathematics: linear algebra)						5
	Generalized co-ordinates, Lagrange's equations						5
	Single-DOF and multi-DOF vibration						10
	Vibration Absorber						3
	Torsional vibration						5
	Periodic excitation and Fourier series, impulse and step response						8
	Vibration in continuous systems						5
	Self-excited vibration, Criterion of stability; Effect of friction						6
	Introduction to nonlinear vibration						9
Text Books, and/or reference material	Suggested Text Books: 1. Mechanical Vibrations, S. S. Rao, Pearson 2. Fundamental of Vibrations Leonard Meirovitch, Mc-Graw Hill 3. Vibration and Control, D. J. Inman, John Willey Reference Books: 1. Mechanical Vibrations, S. Tamadonni & Graham S. Kelly, Schaum's Out line Series, Mc-Graw Hill. 2. Vibration Condition Monitoring of Machines, J. S. Rao, Tata Mc-Graw Hill						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ME 2051	**Machine Dynamics Laboratory**	PEL	**0**	**0**	**3**	**3**	**1.5**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
ME2051		CT+EA					
Course Outcomes	CO1: Acquire basic idea about the rotor balancing CO2: To understand the method of implementation of different control laws						
Topics Covered	Experiment on rotor balancing						12
	Experiment on Gyroscope						12
	Experiment on Digital Pendulum System						8
	Experiment on Twin Rotor MIMO System						8
	Problems as assigned by the respective teachers						16

Text Books, and/or reference material	**Text Books:** 1. Theory of Mechanisms and Machines, Ghosh, Mallik 2. Modern Control Engineering, Ogata
	Reference Books 1. Theory of Machines and Mechanisms, Shigley, Uicker 2. Automatic Control System, Kuo

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ME 2052	**Computer Aided Design Laboratory**	PEL	**0**	**0**	**3**	**3**	**1.5**
Pre-requisites Machine Design, Analysis & synthesis of Mechanisms		Course Assessment methods (Continuous (CT) and end assessment (EA))					
ME2051		CT+EA					
Course Outcomes	• CO1: Able to understand scope and application of CAD/CAM tools in industry • CO2: Able to learn geometric modelling and computer graphics concept in CAD tools • CO3: Able to learn CAE software packages						
Topics Covered	Solid Modeling using software packages Graphics programming using MATLAB Demonstration of CAE software packages like ANSYS, ADAMS Computer Aided Analysis of Mechanisms						
Text Books, and/or reference material	**Text Books:** 1. Mastering CAD/CAM by I. Zeid 2. Computer Graphics by Roy A Plastock						
	Reference Books 1. Finite Element Method by J.N.Reddy						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ME 2053	Mini Project with Seminar	PCR	**0**	**0**	**4**	**4**	**2**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA)					
NA		CT+EA					
Course Outcomes	CO1: To be able to conduct review of literature to arrive at selected advanced topic for project work. CO2: Ability to interpret ideas and thoughts into practice in a project. CO3: Ability to analyze the gap between theoretical and practical knowledge. CO4: To be able to write and present a technical report with suitable conclusion as per international standards CO5: To be able to discuss and depend the outcome of the report in a seminar						
Topics Covered	Project as decided based on literature survey with consultation with the supervisor						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ME 3051	DISSERTATION - I	PCR	**0**	**0**	**24**	**24**	**12**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NA		CT+EA					
Course Outcomes	CO1: Ability to interpret ideas and thoughts into practice in a project. CO2: Ability to analyze the gap between theoretical and practical knowledge. CO3: Ability to compose technical presentation in the conferences. CO4: Ability to prepare for publishing papers in journals. CO5: Ability to propose for the patent rights for the projects.						
Topics Covered	Project as decided based on literature survey with consultation with the supervisor						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ME 3052	**Seminar (Non Project)**	PCR	**0**	**0**	**4**	**4**	**2**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NA		CT+EA					
Course Outcomes	CO1: To be able to conduct review of literature to arrive at selected advanced topic for seminar. CO2: To be able to summaries the concept of the chosen topic systematically after considerable study of the content from primary as well as secondary sources CO3: To be able to write and present a technical report with suitable conclusion as per international standards CO4: To be able to discuss and depend the outcome of the report in a seminar						
Topics Covered	Topics decided by consultation with the supervisor						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ME 4051	**DISSERTATION - II / INDUSTRIAL PROJECT**	PCR	**0**	**0**	**24**	**24**	**12**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NA		CT+EA					
Course Outcomes	CO1: Ability to interpret ideas and thoughts into practice in a project. CO2: Ability to analyze the gap between theoretical and practical knowledge. CO3: Ability to compose technical presentation in the conferences. CO4: Ability to prepare for publishing papers in journals. CO5: Ability to propose for the patent rights for the projects.						
Topics Covered	Project as decided based on literature survey with consultation with the supervisor						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ME 4052	**Project Seminar**	**PCR**	**0**	**0**	**4**	**4**	**2**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NA		CT+EA					
Course Outcomes	CO1: Ability to assess knowledge in the subject and the project. CO2: Ability to integrate technical question through all the years of study. CO3: Ability to express and communicate.						

SYLLABUS OF ELECTIVE SUBJECTS

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ME9011	**Applied Computational Methods**	PEL	**3**	**0**	**0**	**3**	**3**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Engineering Mathematics in B. Tech Level		CT+EA					
Course Outcomes	CO1: Students will be able to understand common numerical methods and how they are used to obtain approximate solutions. CO2: Derive numerical methods for various mathematical operations and tasks, such as interpolation, differentiation, integration, the solution of linear and nonlinear equations, and the solution of differential equations. CO3: Analyze and evaluate the accuracy of common numerical methods.						

Topics Covered	Topics	Hours
	Solution of linear simultaneous equations, matrix Inversion	6
	Solution of non-linear equation of one variable and solution of system of non-linear simultaneous equation	6
	Interpolation and curve fitting	4
	Numerical differentiation and integration	4
	Solution of ordinary differential equations and solution of partial differential equations	4
	Discrete and Fast Fourier transformation	5
	Analysis of Eigen value problems	4
	Application to different types of Boundary value, Initial value and Eigen value problems	4
	Brief discussion on software for numerical solution	2

Text Books, and/or reference material	**Text Books:** 1. Advanced Engineering Mathematics, E. Kreyszig 2. Numerical Methods for Scientist and Engineers, R. W. Hamming 3. Applied Mathematics for Engineers and Physicists By Pipes and Harvill
	Reference Books: 1. Introduction to Numerical Analysis, F. B. Hildebrand 2. Fundamentals of Engineering Numerical analysis, P. Moin

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ME 9012	**Introduction to Non-linear Dynamic Systems and Control**	PCR	**3**	**0**	**0**	**3**	**3**
Pre-requisites Nonlinear Vibrations Mechanical Vibrations		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes	● CO1: Understanding the various characteristics of nonlinear dynamic system. ● CO2: Development of solution procedures employing approximate methods. ● CO3: Develop the concept of stability and different methods for stability and bifurcation analysis. ● CO4: Analysis of nonlinear system employing numerical techniques and comparing the results with approximate methods.						
Topics Covered	Topics — Hours Introduction, General properties of nonlinear systems, Phase plane analysis, Equilibrium solutions, Active and feedback concepts for control — 4 Well-developed analytical/semi-analytical and numerical methods for analysis — 12 Study of periodic, sub-harmonic, super-harmonic and chaotic motions of uncontrolled and controlled nonlinear dynamic systems — 9 Definition of stability, Stability of linear systems, Stability of nonlinear systems, Liapunov theorems, frequency domain criteria, stability of fixed points, stability of periodic solutions — 9 Control of periodic, sub-harmonic, super-harmonic and chaotic motions — 10						
Text Books, and/or reference material	Suggested Text Books: 1. Nayfeh, A. H., and Mook, D. T., Nonlinear Oscillations, Wiley-Interscience. 2. Hayashi, C. Nonlinear Oscillations in Physical Systems, McGraw-Hill. Reference Books: 1. Nonlinear Ordinary Differential Equations: An Introduction for Scientists and Engineers, D. Jordon and P. Smith, Oxford 2. Evan-Ivanowski, R. M., Resonance Oscillations in Mechanical Systems, Elsevier. 3. Nayfeh, A. H., and Balachandran, B., Applied Nonlinear Dynamics, Wiley. 4. Seydel, R., From Equilibrium to Chaos: Practical Bifurcation and Stability Analysis, Elsevier.						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ME9013	**Theory of Plates and Shells**	PEL	**3**	**0**	**0**	**3**	**3**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Advanced Mechanics of Solids		CT+EA					
Course Outcomes	CO1: Students will be able to use different theories to plate and shell CO2: Students will be able to use Theory of virtual displacement to get governing equation of different structural members like beams, plates shells etc. CO3: Students will be able to solve different plate, shell problems using analytically and numerically						
Topics Covered	Stress strain relations, strain displacement relation, equations of equilibrium, virtual work principle, Classical plate theory, FSDT, HSDT. (6) Pure bending and cylindrical bending of isotropic rectangular plates, Navier and Levy solutions of rectangular plates (6) Bending of circular plates (4) Bending analysis of laminated composites plates (6) Approximate solution methods for plate problems (6) Dynamics of Plates (3) Basic Concepts of Shell Type of Structures – Membrane and Bending Theories for Circular Cylindrical Shells (9)						
Text Books, and/or reference material	**Text Books:** 1. Theory and Analysis of Elastic Plates and Shells, J. N. Reddy 2. Theory of Plates and Shells, S. Timoshenko						
	Reference Books: 1. Mechanics of Laminated Composite Plates and Shells Theory and Analysis, J. N. Reddy 2. Theories and Applications of Plate Analysis, R. Szilard 3. Plates Theory and Applications By K. Bhaskar and T. K. Varadan						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ME9014	**Operations Research**	PEL	**3**	**0**	**0**	**3**	**3**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	CO1: Students will be able to discuss the history, concepts, formulations and applications of operations research. CO2: Students will be able to analyze and solve conflicting problems on constrained linear optimization problems having single and multiple objectives. CO3: Students will be able to apply integer, dynamic programming methods for solving relevant problems.						
Topics Covered	Origin, growth, definition, methodology and application of OR. 2 Linear Programming, Mathematical Modelling, Graphical Method of Solution, Sensitivity						

	Analysis.	10
	Simplex Method, Big M and 2-Phase Methods, Duality in LP.	10
	Transportation problem.	4
	Assignment Problem	3
	Sequencing problem.	3
	Queuing model and Simulation.	4
	Competitive Decision Making, Game Theory.	4
	Duality Theory and Sensitivity Analysis.	4
	Integer Programming, Binary Integer Programming.	4
	Dynamic Programming.	4
	LP- Softwares	4
Text Books, and/or reference material	**Text Books:** **1.** Basu, S. K., Pal, D. K., Bagchi, H., Operation Research for Engineers, 2nd Edition, Oxford & IBH Publishing Co. Pvt. Ltd., 1998 **2.** Hillier, Fredrick S. and Lieberman, Gerald J., Introduction to Operations Research, 7th Edition, TMH, 2001. **3.** Taha, H. A., Operation Research, McMillan Publishing Co., London, 1982.	
	Reference Books: **1.** Churchman, C. M., Ackoff, R. L., Arnoff, E.L., Introduction to Operation Research, Asia Publishing o., 1962 **2.** Hanssmann, F., Operations Research in Production and Inventory Control, John Wiley & Sons, Inc., London, 1962.	

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ME 9015	**Theory of Elasticity and Plasticity**	PEL	**3**	**0**	**0**	**3**	**3**
Pre-requisites		Machine design and production engineering courses in any B.Tech Mechanical Engineering Program.					
Strength of Materials		CT+EA					
Course Outcomes	CO1: Students will be able to identify the importance of use of properties of Plasticity and Elasticity. CO2: Students will be able to gather knowledge about mechanics of different materials. CO3: Students will be able to solve the problems of flexure in Cartesian as well as polar coordinate systems. CO4: Apply different numerical and energy methods to solve problems of elastic materials. CO5: Students will be able to gather knowledge of mechanics of metal forming.						
Topics Covered	• Introduction to elasticity: concept of stress and strain, Scalar, Vector, Matrix, and Tensor definition, Index notation, Kronecker Delta and alternating Symbol, Coordinate transformation. (4) • Plane stress and Plane strain: Two dimensional problems in Cartesian and polar coordinates. (8) • Numerical and energy methods: Strain Energy and related Principles, Principle of Virtual work, Principle of Minimum Potential Energy and Complementary Energy, Rayleigh-Ritz Method. (8) • Thermal stresses: Thermal stresses in bars, Thermal bending of beam, Basic						

	equation of Thermo elasticity. (2) • Introduction to plasticity: Fundamentals of plastic deformation, Theories of failure and yield criteria of metals. (6) • Mechanics of metal forming processes - forging, rolling, drawing, bending, and extrusion. Friction and lubrication in metal forming processes. Defects in metal working. (12)
Text Books, and/or reference material	Text Books: 1. Theory of Elasticity, Timoshenko and Goodier 2. Engineering Plasticity: Theory and application to metal forming Processes, R. A. C. Slater
	Reference Books: 1. Applied Plasticity, J. Chakrabarty

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ME9016	**Mechatronics**	PEL	**3**	**0**	**0**	**3**	**3**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Machine Dynamics and Control		CT+EA					
Course Outcomes	CO1: Students will be able to identify the importance of amalgamation between the electronics and electro-mechanical systems. CO2: Students will be able to formulate and evaluate behavior of linear time continuous control systems. CO3: Students will be able to formulate the procedure for converting analog signals to digital form and vice-versa. CO4: Students will be able to describe signals and its processing by modern electronic methods. CO5: Students will be able to identify and critically evaluate current developments and emerging trends within the field of mechatronic systems.						
Topics Covered	Mechatronic Systems: Introduction, Application of Mechatronics. 2 Sensors and Transducers - Brief review, Simple electronic elements & Operational Amplifiers. 4 Actuators: Pneumatic, Hydraulic, Electrical & Mechanical actuation system, Micro-actuators. 6 Modelling and Simulation of Physical System: System models, Dynamic responses of the system, System transfer functions. 6 Digital logic: Number systems, Boolean algebra, Logic gates - Application gate, Design of logic of digital logic gates. 6 Microprocessors and Micro-Controllers: Introduction, Microprocessor Architecture, Instruction codes, General requirements for implementation issues, Examples. 6 Programmable Logic Controllers: Basic structure, I/O processing, Programming, Timer, Inter relays and Counters. 8 Signal conditioning & Digital communication system: Basics of signal conditioning, Filtering, Data acquisition and Digital signal processing, Digital communication and Communication interface. 8 Mechatronic Systems, Case Studies. 10						
Text Books, and/or reference	**Text Books:** 1. Alciatore, D. G. and Histand, M. B., Introduction to Mechatronics and Measurement Systems, McGraw Hill Publications, 4th Edition, 2012.						

material	2. Bolton, W., Mechatronics, Pearson Education India, 2008. 3. Gaonkar, R.S., Microprocessor Architecture, Programming and Applications with 8085, Penram Publishers India, 6th Edition, 2013.
	Reference Books: 1. Malvino, A. P., and Bates, D. J., Electronic Principles, TMH Publishing Company Ltd., New Delhi, 8th Edition, 2016. 2. Nise, N. N., Control Systems Engineering, 6th Edition, John Wiley & Sons, Inc., USA, 2011.

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ME 9017	**Microsystem Design**	PEL	**3**		**0**	**3**	**3**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Solid Mechanics, Fluid Mechanics, Machine Design		CT+EA					
Course Outcomes	CO1: Able to understand scope and application of Microsystems CO2: Able to learn science behind micro system design. CO3: Students will be able to analyze micro system by computer aided tools CO4: Able to understand the different manufacturing technologies for micro system.						
Topics Covered							Hours
	Introduction: Overview of Microsystems and MEMS, Scaling laws in miniaturization, Application of micro systems						2
	Working Principles of Microsystems: Microsensors like Piezoresistive pressure sensors, micro-accelerometer, optical sensors etc., microactuators, micro pumps, micro valves, micro gears etc.						7
	Engineering Science for Microsystem Design and Manufacturing: Scaling effect in geometry, molecular theory of matter and intermolecular forces.						4
	Rigid body Mechanics for Microsystem Design: Scaling effect in dynamics, force and vibration analysis						4
	Mechanics of Solid for Microsystem Design: Scaling effect in elasticity, bending analysis of thin plates and beams, thin-film mechanics etc.						5
	Thermo-fluid Analysis for Microsystem Design: Scaling effect in fluid flow and heat transfer, fluid flow in submicrometer scale, microfluidics systems, heat conduction in solids in submicron level.						4
	Modeling of Coupled Electromechanical Systems: Scaling effect in electrostatic and electromagnetic forces, coupled electromechanics of static and dynamic microsystems						4
	Material for Microsystems and MEMS						2
	Modern Computational Tools for Microsystems Design and Analysis:						2
	Microsystem Fabrication Technologies: Thin film deposition, Lithography, etching, LIGA, silicon micromachining, inkjet printing etc.						6
	Microsystem Packaging:						2
Text Books, and/or reference	**Text Books:** Text Books: 1. Microsystem Design by Stephen D Senturia 2. Micro and Smart Systems, by Ananthasuresh, Vinoy, Gopalakrishnan, Bhat, Aatre						

material	3. MEMS and Microsystems Design & Manufacture, by Tai Ran Hsu 4. Introduction to Micromechanisms and microactuators, by A.Ghosh, B. Corves
	Reference Books: 1. An Introduction to MEMS Engineering, by Nadim and Williams 2. Foundation of MEMS, by Chang Liu

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ME9018	**Finite Element Methods**	PEL	**3**	**0**	**0**	**3**	**3**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Advanced Mechanics of Solids		CT+EA					
Course Outcomes	CO1: Students will learn learn the theory and characteristics of finite elements that represent engineering structures like bar and beam. CO2: Students will be able to solve structural, thermal, dynamic problems. CO3: Students will be able to use computer to sole FEM problems.						
Topics Covered	Brief review of mathematical concept, Matrix, gauss elimination method, Eigenvalue solution, Numerical Integration, Weighted residual methods, calculus of variation and Rayleigh-Ritz method (6) Introduction to finite element methods: Direct approach for standard discrete system. Potential Energy approach and virtual work approach, Variational approach and Galerkin's weighted residual approach for continuum (6) Interpolation polynomial – Lagrangian and Hermite. Natural Co-ordinates, Pascal triangle, concept of continuity, convergence criteria (4) Common elements: Bar elements, beam elements, triangular Elements, rectangular elements etc. Lagrangian Elements and Serendipity Elements. Concept of isoparametric elements (6) Concept of time-independent field problem and time independent field problem involving differential equations. Different types of Boundary conditions (6) Concept of mass matrix. Vibration problem and dynamic response problem (6) Introduction to geometric non-linearity and material non-linearity in finite element analysis (3) Computer procedure for finite element analysis (3)						
Text Books, and/or reference material	**Text Books:** 1. An Introduction to the Finite Element Method, J. N. Reddy 2. Finite Element Procedures By K. J. Bathe 3. Text book of Finite Element analysis, P. Seshu						
	Reference Books: 1. The Finite Element Method in Engineering, S. S. Rao 2. The Finite Element Method its Basis and Fundamental , O. C. zienkiewich, R. L. Taylor, J. Z. Zhu 3. The Finite Element Method in Engineering by S. S. Rao						

<table>
<tr><td colspan="7">Department of Mechanical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ME9019</td><td>Robotics</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="4">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">Knowledge on Mechanisms</td><td colspan="4">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">CO1: Students will be able to discuss the history, concepts and key components of robotics technologies.
CO2: Students will be able to analyse and solve problems spatial transformation, forward and inverse kinematics, dynamics of ulators, jacobian and singularities, joint trajectory for motion planning.
CO3: Students will be able to describe and compare various robot grippers, sensors, actuators and controllers and their perception.</td></tr>
<tr><td>Topics Covered</td><td colspan="6">Introduction to Robotics: Definition, Anatomy, Coordinate Systems, Work Envelopes, Basic structure, classification, applications of robots. 4
Robot Arm Kinematics: Frame transformation, Denavit-Hartenberg convention, Forward and Inverse kinematics of serial manipulator. 12
Linear and Angular Velocity of Links and Statics of Serial manipulator: Jacobians, Singularities. 8
Introduction to Dynamics of Serial Manipulators: Lagrange-Euler formulation. 8
Trajectory Planning of Manipulator: Joint space scheme, Cartesian space scheme. 6
Robot Sensors: Contact type, non-contact type, internal sensor, External sensor, Range sensor, Proximity sensor, touch sensor, Force and torque sensor, Encoders, etc. 10
Robot Grippers. 6
Robot Controllers 2</td></tr>
<tr><td rowspan="2">Text Books, and/or reference material</td><td colspan="6">Text Books:
1. Saha, S. K., Introduction to Robotics, TMH Publishing Company Ltd., New Delhi
2. Pratihar, D. K., Fundamentals of Robotics, Narosa Publishing House, India
3. Fu, K., Gonzalez, R. and Lee, C. S. G., Robotics: Control, Sensing, Vision and Intelligence¸ McGraw- Hill
4. Craig, J. J., Introduction to Robotics: Mechanics and Control, 2nd Edition, Addison-Wesley, 1989.</td></tr>
<tr><td colspan="6">Reference Books:
1. Ghosal, A., Robotics: Fundamental Concepts and Analysis, Oxford University Press, 2nd reprint, 2008.
2. Spong, M. W., Hutchison, S., and Vidyasagar, M., Robot Modeling and Control, Wiley India, New Delhi, 2006.</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ME9020</td><td>Knowledge Based Systems</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Students will be able to understand need of soft computing techniques
CO2: Students will be able to apply knowledge of different soft computing methods for solving engineering problems
CO3: Students will be able to apply combined soft-computing techniques</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction to expert systems – Definition, Need for expert systems, Methods of developing expert system – offline training/learning AND on-line training/learning Tools for developing expert systems – Hard Computing vs. Soft Computing. 6
Fuzzy Set Theory, Fuzzy Logic Controllers (FLC). 10
Neural Network (NN) Controllers – back propagation network, SOM, radial basis function networks, recurrent neural networks etc. 10
Learning/optimisation tools – traditional (direct search and gradient based) and non-traditional (genetic algorithms (GAs), simulated annealing etc.) techniques. 16
Combined techniques of soft computing – GA-FLC, GA-NN, NN-FLC, GA-FLC-NN
Some Applications
10
MatLab toolbox on GA, FLC and NN.
4</td></tr>
<tr><td rowspan="2">Text Books, and/or reference material</td><td colspan="7">Text Books:
1. D. K. Pratihar, Soft Computing, Narosa Publishers, 2011S.S. Rao, Engineering Optimization, Theory and Practics, 3rd Enlarged Edition, New Age International Publishers, New Delhi, 2010.
2. David E. Goldberg, Genetic Algorithms in Search, Optimization and Machine Learning, Addison-Wesley, Reading, Mass, 1989.
3. Simon Haykin, Neural Network and Learning Machines, 3rd Edition, Person Education, India
4. Timothy J. Ross, Fuzzy Logic with Engineering Applications, 3rd Edition, Wiley, 2011.</td></tr>
<tr><td colspan="7">Reference Books:
1. Soft Computing and Its Applications, Vol. 1 & 2, Kumar S. Ray, Apple Academic Press</td></tr>
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<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ME 9022</td><td>Modern Manufacturing Processes</td><td>PCL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2"></td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Cutting edge technology for nonconventional/ precision machining.
CO2: Emerging trends in metal removal processes
CO3: Exposure to basic Micromachining Processes</td></tr>
<tr><td rowspan="13">Topics Covered</td><td colspan="5">Topics</td><td colspan="2">Hours</td></tr>
<tr><td colspan="5">Introduction</td><td colspan="2">1</td></tr>
<tr><td colspan="5">ECM: Working Principle; ECM Machine Tool; Process performances; Advantages, limitations and applications; ECG- Working Principles; ECG Machine Tool; Process performances; Advantages, limitations and applications; Electrochemical Deburring (ECDe), Shaped Tube Electrolytic Machining (STEM).</td><td colspan="2">7</td></tr>
<tr><td colspan="5">EDM: Working Principles, EDM Machine Tool – Power Supply, Dielectric System, Electrodes, Servo-system, Pulse generating Circuits and analysis, Process Variables and Process Characteristics; Electrical Discharge Grinding</td><td colspan="2">6</td></tr>
<tr><td colspan="5">Wire-cut EDM: Working Principles, EDM Machine Tool, Process Variables and Process Characteristics</td><td colspan="2">2</td></tr>
<tr><td colspan="5">USM: Working Principles, USM Machine Tool, Mechanics of cutting, Process capabilities, Advantages, limitations and applications.</td><td colspan="2">2</td></tr>
<tr><td colspan="5">LBM: Production of LASERs, Working Principles of LBM, Types of LASERs, Process characteristics, Advantages, Limitations and Applications.</td><td colspan="2">4</td></tr>
<tr><td colspan="5">EBM: Production of Electron Beam, Working Principles of EBM, Focusing and control of electron beam, Process characteristics, Advantages, Limitations and Applications.</td><td colspan="2">3</td></tr>
<tr><td colspan="5">AJM, Water Jet Machining and Abrasive Water Jet Machining</td><td colspan="2">4</td></tr>
<tr><td colspan="5">Chemical Machining</td><td colspan="2">2</td></tr>
<tr><td colspan="5">Microfabrication and Micromachining</td><td colspan="2">7</td></tr>
<tr><td colspan="5">Rapid Prototyping</td><td colspan="2">4</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Nonconventional Machining Process, V.K.Jain
2. Modern Machining Process, Pandey and Shaw

Reference Books
1. Manufacturing Science, Ghosh and Mallik
2. Nonconventional Machining Process, P.K.Misra</td></tr>
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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ME9023	**Computer Aided Design**	PEL	**3**	**0**	**0**	**3**	**3**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Machine Design		CT+EA					
Course Outcomes	CO1: Able to understand scope and application of CAD/CAE tools in industry CO2: Able to learn geometric modeling and computer graphics concept in CAD tools. CO3: Students will be able to analyze mechanisms by computer aided tools CO4: Able to understand the different design analysis and optimization tools in CAD.						
Topics Covered	Introduction: Current trends in Design & Manufacturing, Fundamental concept of CAD-CAM-CAE, Product Life-cycle. (2) Computer Graphics: Fundamentals of Geometric transformations, Viewing transformations, Projections, Clipping, & Hidden line/surface removal, Graphics standards, CAD-CAM Data Exchange. (8) Geometric Modeling: Types and mathematical representation of Wire-frame entities, Surface entities, Solid modeling and concepts of B-rep and CSG representation schemes. (10) Engineering Analysis Tools: Computer aided analysis of multi-body systems, Role of Finite Element Modeling (FEM) in design. (6) Design Optimization: Problem formulation, unconstrained and constrained optimization problems, Non-linear programming methods. (10) Virtual Prototyping: Introduction to Virtual Prototyping & Virtual Reality Tools and its applications in Mechanical Engineering. (4)						
Text Books, and/or reference material	**Text Books:** 1. Mastering CAD/CAM, I. Zeid 2. Geometric Modeling, M. Mortenson						
	Reference Books: 1. Mathematical Elements for Computer Graphics, Roger, Adams 2. Engineering Optimization, Theory and Practices, S. S. Rao						

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ME9024	**Mechanics of Composite and Functionally Graded Materials**	PEL	**3**	**0**	**0**	**3**	**3**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Advanced Mechanics of Solids		CT+EA					
Course Outcomes	CO1: Students will learn why and how different materials are combined to get a new material with better properties and what will be the properties of new materials.						

	CO2: Students will be able to analyze composite structures like beam plates. CO3: Students will learn about the mechanics FGM.
Topics Covered	Composites, various reinforcement and matrix materials (2) Manufacturing of composites materials (3) Concept of orthotropic, transversely isotropic material, stress-strain relation for orthotropic and transversely isotropic material. Engineering constants for these materials, Transformation of stress and strain. (8) Micromechanical behavior of lamina (6) Macro mechanical behavior of lamina, Classical lamination theory, Laminate stiffness of a few cases, Stress strain variation in a laminate (8) Equation of equilibrium for laminated plates for bending, Solution technique for bending of simply supported laminated plates under uniformly distribute transverse load. (7) Failure criterion of composites (3) Introduction to FGM (3)
Text Books, and/or reference material	**Text Books:** 1. Fiber-Reinforced Composites: Materials, Manufacturing, and Design, P. K. Mallick 2. Mechanics of Composite Materials, R. M. Jones 3. The behaviour of Structures Composed of Composite Materials By J. R. Vinson and L. Sierakowski
	Reference Books: 1. Mechanics of Laminated Composite Plates and Shells Theory and Analysis, J. N. Reddy 2. Engineering Mechanics of Composite Materials, Daniel

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ME 9025	**Modeling and Simulation of Mechanical Systems**	PEL	**3**	**0**	**0**	**3**	**3**

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
ME1001	CT+EA

Course Outcomes	CO1: Students will be able to identify the importance of modelling and simulation of Engineering systems CO2: Students will be able to model and simulate behavior of any engineering system. CO3: Students will be able to interrelate between systems in different energy domains.
Topics Covered	Elements of analytical mechanics; classification of constrains, Principles of virtual work, Lagrange's first equation. Lagrange's second equation. Hamilton's equations. (6) Nonholonomic mechanical system dynamics, Routh and Gibb's equation, Kane dynamics with application to multi body systems. (6) Modelling of systems involving continuous medium. Hamilton's principle for continuous medium. Elements of thermo-continuum and theory of constitutive relations. (8) Modelling and Simulation of Physical System: System models, Dynamic responses of the system, System transfer functions.(6) Fundamental topics in bond graph modelling of physical systems: Elements of multi-bond graphs, Thermo-mechanical bond graphs and continuous systems and other systems of

	typical interest. Introduction to various system simulation software. (14)
Text Books, and/or reference material	Text Books: 1. Advanced Dynamics of Mechanical Systems, F.Cheli, G.Diana 2. Bondgraph in Modeling, Simulation& Fault Identification, Mukherjee, Karmakar, Samantaray
	Reference Books 1. System Dynamics, D. C. Karnopp, D. L. Margolis, R. C. Rosenberg 2. Modeling and Simulation of Dynamic Systems, R.L.Woods, K.L.Lawrence

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ME 9026	**Tribology**	PEL	**3**	**0**	**0**	**3**	**3**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Mechanics, Solid Mechanics, Fluid Mechanics		CT+EA					
Course Outcomes	• CO1: To learn the basic knowledge of surface topography and contact between engineering surfaces. • CO2: To learn the basic theory and application of friction and wear for different materials • CO3: To learn about lubricants and lubrication for different bearings • CO4: Introduced to Biotribology of human joints • CO5: Introduced to Microtribology for MEMS applications						
Topics Covered	• **Surface topography:** Measurement of surface topography; Quantifying surface roughness; The topography of engineering surfaces. (2) • **Contact between surfaces:** Hertzian contact – sphere on sphere contact and cylinder on cylinder contact; Contact between rough surfaces. (4) • **Friction and Wear of contact surfaces:** Laws and Theories of friction and wear; Friction and Wear of different materials; Application to friction materials. (8) • **Lubricants and lubrication:** Viscosity of lubricants; Composition and properties of oils and greases; Reynolds equation; Type of lubrications - Hydrostatic lubrication, Hydrodynamic lubrication; Elastohydrodynamic lubrication; Boundary lubrication, and application to bearings. (16) • **Microtribology:** Surface forces and adhesion; Atomic force microscopy (AFM); Friction, wear and lubrication on atomic level; Applications to MEMS. (6) • **Biotribology:** Natural human joints; Structure and properties of articular cartilage; Mechanism of synovial lubrication: Mechanism of articular cartilage damage; Artificial joint replacements; Skin Tribology (6)						
Text Books, and/or reference material	Text Books: 1) Engineering Tribology - Dr. Prasanta Sahoo, PHI Publisher 2) Introduction to Tribology of Bearings -- B. C. Majumder, S Chand Publisher Reference Books: 1) Principles of Tribology-- J.Halling, Palgrave Macmillan Publisher 2) Basic Lubrication Theory - Alastair Cameron, Ellis Horwood Ltd						

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ME 9028	**Material Handling Equipment**	**PEL**	**3**	**1**	**0**	**4**	**4**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
ME1001		CT+EA					
Course Outcomes	CO1: Students will be able to identify the importance of use of mechanical handling machineries. CO2: Students will be able to design different types of conveyors and cranes.						
Topics Covered	Classification of materials and equipment. 2 Conveying equipment: Belt conveyor, Construction and layouts, Belt selection and power calculation. 8 General features and calculations of capacity and power of bucket elevator. 2 Apron, Scraper and screw conveyors; Roller conveyor, Chain-trolley conveyor, pneumatic conveying. 6 Principles of working of vibratory conveyor, high angle conveyor, pipe conveyor, long						

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ME9029	**Optimization in Engineering Design**	PEL	**3**	**0**	**0**	**3**	**3**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	CO1: Students will be able to describe and formulate optimization problems CO2: Students will be able to apply knowledge of different optimization methods for solving engineering problems CO3: Students will be able to differentiate between optimization methods and suggest a suitable technique applicable for a specific problem.						
Topics Covered	Introduction: Engineering Application, Statement and Classification of the Optimization Problem, Classification, formulation procedures. 4 Classical Methods: Single Variable Optimization; Multivariable Optimization without any Constraints with Equality and Inequality Constraints, Kuhn–Tucker Conditions; Linear Optimization Methods, One-Dimensional Minimization Method. Unimodal Function. 6 Elimination Methods: Exhaustive search, Fibonocci and Golden Method. 4 Interpolation Method – Quadratic and Cubic Interpolation Method. 2 Unconstrained Minimization Method -- Univariate, Conjugate Directions, Steepest Descent (Cauchy) Method, Newton's Method, Marquardt Method, Quasi-Newton Method. 6 Constrained Minimization Method, Random Search Methods, Sequential Quadratic Programming. Basic Approach of the Penalty Function Method, Interior Penalty						

	Function Method, Exterior Penalty Function Method. 5 Non-traditional Optimization Techniques - Genetic Algorithms. Simulated annealing. Particle swarm optimization. Ant Colony Optimization. Tabu search. 16 Reduction of size of an optimization problem. Scaling of design variables and constraints. 3 Multi-objective optimization problems, DPGA, NSGA 6 Introduction to optimization Toolbox in MATLAB. 4
Text Books, and/or reference material	**Text Books:** 1. S.S. Rao, Engineering Optimization, Theory and Practics, 3rd Enlarged Edition, New Age International Publishers, New Delhi, 2010. 2. Ashok D. Belegundu and Tirupathi R Chandrupatla, Optimization Concepts and Applications in Engineering, Pearson Education 1999, First India Reprint, 2002.
	Reference Books: 1. G. N. Vanderplaats, Numerical Optimization Techniques for Engineering Design with Applications, McGraw-Hill, New York, 1984. 2. R. L. Fox, Optimization Methods for Engineering Design, Addison- Wesley, Reading, Mass, 1971.

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ME 9030	**Design of Machine Tools**	PCL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Fundamental knowledge of Design of Machine Elements		CT+EA					
Course Outcomes	CO1: In depth study of machine tools construction and design. CO2: Introduction to machine tools automation. CO3: Introduction of Machine tools control system CO4: Familiarisation with NC and CNC Machine tools						
Topics Covered	Topics					Hours	
	Machine Tools Drives: Layout and Design of Speed and Feed Gear boxes, Stepless speed variation.					12	
	Machine tool guides beds and columns.					3	
	Hydrostatic and hydrodynamic lubrication.					3	
	Design of lead screws, recirculating ball-screws.					4	
	Design of machine tool spindles.					3	
	Static and dynamic stiffness of machine tool structures. Vibration of machine tools, Chatter and stick slip vibrations.					6	
	Control of machine tools: Hydraulic and Electrical controls, Numerical control.					8	
	Static and dynamic acceptance tests, Built in inspection units.					3	
Text Books, and/or reference material	Text books: 1. Principle of Machine Tools, Sen and Bhattacharya 2. Computer Control of Manufacturing Systems, Koren Y. Reference books: 1. Machine Tool Engineering, N.K.Mehta 2. Numerical Control & Computer Aided Manufacturing, Kundra, Rao, Tiwari.						

<table>
<tr><th colspan="7">Department of Mechanical Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ME9044</td><td>Fluid Power Systems and Control</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Fluid Mechanics, Control Engineering</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">CO1: To build up concept of hydraulic and pneumatic power system and their application areas.
CO2: To familiarise the students about functioning of several components of hydraulic power system and techniques for dynamic analysis of those components.
CO3: To make them able to design hydraulic power pack using several components for particular application according to specific requirements.
CO4: To make them understood the procedures to control the overall hydraulic power system and troubleshoot the problems arising out.</td></tr>
<tr><td>Topics Covered</td><td colspan="6">Introduction: introduction, concept of hydraulic and pneumatic power system and their application, advantages and disadvantages; basic hydraulic and pneumatic circuit, fluid flow fundamentals, flow through orifice and conduit, minor losses.(5)
Hydraulic Fluid: density, viscosity, effective bulk modulus; thermal properties and equation of state; chemical properties-contamination and filtration; types of hydraulic fluid, selection of hydraulic fluid (3)
Hydraulic Pump, Motor and Actuator: types and construction of basic hydraulic pumps and motor; rotary and linear actuators-types and construction, dynamics of hydraulic pumps and motor. (6)
Control Valves: types of valves and their configurations and symbols, spool valves, poppet valve, flapper nozzle valve, functioning of pressure relief and pressure reducing valves, direction control valves and pressure compensated flow control valves and their dynamic analysis (10)
Fluid Power System and Dynamics: basic fluid power systems; dynamics of valves, valve flow characteristics, flow force and spool stiction, friction in valve and actuators, leakage flow through valve and actuator ; transmission line dynamics, actuator dynamics, hydraulic accumulator. (14)
Electro-hydraulic Servo System: types of EHSVs, permanent magnet torque motor, two stage flapper nozzle EHSV dynamics with feedback control, design and control of elctro-hydraulic servo mechanism, stability and frequency response analysis (10)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="6">Text Books:
1. Hydraulic Control System by Merritt H, John Wilely and Sons Inc.
2. Fundamentals of Fluid Power Control by Watton J. Cambridge University Press.
3. Fluid Power Engineering by M G Rabie, McGraw Hill
Reference Books
1. Fluid Power Systems: modeling, simulation and microcomputer control by John Watton, Prentice Hall International.
2. Fluid Power Control by Blackburn, J. F., G. Reethof, and J. L. Shearer, New York: Technology Press of M. I. T. and Wiley.</td></tr>
</table>

PROGRAM OUTCOMES

PO1: Technical knowledge: Project work improves the knowledge of students about Machine Design as the allotted topics are based on the Machine Design field.

PO2: Technical report writing: For executing the project work and compilation of the data, the presentation of results a technical report writing skill is required. Therefore, project work develops the technical report writing skill in the students.

PO3: Demonstrate a degree of mastery: The execution of project work and compilation of the data, a planning is required. Therefore, project work develops the planning ability in students. Students analyze, evaluate and apply the collected information /data systematically and on that basis make defensible decisions.

PO4: Professional ethics and responsibilities: While writing project report, students are instructed to follow ethical practice by directing them to avoid plagiarism and citing the works of other researchers properly in the text.

PO5: Life-long learning: Execution of the project work develops the ability in the students to continuously update their knowledge through internet portals, journals, text books, reference books. They come to know via internet that information has been continuously modified and not remain limited to text books, and therefore, updating the knowledge on the regular basis is essential.

MAPPING BETWEEN COURSES AND POs

Course Code	Course Title	Connected POs
ME 1001	Machine Dynamics and Control	PO1, PO2, PO3
ME 1002	Advanced Mechanics of Solids	PO1, PO2, PO3, PO4
ME 1003	Analysis and Synthesis of Mechanisms	PO1, PO2, PO3, PO4
ME 1051	Computational Laboratory	PO1, PO2, PO3, PO4, PO5

ME 2001	Machine Design	PO1, PO2, PO3, PO5
ME 2002	Mechanical Vibrations	PO1, PO3, PO5
ME 2051	Machine Dynamics Laboratory	PO1, PO2, PO3, PO4, PO5
ME 2052	Computer Aided Design Laboratory	PO1, PO2, PO3, PO4, PO5
ME 2053	Mini Project with Seminar	PO1, PO2, PO3, PO4, PO5
ME 3051	Dissertation - I	PO1, PO2, PO3, PO4, PO5
ME 3052	Seminar - Non-Project	PO1, PO2, PO3, PO4, PO5
ME 4051	Dissertation - II	PO1, PO2, PO3, PO4, PO5
ME 4052	Project Seminar	PO1, PO2, PO3, PO4, PO5

MAPPING BETWEEN COs AND POs

Points are given in terms no (**N**), low (**L**), medium (**M**) and high (**H**) correlation.

Course Code	**Course Title**	**COs**	**POs**				
			PO1	**PO2**	**PO3**	**PO4**	**PO5**
ME 1001	Machine Dynamics and Control	CO1	H	M	H	N	H
		CO2	H	N	M	N	N
		CO3	H	N	M	N	L
		CO4	H	H	H	N	H
		CO5	H	N	H	N	H
ME 1002	Advanced Mechanics of Solids	CO1	H	N	H	N	M
		CO2	H	M	H	N	M
		CO3	H	M	H	N	H
ME 1003	Analysis and Synthesis of Mechanisms	CO1	H	M	H	N	N
		CO2	H	M	H	N	H
		CO3	H	M	H	N	N
ME 1051	Computational Laboratory	CO1	H	H	H	M	N
		CO2	H	H	H	N	N
		CO3	H	H	H	N	N
ME 2001	Machine Design	CO1	H	N	H	N	N

		CO2	H	N	M	N	L
		CO3	H	N	H	N	N
		CO4	H	H	H	N	H
		CO5	H	N	H	N	M
ME 2002	Advanced Mechanical Vibrations	CO1	H	N	L	N	N
		CO2	H	N	H	N	L
		CO3	H	N	M	N	L
		CO4	H	N	M	N	M
ME 2051	Machine Dynamics Laboratory	CO1	H	H	H	M	N
		CO2	H	H	H	M	M
ME 2052	Computer Aided Design Laboratory	CO1	H	H	H	N	M
		CO2	H	H	H	N	M
		CO3	H	N	M	N	N
ME 2053	Mini Project with Seminar	CO1	H	H	H	H	H
		CO2	H	M	H	L	N
		CO3	H	H	H	H	H
ME 3051	Dissertation - I	CO1	H	H	H	H	H
		CO2	H	M	H	L	N
		CO3	H	H	H	H	H
ME 3052	Seminar Non-Project	CO1	H	N	H	H	H
		CO2	H	H	H	L	N
		CO3	L	H	L	M	N
		CO4	L	H	L	H	M
ME 4051	Dissertation - II	CO1	H	H	H	H	H
		CO2	H	M	H	L	N
		CO3	H	H	H	H	H
ME 4052	Project Seminar	CO1	H	N	H	N	H
		CO2	H	H	H	N	H
		CO3	H	M	H	M	M
		CO4	H	H	H	M	H

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