Kolhapur Institute of Technology's College of Engineering, Kolhapur

Teaching and Evaluation scheme for

First Year M. Tech. Program in CAD/CAM/CAE Semester-I

Course Code	Course Name	Hr/Week			Credits		Evaluation Scheme			
							Component	Marks		
		L	T	P				Max	Min for Passing	
PCCC0101	Theory of Elasticity and Plasticity	3	1	-	4		ISE-I	10	20	40
							MSE	30		
							ISE-II	10		
							ESE	50	20	
PCCC0102	Computer Aided Manufacturing	3	1	-	4		ISE-I	10	20	40
							MSE	30		
							ISE-II	10		
							ESE	50	20	
PCCC0103	Advanced Finite Element Analysis	3	1	-	4		ISE-I	10	20	40
							MSE	30		
							ISE-II	10		
							ESE	50	20	
PCCC0161	Research Methodology*	2	-	-	-		ESE	50	20	
PCCC01**	Professional Elective-I	3	1	-	4		ISE-I	10	20	40
							MSE	30		
							ISE-II	10		
							ESE	50	20	
PCCC01**	Professional Elective-II	3	1	-	4		ISE-I	10	20	40
							MSE	30		
							ISE-II	10		
							ESE	50	20	
PCCC0131	CAD/CAM Lab	-	-	2	1		ISE	50	20	
							ESE (P.O.E.)	50	20	
PCCC0132	Design and Analysis Lab I	-	-	2	1		ISE	50	20	
							ESE (P.O.E.)	50	20	
PCCC0141	Seminar I			2	1		ESE	100	40	
	Total	15+2	5	6	23		Total Credit: 23 Total Contact Hours/Week: 26+2 hrs			

*Audit Course

Kolhapur Institute of Technology's College of Engineering, Kolhapur

List of Professional Electives:

Course Code	Elective – I	Course Code	Elective – II
PCCC0121	Modelling and Simulation of Manufacturing Systems	PCCC0125	Mechanics of Composite Materials
PCCC0122	Technology Management	PCCC0126	Advanced Casting Technology
PCCC0123	Quality and Reliability Engineering	PCCC0127	Advanced Welding Technology
PCCC0124	Optimization Techniques		

ISE: In Semester Evaluation
MSE: Mid Semester Examination
ESE: End Semester Examination

Kolhapur Institute of Technology' College of Engineering, Kolhapur

Teaching and Evaluation scheme for

First Year M. Tech. Program in CAD/CAM/CAE Semester-II

Course Code	Course Name	Hr/Week			Credits		Evaluation Scheme			
							Component	Marks		
		L	T	P				Max	Min for Passing	
PCCC0204	Additive Manufacturing	3	1	-	4		ISE-I	10	20	40
							MSE	30		
							ISE-II	10		
							ESE	50	20	
PCCC0205	Manufacturing System Design	4	1	-	5		ISE-I	10	20	40
							MSE	30		
							ISE-II	10		
							ESE	50	20	
PCCC0206	Product Life Cycle Management	3	1	-	4		ISE-I	10	20	40
							MSE	30		
							ISE-II	10		
							ESE	50	20	
PCCC0262	Industrial Ethics and Human Values (Audit)*	2	-	-	-		ESE	50	20	
PCCC02**	Professional Elective III	3	1	-	4		ISE-I	10	20	40
							MSE	30		
							ISE-II	10		
							ESE	50	20	
PCCC02**	Professional Elective IV	3	1	-	4		ISE-I	10	20	40
							MSE	30		
							ISE-II	10		
							ESE	50	20	
PCCC0233	Automation and Simulation Lab	-	-	2	1		ISE	50	20	
							ESE (O.E.)	50	20	
PCCC0234	Design and Analysis Lab.II	-	-	2	1		ISE	50	20	
							ESE (P.O.E.)	50	20	
PCCC0242	Seminar II			2	1		ESE	100	40	
PCCC0243	Mini-Project			2	1		ISE	50	20	
	Total	16+ 2	4	8	25		Total Credit: 25 Total Contact Hours/Week: 28 +2 hrs			

*Audit course

Kolhapur Institute of Technology's College of Engineering, Kolhapur

List of Professional Electives:

Course Code	Elective – III	Course Code	Elective – IV
PCCC0221	Industrial Automation and Robotics	PCCC0225	Computational Fluid Dynamics
PCCC0222	Mechatronic System Design	PCCC0226	CAD/CAM/CAE Practices in Metal Forming
PCCC0223	MEM's and Nano Technology	PCCC0227	Mechanical Vibrations
PCCC0224	Product Design and Development	PCCC0228	Tribology

ISE: In Semester Evaluation
MSE: Mid Semester Examination
ESE: End Semester Examination

Kolhapur Institute of Technology' College of Engineering, Kolhapur

Teaching and Evaluation scheme for

Second Year M. Tech. Program in CAD/CAM/CAE Semester-III

Course Code	Course Name	Hr/Week			Credits		Evaluation Scheme		
		L	T	P			Component	Marks	
								Max	Min for Passing
PCCC0343	Industrial Training*	-	-	-	2		ISE	50	20
PCCC0351	Dissertation Phase-I	-	-	-	2		ISE-I	50	20
					4		ISE-II	100	40
PCCC0352	Dissertation Phase-II				4		ESE(OE)	100	40
Total Credits					**12**		**Total Marks**	**300**	
Contact Hours/week : 5/Student/week									

*Student should undergo industrial training of 15days during vacation after F.Y.Part II

Kolhapur Institute of Technology' College of Engineering, Kolhapur

Teaching and Evaluation scheme for

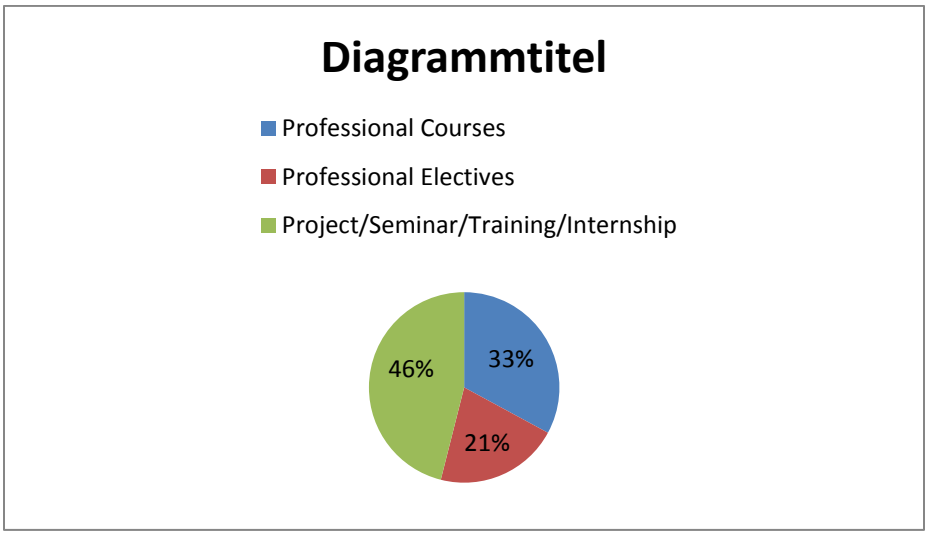
Second Year M. Tech. Program in CAD/CAM/CAE Semester-IV

Course Code	Course Name	Hr/Week			Credits		Evaluation Scheme		
		L	T	P			Component	Marks	
								Max	Min for Passing
PCCC0453	Dissertation Phase- III	-	-	-	4		ISE-I	100	40
		-	-	-	4		ISE-II	100	40
PCCC0454	Dissertation Phase- IV	-	-	-	8		ESE	200	80
Total Credits					**16**		**Total Marks**	**400**	
Total Contact Hours: 5/student/week									

Kolhapur Institute of Technology' College of Engineering, Kolhapur

Program Credit Distribution

Curriculum Component	Credits
Professional Courses	25
Professional Electives	16
Project/Seminar/Training/Internship	35
Total	**76**

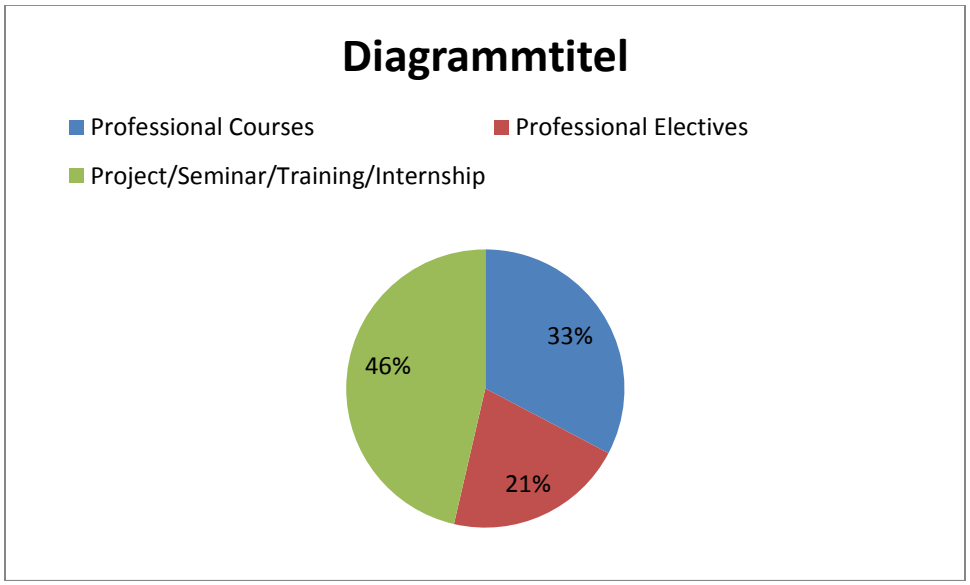


CAD/CAM/CAE (PG)

Kolhapur Institute of Technology' College of Engineering, Kolhapur

Program Credit Distribution Percent wise

Curriculum Component	Percentage
Professional Courses	32.895
Professional Electives	21.053
Project/Seminar/Training/Internship	46.667
Total	**100**



CAD/CAM/CAE (PG)

Title of the Course: Theory of Elasticity and Plasticity Course Code: PCCC0101	L 3	T 1	P	Credit 4

Course Pre-Requisite: Acquaintance with the basic concepts of Mechanics of Materials and Machine Design.

Course Description:

The theory of plasticity serves as a background for performing nonlinear analysis (Material nonlinearity) by the Finite element method.

Course Objectives:

1. To understand the fundamentals of elasticity and plasticity in comparison with the mechanics of deformable bodies.
2. To develop systematic knowledge of basic concepts like stress, strain, equilibrium, compatibility and failure theories, relate the stresses and strains in terms of elastic constants and understand the importance of these constants.

3. To understand the fundamental concepts of stress analysis in two dimensions using stress functions.

4. To compute the solution for engineering problems using the concept of strain energy related equations.

5. To learn to design machine elements by using the phenomenon of fatigue and the respective design methodology.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	The student shall be able to apply the basic concepts of elasticity and plasticity while understanding the limitations of the 'Mechanics of Materials'.	III	Applying
CO2	The student shall be able to select the correct analytical techniques to :(i) determine internal forces, stresses and strains (ii) predict failure of simple components.	III	Applying
CO3	The student shall be able to characterize materials with elastic constitutive relations and calculate displacements, stresses etc for simple beam problems (cantilever, simply supported) using stress functions.	V	Evaluating
CO4	The student shall be able to select the energy methods and obtain solutions to elastic bodies subjected to various loads.	III	Applying
CO5	The student shall be able to analyse the problems involving fluctuating loads by using the respective design methodology.	IV	Analyzing

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1	1	2	
CO2		1	2
CO3		1	2
CO4	1	2	
CO5		1	2

1: low, 2:medium, 3:high

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1:--- Analysis of Stress Basic concepts: Body force, Surface Force, Stresses, Components of Stresses, State of stress at a point, Stress components on an arbitrary plane, Principal stresses, Shear stresses, Stress transformation, Mohr's circle in 3D, Plane stress, Differential equations of equilibrium, Boundary conditions, Stress invariants, Octahedral stresses, Decomposition of a state of stress.	9-- **Hrs.**
Unit 2:--- Analysis of Strain Deformation, Strain displacement relations, Strain components, State of strain at a point, Dilatation, Compatibility conditions, Plane strain	5 -- **Hrs.**
Unit 3:--- Stress- Strain relations Generalized Hooke's Law in terms of elastic constants, Relations between elastic constants, Displacement equations of equilibrium, Saint Venant's principle	4 -- **Hrs.**
Unit 4(A):--- Two dimensional problems in Cartesian co-ordinates Airy's stress function, Biharmonic equilibrium equations, Investigation for simple beam problems: (a) Bending of a cantilever beam with end load. (b) Simply supported beam with uniform load.	6 -- **Hrs.**
Unit 4(B):--- Analysis of axi-symmetric problems and Torsion **Axi-symmetric problems:** General equations in polar co-ordinates, Thick-walled cylinder subjected to external and internal pressure, Rotating disc as a 2D problem, Shrink fits **Torsion:** Torsion of prismatic (circular and elliptical cross-section) bars, Soap film analogy, Membrane analogy	7 -- **Hrs.**
Unit 5 :--- Energy Methods Concept of elastic strain energy, Strain energy due to axial force, shear force, torsion, bending moment, Principle of superposition, Maxwell-Betti-Rayleigh reciprocal theorem, Castigliano's theorems, Principle of virtual work.	8 -- **Hrs.**

Unit 6 :--- Plasticity Basic concepts and yield criteria ; Plastic stress-strain relations, Prandtl- Rouss Saint Venant, Levy-Von Mises,Experimentalverification of the Prandtl- Rouss equation Upper and lower bound theorems and corollaries, Application to problems: Uniaxial tension and compression, Stages of plastic yielding, Elasto-plastic analysis of torsion and bending problems, torsion of a bar of oval section (Sokoloskey's method), problems of spherical and axial symmetry, slip lines and plastic flow, strain hardening.	9 -- **Hrs.**

Textbooks:

1. S. P. Timoshenko and J N Goodier, "**Theory of Elasticity**", McGraw Hill Book Company.
2. L. S. Srinath, "**Advanced Mechanics of Solids**", Tata McGraw Hill Book Company .
3. Richard G Budynas, "**Advanced Strength and Applied Stress Analysis",** McGraw Hill , New Delhi, Second Edition, 2011.
4. Engineering Plasticity - Theory and Application to Metal Forming Process -R.A.C..Slater, McMillan Press Ltd., 1977
5. Theory of Plasticity and Metal forming Process - Sadhu Singh, Khanna Publishers, Delhi, 1999.

References:

1] Sadhusingh, "**Theory of Elasticity**", Khanna Publishers, New Delhi, Fourth Edition, 2012.
2] Wang C. T. , "**Applied Elasticity**", McGraw Hill, New Delhi, 1990.
L. D. Landau and E. M. Lifshitz, "**Theory of Elasticity",** Vikas Publishing House Private. Ltd, New Delhi.
3] T. G. Sitharam, "**Applied Elasticity**", Interline Publishing.
4] Phillips, Durelli and Tsao, "**Analysis of Stress and Strain"** McGraw Hill Book Company.
5] Introduction to the Theory of Plasticity for Engineers- Haffman and Sachs, LLC, 2012.
6] Theory of plasticity - J Chakrabarty, Butterworth, 2006.
7] Plasticity for Mechanical Engineers - Johnson and Mellor, Van Nostrand, 1966.

Unit wise Measurable students Learning Outcomes:

1. The student shall be able to calculate the stresses generated in bodies owing to the presence of various forces.
2. The student shall be able to calculate the strains / displacements in bodies due to the presence of various forces.
3. The student shall be able to establish relations between the elastic constants using the appropriate constitutive relations
4a. The student shall be able to calculate displacements and stresses in a simple beam problems.
4b. The student shall be able to apply the principles of axisymmetry and soap film analogy to problems involving pressure vessels (thick and thin walled)and bars subjected to torsion.
5. The student shall be able to calculate the strains / displacements/forces using the energy methods.
6. The student shall be able to apply the equations of plasticity using the appropriate yield criterion for the loading situations.

Title of the Course: Computer Aided Manufacturing Course Code:PCCC0102	L	T	P	Credit
	3	1		4

Course Pre-Requisite: --

Course Description Computer Aided Manufacturing is a course that covers modern tools and methods for manufacturing parts using CNC machines. The topics include Introduction, Features and control systems of CNC machines along with CNC part programming.

Course Objectives:

1.To Explain basics of manufacturing and Numerical Concept
2. To Explain various features of CNC machines.
3.To Develop CNC part program for given component
4. To Explain Various control loops of NC system .
5.To Select appropriate cutting tools and cutting tool materials to machine part on CNC machine.
6.To Explain the concept of Adaptive Control Systems.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive	
		level	Descriptor
CO1	Explain basics of manufacturing and Numerical Concept.	2	Explain
CO2	Explain various features of CNC machines	2	Explain
CO3	Develop CNC part program for given component.	3	Develop
CO4	Explain Various control loops of NC system .	4	Dissect
CO5	Select appropriate cutting tools and cutting tool materials to machine part on CNC machine	5	Select
CO6	Explain the concept of Adaptive Control Systems	2	Explain

CO-PO Mapping:

CO\PO	1	2	3
CO1	1	2	
CO2		2	1
CO3		2	
CO4		3	
CO5	1		
CO6			3

1: low, 2:medium, 3:high

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:	
Unit 1:--- Introduction to Manufacturing: Basic Concepts of Manufacturing, Fundamentals of Numerical Control-Definition of NC, Elements of NC – MCU, Machine & Program of instructions, Axis of motions – Right hand rule, MCU – CLU & DPU, Advantages of NC systems, Classification of NC Systems- Point to point Vs Contouring, Incremental Vs Absolute, Open loop Vs Closed loop	6 **Hrs.**
Unit 2 Features of NC Machine Tools- Fundamentals of Machining, Design considerations of NC Machine tools- Accuracy, Repeatability & Precision, Rigidity, strength to weight ratio, Concept of lost motion, Methods to improve machine accuracy- Tool deflection and chatter, Lead screw – backlash and lost motions, Thermal deformation- Increasing productivity with NC machines, Machining Centers & Turning Centers, MCU functions	6 **Hrs.**
Unit 3: NC Part Programming- Introduction to NC Part Programming- Manual Part Programming, Computer Assisted Part Programming, Manual Part programming- Basic concepts, Blocks, Word address format, Tab sequence format, Tape format – G, M, F, T codes, Computer Aided Programming- Post processors, APT programming- General Description, Geometric Expressions, Motion Statements- Post processor statements, Other Programming Systems	6 **Hrs.**
Unit 4 Control loops of NC Systems- Introduction, Control of Point to Point systems- Incremental Open-Loop Control, Incremental Closed-Loop Control, Absolute Closed-Loop Circuit, Control Loops in Contouring Systems- Principle of Operation, Mathematical Analysis, Positional Control, Operation of a Two-axis system	6 **Hrs.**
Unit 5: CNC Tooling- Cutting tool materials-High Speed Steel – HSS, Cemented Carbides, Coated Carbides, Ceramics, Turning Tool Geometry, Milling Tooling system, Tool pre-setting, Automatic Tool Changers (ATC), Work holding systems, Cutting Process Parameter Selection, Milling Time Estimation, Drilling Time Estimation, Turning Time and Power Estimation	6 **Hrs.**
Unit 6:--- Adaptive Control Systems-Introduction, Adaptive Control with Optimization (ACO), Adaptive Control with Constraints (ACC)- Basic concepts, ACC system for turning, Adaptive Control for Grinding, Cost analysis in Machining, Geometric Modeling (CAD)-Introduction, Parametric & Non-parametric Curves, Introduction to Bezier and B- Splines, Geometric Transformations-Rotate, Revolve, Translate	6 **Hrs.**

Textbooks:

1. P. N. Rao "CAD/Cam principles and operations", Tata McGraw Hill
2. Ibrahim Zeid "CAD/CAM – Theory and Practice" Mc Hill, International edition,1998
3. Tilak Raj – "CNC Technology and Programming", Dhanpat Rai Publication Company.
4. Robert Quesada, T.Jeyapoovan "Computer Numerical Control: Machining and Turning Centers" , Pearson Education.

References:

1. Jon Stenerson and Kelly Curran "Computer Numerical Control", Prentice-Hall of India Pvt. Ltd. New Delhi.
2. Reference Manuals of FANUC, Siemens, Mazak, etc
3. Thomas M. Crandell "CNC Machining and Programming, Industrial Press
4. Bedworth, Wolfe and Henderson – "Computer aided design and manufacturing" McGraw Hill

Unit wise Measurable students Learning Outcomes:

1.Students shall be able to Explain basics of manufacturing and Numerical Concept.
2.Students shall be able to Explain various features of CNC machines
3.Students shall be able to Develop CNC part program for given component
4.Students shall be able To Explain Various control loops of NC system
5.Students shall be able to Select appropriate cutting tools and cutting tool materials to machine part on CNC machine
6.Students shall be able to Explain the concept of Adaptive Control Systems

Title of the Course: Advanced Finite Element Analysis Course Code: PCCC0103	L	T	P	Credit
	3	1	-	4

Course Pre-Requisite:

1. Fundamentals of Strength of Materials
2. A basic understanding of vectors, matrices and partial differential equations for thermal and mechanical problems.
3. Fundamentals of Finite Element Analysis

Course Description:

A finite element method (abbreviated as FEM) is a numerical technique to obtain an approximate solution to a class of problems governed by elliptic partial differential equations. Such problems are called as boundary value problems as they consist of a partial differential equation and the boundary conditions. The initial value problems which consist of a parabolic or hyperbolic differential equation and the initial conditions (besides the boundary conditions) cannot be completely solved by the finite element method. The parabolic or hyperbolic differential equations contain the time as one of the independent variables. To convert the time or temporal derivatives into algebraic expressions, another numerical technique like the finite difference method (FDM) is required.

Course Objectives:

1. The objective of this course is to learn advanced topics in Finite Element methods so that this tool can be used for analysis, design, and optimization of engineering systems.
2. Study of error estimation in Numerical solutions
3. To provide the mathematical foundations of the finite element formulation for engineering applications
4. To expose students to some of the recent trends and research areas in finite element analysis.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Bloom's Cognitive Descriptor
CO1	Analyze linear, nonlinear and simple time-dependent problems in structural discipline using finite element methods	1	Analyze
CO2	Undertake projects in deformation and transient nature	3	Undertake
CO3	Develop special FEA codes for solving nonlinear problems	4	Develop
CO4	Estimate the errors in Finite Element Analysis	5	Estimate

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1			2
CO2	1		1
CO3	2		1
CO4			1

1:low, 2: medium, 3: high

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.

MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.	
Course Contents:	
Unit 1:--- **Integral Formulation and Variation Methods** Introduction to Finite Element Method, comparison with other methods, Need for weighted-integral forms, relevant mathematical concepts and formulate, weak formulation of boundary value problems, variational methods, Rayleigh-Ritz method and weighted residual approach.	6 **Hrs.**
Unit 2:--- **Two-Dimensional Problems: Beam and Truss** Introduction; Local and global coordinate systems; Transformation of vectors in two and three dimensional spaces; Finite Element Modeling of a basic truss element in local coordinate system using energy approach; Assembly of the Global Stiffness Matrix and Load vector, two dimensional problems on beam and truss	8 **Hrs.**
Unit 3:--- **Applications to Solid and Structural Mechanics Problems** External and internal equilibrium equations, one-dimensional stress-strain relations, plane stress and strain problems, axis symmetric and three dimensional stress strain problems, strain displacement relations, boundary conditions compatibility equations, frames and solid of revolution, computer programs.	8 **Hrs.**
Unit 4:--- **Applications to Heat Transfer Problems** Variational approach, Galerikn approach, two dimensional steady state problems for conduction, convection and radiation, transient problems.	6 **Hrs.**
Unit 5:--- **Applications to Fluid Mechanics Problems** Inviscid incompressible flow, potential function and stream function formulation, incompressible viscous flow, stream function, velocity-pressure and stream function voricity formulation, solution of incompressible and compressible fluid film lubrication problems, Additional Applications: Steady state and transient field problem.	7 **Hrs.**
Unit 6:--- **Error Estimates and Adaptive Refinement** Sources of error – Ill-conditioning – The condition number – Diagonal decay test – Disretization error – Multimesh extrapolation – Mesh revision methods – Gradient (stress) Recovery and Smoothing – Adaptive meshing - h refinement with adaptivity – adaptive refinement,	6 **Hrs.**
References: 1] Bathe K.J. Finite Element Procedures. Prentice Hall, 1996. 2] Belytschko, T. et al. Nonlinear Finite Elements for Continuum and Structures, John Wiley & Sons, 2000 3] Cook, R.D. et al. Concepts and Applications of Finite Element Analysis, John Wiley &	

Sons, 2004.
4] Zienkiewicz, O.C. and Taylor, R.L. The Finite Element Method, Butterworth 5. Heinemann, 2000.
5] Finite Element Analysis – Theory & Practice by Fagan (Longman Scientific & Technical)
6] Fundamentals of Finite Element Analysis, David Hutton, TMH
7] Finite Element Method versus Classical Methods,- H.S. Govinda Rao, New Age International Publishers
8] An Introduction to Finite Element Analysis by J. N. Reddy, (Tata McGraw- Hill Pub. Co.)
9] The Finite Element Method: Linear Static and Dynamic Finite Element Analysis by T. J. R. Huges, Dover Publications, 2000
10] Finite Element Procedures by Bathe, Prentice-Hall.
11] Finite Element Analysis by P. Seshu (PHI)
12] Practical Finite Element Analysis - Nitin Gokhale (Finite To Infinite, Pune)
13] Introduction to Finite Elements in Engineering by Chandrupatala and Belegundu.
14] Concepts & Application of Finite Element Analysis by R. D. Cook, D. S. Malku, (John Wiley & Sons)
15] The Finite Element Methods, 3/e –Sienkiewicz(Tata McGraw Hill).

Course Title:	Modelling and Simulation of Manufacturing Systems	L	T	P	Credit
Course Code:	PCCC0121	3	1	-	4

Course Pre-requisites: Basics of statistics and industrial engineering

Course Description:

This course aims to introduce students to system modelling and simulation techniques for better knowledge of different variations in the manufacturing systems which will be useful for improving productivity of the manufacturing systems.

Course Objectives:

This subject provides students with

1. The basic system concept and definitions of system;
2. Techniques to model and to simulate various systems;
3. The ability to analyze a system and to make use of the information to improve the performance.

Course Learning Outcomes

CO	After the completion of the course the student should be able to	Bloom's Cognitive	
		Level	Descriptor
1	**Classify** simulation and analytical models used in manufacturing system environment	II	Understanding
2	**Make use of** random numbers generation process and variants to execute a simulation model	III	Applying
3	**Design** and **evaluate** a given manufacturing system using simulation.	V VI	Creating and evaluating
4	**Evaluate** queuing networks in the context of manufacturing	V	Evaluating

CO-PO Mapping

CO	PO1	PO2	PO3
CO1			**1**
CO2	**1**		**1**
CO3	**2**		**2**
CO4			**2**

1:low, 2:medium, 3:high

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE1	10
MSE	30
ISE2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc. MSE: Assessment is based on 50% of course content (Normally first three modules) ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents

Unit	Unit Contents	Hours
1	**Introduction to System and simulation:** Concept of system and elements of system, Discrete and continuous system, Models of system and Principles of modelling and simulation, Monte carlo simulation, Types of simulation, Steps in simulation model, Advantages, limitations and applications of simulation, Applications of simulation in manufacturing system	**8 Hrs**
2	**Random numbers:** Need for RNs, Technique for Random number generation such as Mid product method, Mid square method, and Linear congruential method, Pseudo-Random Number Generation Using Excel, Properties of Random Numbers	**7Hrs**
3	**Input data analysis**, Verification and validation of simulation models, Input Data Collection, Data Collection Problems, Practical Suggestions	**5 Hrs**

4	**Output Data Analysis**: Introduction, Types of Simulation with Respect to Output, Analysis, Stochastic Process and Sample Path, Sampling and Systematic Errors, Mean, Standard Deviation and Confidence Interval	**7 Hrs**
5	**Design and evaluation of simulation experiments:** Development and analysis of simulation models using simulation language with different manufacturing systems Introduction to Discrete Event Simulation, The Methodology of Discrete Event Simulation	**7 Hrs**
6	**Queueing models:** An introduction**,** M/M/1 and M/M/m Models with examples, Open Queueing and Closed queueing network	**6 Hrs**

Textbook

1. Discrete Event System Simulation: VTU by Jerry Banks, Pearson Publication

Reference Books

1. J.Banks, J.S. Carson, B. L. Nelson and D.M. Nicol, “Discrete Event System Simulation”, PHI, New Delhi, 2009.
2. A.M. Law and W.D.Kelton, “Simulation Modeling and Analysis”, Tata McGraw Hill Ltd, New Delhi, 2008.
3. N. Viswanadham and Y. Narahari, "Performance Modeling of Automated Manufacturing Systems", PHI, New Delhi, 2007.

Title of the Course: Technology Management Course Code: PCCC0122	L	T	P	Credit
	3	1		4

Course Pre-Requisite:

Course Description:

Course Objectives:

1. To explain concept, need and issues of technology management.
2. To discuss strategic management of technology and organizational aspects of technology management.
3. To illustrate concept of acquiring technology through technology transfer and through R&D.
4. To discuss social issues in management of technology.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Explain the concept and issues of technology management	2	Understanding
CO2	Discuss strategies and organizational aspects of technology management	6	Creating
CO3	Illustrate concept of acquiring technology through technology transfer and through R&D	2	Understanding
CO4	Explain the different IPR and their exclusions	2	Understanding
CO5	Discuss social issues in technology management	6	Creating

CO-PO Mapping:

CO	1	2	3
CO1			1
CO2			2
CO3			3
CO4			3
CO5			1

1:low, 2:medium, 3:high

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with 60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:	
Unit 1:--- **Concepts of Technology Management**: Description, Scope & Implications, Its relation to business management, systems Holistic Model of Management of Technology (MOT), Operational and Management Issues, Classification of Technology, Technology cycle, Industry-Institute partnership for targeted basic research.	**6 Hrs.**
Unit 2:--- Strategic Management of Technology: Technology-strategy relationship, Elements of technology strategy and formulation of a technology strategy, Innovation Management Integration of technology strategy and business strategy for competitive success technology, the environment and sustainable development, Technology Management Evaluation	**8 Hrs.**
Unit 3:--- **Organizational Aspects of Technology Management**: Human dimension of technology and concepts of the entrepreneur, Organizational cultures and structures for promotion of creativity and innovation, the learning organization, the imperative of knowledge management	**8 Hrs.**
Unit 4:--- **Acquiring Technology Through Research and Development**: The concepts of invention and innovation, Definition and classifications of research and development, new product development, Challenges in commercializing research results, Importance of Research and Development (R&D), Production costs and R&D; Translation of R & D efforts to technology	**6 Hrs.**
Unit 5:--- **Acquiring Technology through Technology Transfer**: Definition, Source, Model of TT, System of TT with Public and Private Enterprises, Success and failure factors in technology transfer **Intellectual Property Rights**: Different IPR, Patentable and non-patentable inventions, statutory exceptions, Persons entitled to apply for patents.	**6 Hrs.**
Unit 6:--- **Social Issues in Technology Management:** Social Issues, Technological Change and Industrial Relations- Implementation of rationalization and automation in India; Impact of technological change, Technology Assessment and Environmental Impact Analysis (EIA)- Environmental impact analysis process- Guidelines on the scope of EIA; Issues in preparation of EIA report; Elements of the environmental problem	**6 Hrs.**
Textbooks: 1. Hand Book of Technology Management, by Gerard H. Gaynor, McGraw Hill. 2. Strategic Management of Technological Innovation, 2/e (SIE) by SCHILLING, MELISSA, Tata McGraw Hill 3. Strategic Management, Pearce John, Rovinson, Richard, Tata McGraw Hill	
References books: 1. Change Management, Tata McGraw Hill, Sharma, Radha 2. Business Policy and Strategic Management, Kazmi Azhar, Tata McGraw Hill 3. The Management of Intellectual Property, Satyawrat Ponkshe, Ponkshe & Bhate Publications, Pune. 4. Creating Breakthrough Products : Innovation from Product Planning to Program Approval, Jonathan Cagan, Craig M. Vogel, Pearson Education 5. Strategic Management of Technology and Innovation, Robert A. Burgelman, Clayton	

M. Christensen, Steven C. Wheelwright, and Modesto A. Maidique
6. Strategic Human Resource Management by Greer
7. Managing Technical People by Humphrey, Pearson.
8. Product Design & Development by Karl T. Ulrich & Steven Eppinger, Tata McGraw Hill.

Unit wise Measurable students Learning Outcomes:

1. To explain fundamentals and concept of technology management.
2. To explain the strategic management of technology.
3. To explain organizational aspects of technology management.
4. To explain role of research in technology management.
5. To explain concept of technology transfer.
6. To discuss social and environmental issues in technology management.

Title of the Course: Quality & Reliability Engineering	L	T	P	Credit
Course Code: PCCC0123	3	1		4

Course Pre-Requisite: Knowledge of Mathematics & Statistics is required

Course Description:

Course Objectives:

i.To summarize reliability engineering and its management throughout the product life cycle.

ii. To perform reliability engineering analysis.

iii. To compute reliability engineering parameters and estimates for applications in mechanical devices and manufacturing environments.

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Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive	
		level	Descriptor
CO1	Apply concepts and methods of reliability analysis to failure data from different engineering disciplines.	1	Understand
CO2	To develop probability distribution models (exponential, Weibull, etc.) for failure time analysis	3	Develop
CO3	Acquire ability to model system reliability.	6	Design
CO4	Acquire ability to root cause, correct, and document system failures	5	Evaluate
CO5	Acquire ability to apply system reliability analyses	4	Analyse

CO-PO Mapping:

CO	1	2	3
CO1	1		1
CO2	1		1
CO3	1		1
CO4			1
CO5			2
CO6			2

1: low, 2:medium, 3:high

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10

MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1:---Quality:Basic concepts, need for Quality, principles of TQM, Quality, cost and system effectiveness, Life characteristic phases, modes of failure, Areas of reliability,Quality and reliability assurance rules, product liability, Importance of Reliability,	-- **6 Hrs.**
Unit 2:--- Data Analysis: Causes and types of failures. Reliability expressions for constant, increasing and decreasing hazard rates. Probability plots for various distributions (exponential, Weibull, Normal and Gamma). Series, parallel, series-parallel, standby and k-out-of-m modeling.	--6 **Hrs.**
Unit 3:--System reliability evaluation techniques, including methods of bounds, decomposition and transformation techniques.Single and Multiple variable inversion techniques for minimizing system reliability expression. Analysis of dependent failures: Reliability computations using similar and dissimilar stress-strength distributions (exponential, Weibull, normal and Gamma).	--6 **Hrs.**
Unit 4:-- Time dependent stress-strength distributions: fatigue failures, Recent trends in reliability evaluation techniques Maintained systems and various definitions associated with them. Type of Maintenance. Maintainability analysis	--6 **Hrs.**
Unit 5:---Markov Models for reliability, availability and MTTF computations. Renewal Theory Approach. Maintainability design considerations. Life Cycle Costs. Life/Durability Tests of devices/ components, environmental testing of components/ circuits/ equipments, vibration and endurance tests**.**	-- **6Hrs.**
Unit 6:-- Study of degradation characteristics, failure rates of components/ devices under environmental factors. Accelerated testing, parameter estimation, accelerated testing of devices and calculation of MTTF	-- **6Hrs.**

Textbooks:

1. Kumamoto, H., Henley, E., 1996. Probabilistic risk assessment and management for engineers and scientists, 2nd Edition. IEEE Press.
2. Bahr, N., 1997. System safety engineering and risk assessment- a practical approach. Taylor & Francis, Washington DC.
3. Henley, E., Kumamoto, H., 1981. Reliability engineering and risk assessment. Prentice-Hall Inc, New Jersey.

References:

1. Reliability Engineering, E Balgurusamy, Tata McGraw Hill
2. 2. Andrew K.S.Jardine & Albert H.C.Tsang, "Maintenance, Replacement and Reliability",Taylor and Francis, 2006.
3. Bikas Badhury & S.K.Basu, "Tero Technology: Reliability Engineering and

MaintenanceManagement", Asian Books, 2003.
4. Seichi Nakajima, "Total Productive Maintenance", Productivity Press, 1993.
5. Sushil Kumar Srivastava, Maintenance Engineering and Management, S.Chand

6. Dale H. Besterfiled, "Total Quality Management", Pearson Education Asia

10.Subburay Ramasamy, Total Quality Management (Mc Graw- Hill)
11.V.A.Kulkarni,A.K.Bewoor ,Quality Control(Wiley India)
.

Course Title:	Optimization Techniques	L	T	P	Credit
Course Code:	PCCC0124	3	1	-	4

Course Pre-requisites: Introduction to operations research, simplex method, basic knowledge of solving mathematical functions.

Course Description:

This course aims to give introduction to constrained and non-constrained optimization, different methods used to optimize functions formed for solving for day to day engineering problems.

Course Objectives:

The objectives of the course are:

1. to introduce the fundamental concepts of Optimization Techniques.
2. to make the learners aware of the importance of optimizations in real scenarios.
3. to provide the concepts of various classical and modern methods of for constrained and unconstrained problems in both single and multivariable.

Course Learning Outcomes

CO	After the completion of the course the student should be able to	Bloom's Cognitive	
		Level	Descriptor
1	**Formulate** optimization problems.	VI	Creating
2	Understand and **apply** the concept of optimality criteria for various type of optimization problems.	III	Application
3	**Solve** various constrained and unconstrained problems in single variable as well as multivariable numerical methods.	III	Application
4	**Apply** the methods of optimization in real life situation.	VI	Creating

CO-PO Mapping

CO	PO1	PO2	PO3
CO1	2		2
CO2			1
CO3	1		1
CO4	2		2

1:low, 2:medium,3:high.

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE1	10
MSE	30
ISE2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc. MSE: Assessment is based on 50% of course content (Normally first three modules) ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents

Unit	Unit Contents	Hours
1	**Linear programming-extensions**: Revised simplex method, Dual Simplex method, Bounded variables method, primal-dual relationships, duality theorems, economic interpretation of dual, dual of transportation model, sensitivity analysis in LPP and transportation models, Karmarkar's interior point algorithm	**8Hrs**
2	**Dynamic programming**: formulation, recursive approach, Goal programming: formulation, graphical solution, algorithm **Integer programming**: Formulation, cutting plane algorithm, Branch and bound algorithm	**8Hrs**
3	**Classical Optimization**: Single and Multi-Variable Optimization, Hessian Matrix, Saddle Point, Lagrange Multipliers, Kuhn-Tucker Conditions **Introduction to Constrained Optimization**: Interior Penalty Function Method, Exterior Penalty Function Method	**4Hrs**
4	**Single-variable Optimization**: Unrestricted Search, Exhaustive Search, Dichotomous Search, Interval-halving Method, Fibonacci Method, Golden-section Method, Quadratic Interpolation Method, Newton Method, Quasi-Newton Method, Secant Method	**12 Hrs**
5	**Multi-variable Optimization**: Evolutionary Optimization Method, Simplex Search Method, Pattern Search Method	**4 Hrs**
6	**Conjugate Direction Method**, Steepest Descent Method, Newton's Method, Conjugate Gradient Method, Davidon-Fletcher-Powell Method	**4Hrs**

REFERENCE BOOKS:

1. Introduction to Operations Research, Hillier and Lieberman, Tata McGraw Hill
2. Quantitative techniques in Management by N D Vohra, 4/e, TataMcGraw Hill
3. Deb K (2004). Optimization for Engineering Design: Algorithms and Examples, Prentice Hall of India.
4. Rao S (1996). Engineering optimization, Theory and Practice, New Age International Publishers
5. Ravindran A, Ragsdell K and Reklaitis G (2006). Engineering Optimization: Methods and Applications, 2nd edition, John Wiley and Sons Inc.

Title of the Course: Mechanics of Composite Materials	L	T	P	Credit
Course Code: PCCC0125	3	1	-	4

Course Pre-Requisite:

1. Fundamentals of materials
2. Fundamentals of Strength of Materials
3. Manufacturing of composite materials

Course Description:

Composites are becoming an essential part of today's materials because they offer advantages such as low weight, corrosion resistance, high fatigue strength, faster assembly, etc. Composites are used as materials ranging from making aircraft structures to golf clubs, electronic packaging to medical equipment, and space vehicles to home building. Composites are generating curiosity and interest in students all over the world. This course emphasizes an overview of composites followed by basic mechanical behavior of composites.

Course Objectives:

1. To develop comprehensive knowledge in mechanical behavior of composite materials.
2. To introduce the mechanics concepts and structural theories of composite materials.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Bloom's Cognitive Descriptor
CO1	Define the basic of structure of composite materials	1	Define
CO2	Demonstrate the knowledge of Fiber-Reinforced materials	2	Demonstrate
CO3	Identify appropriate theories of failure for fiber reinforced materials	3	Identify
CO4	Design and analyze a laminates	6	Design

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1	2	2	
CO2	2		
CO3	1		1
CO4	1		2

1: low, 2:medium, 3:high

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1:--- Introduction to composite materials-Classification-Fiber reinforced composite materials- Utilizing the strength of fibers-Laminae and Laminates-Fibers & Matrices- Fiber surface treatments-Recycling Fiber- Reinforced composites. Micromechanical Analysis of a Lamina- Volume and Mass Fractions, Density, and Void Content- Prediction of engineering properties using micromechanics-Material properties of the fiber and matrix- Determination of thermal expansion coefficients- Determination of Extensional Modulus, Shear Modulus and Poisson's Ratios- strength of materials approach-Semi-Empirical Models-Elasticity approach.	8 **Hrs.**
Unit 2:--- Macro mechanical analysis of a lamina -linear elastic stress-strain characteristics of Fiber-Reinforced material: Stress and deformations in Fiber-Reinforced materials-Maxwell-Betti reciprocal theorem- Stress strain relations- Effects of free thermal strains and moisture strains. The plane-stress assumption-Stress-strain relations for plane stress- Effects of free thermal and free moisture strains- Plane stress & strain relations in a global coordinate system- Transformation relations Transformed reduced compliances & stiffnesses- Effects of free thermal and free moisture strains.	8 **Hrs.**
Unit 3:--- Classical Lamination Theory: Kirchhoff Hypothesis- Laminate Nomenclature-Laminate strains and displacements - Implications of the Kirchhoff Hypothesis-Laminate stresses & strains -Stress distributions through the thickness- Force and moment resultants-Laminate stiffness matrix: ABD Matrix-Classification of laminates and their effect on the ABD Matrix-Elastic couplings.	7 **Hrs.**
Unit 4:--- Failure, Analysis, and Design of Laminates: Symmetric laminates- Cross-ply laminates- Angle ply laminates- Anti symmetric laminates- Balanced laminate-Quasi-isotropic laminates- Failure theories for fiber reinforced materials: Maximum stress criterion- Tsai-Wu criterion- Environmental effects- Effect of laminate classification on the unit thermal force and moment resultants-Interlaminar stresses- Impact resistance-Fracture resistance- Fatigue resistance.	7 **Hrs.**
Unit 5:--- Through-thickness laminate strains- Thickness change of a laminate- Thickness change of a laminate due to free thermal strain effects-Through-thickness laminate coefficient of thermal expansion. Fiber-reinforced laminated beams- Fiber-reinforced laminated plates-Equations governing plate behavior-Governing conditions in terms of displacements-Simplifications to the governing equations. Manufacturing composite laminates- Fabrication- processing- Forming structural shapes- Non autoclave curing- Manufacturing defects.	6 **Hrs.**
References: 1] Stress Analysis of Fiber-Reinforced Composite Materials by Michael W. Hyer and Scott R White, DE Stech Publications, Inc, 2009. 2] Mechanics of composite materials by Autar K. Kaw, Taylor & Francis, 2006. 3] Mechanics of composite materials by Robert Millard Jones, Taylor & Francis, 1999. 4] The behavior of structures composed of composite materials by Jack R. Vinson, R. L. Sierakowski, Kluwer Academic Publishers, 2002.	

Title of the Course: Advanced Casting Technology Course Code:PCCC0126	L	T	P	Credit
	3	1	-	4

Course Pre-Requisite:

Fundamental knowledge of materials and basic metal Casting processes

Course Description:

Casting is the process from which solid metal shapes (castings) are produced by filling voids in molds with liquid metal. The basic steps involved in making castings are patternmaking, molding, melting and pouring, shakeout and cleaning, heat treating, and inspection. Casting is a defect prone manufacturing process. Hence Casting simulation helps to visualize mold filling and casting solidification; to predict sand casting defects. Proficient students will build on the knowledge and skills of the casting Technology course while learning additional forming techniques not covered in previous courses.

Course Objectives

CO1: To Show knowledge in an advanced foundry by taking into account the fundamental of casting process.

CO2: To Explain special molding, core making and advanced casting techniques and modern equipment's in casting operation

CO3: To Analyze manufacturing and management related problems in casting technology.

CO4: To Perform optimization of gating system with use of modern software.

CO5: To Standardize the process with various productivity and quality control techniques in a casting industry

Course Learning Outcomes:

CO	After the completion of the course the student should be able	Bloom's Cognitive level	Descriptor
CO1	To Show knowledge in an advanced foundry by taking into account the fundamental of casting process.	II	Knowledge
CO2	To Explain special molding, core making and advanced casting techniques and modern equipment's in casting operation	IV	Knowledge
CO3	To Analyze manufacturing and management related problems in casting technology.	V	Skill
CO4	To Perform optimization of gating system with use of modern software.	VI	Knowledge
CO5	To Standardize the process with various productivity and quality control techniques in a casting industry	VI	Knowledge

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1	2		
CO2	1		
CO3	1		
CO4		2	
CO5	1		
CO6			1

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30

ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/Moodle quiz/Topic seminar/Group Discussions, Industrial case study etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1: Recent Trends , advancements and Scope In Foundry Industry :	**6Hrs**

Review of conventional method of casting and pattern design, pattern and die design considerations,Position of foundry industry worldwide and in India, analysis of data in respect of production and demand, recent trends in quality specifications like dimensional accuracy, surface finish and property requirements, specifications, properties and applications of modern cast alloys-SG iron,Al – alloys, Cu- alloys, Zn – alloys, Mg -Alloys

Unit 2: Design considerations in manufacturing of pattern, dies and toolings	**7Hrs**

Computer aided casting component design, Computer aided design and manufacturing of patterns and dies, advanced materials for patterns and dies - selection and applications, allowances in patterns and dies, , rapid tooling and use of Rapid prototyping in foundry

Unit 3: Design of Gating System:	**7Hrs**

Elements and types of gating systems, gating ratio pressurized and non-pressurized gating, systems-applications, Risers – types and functions of risers, directional solidification – factor affecting and significance, use of exothermic sleeves, bricks, chills and their types, types and uses of filters, computer aided design for gating and risering systems.Nucleation kinetics, fundamentals of growth, solidification of single-phase alloys, solidification of eutectic alloys, Use of simulation software for casting methoding and metal flow simulation

Unit 4: Advancement in molding and modern casting techniques:	**6Hrs**

Coated Sands & Processing: shell sand, no-bake sand systems, CO_2, sand, cold box sand, ,developments in sand mullers and sand plants, sand reclamation - cost and environmental issues, types of reclamation methods, High pressure molding technology, flaskless molding technology, magnetic molding, Core shooters used in shell core making and cold box process, Mold and core washes / coats – types, applications, selection and significance, Use of ceramic components and filters, their selection and significance, Permanent Mold & Special Casting Techniques: Process parameters for Die casting-gravity, pressure and low pressure, Centrifugal casting, Vacuum casting, Investment casting, Squeeze casting; Advantages, limitations and applications.

Unit 5: Melting and Post processing of Castings:	**7Hrs**

Recent advancement in melting practice, Melting technologies for steels, grey C.I., S.G. iron and compacted graphite iron, Al-Si alloys, Magnesium and Titanium based alloys; Inoculation, modification, de-oxidation, de-gassing, grain refinement treatments for various alloys, advanced methods for chemical analysis for metal compositions and temperature measurement, Fettling and cleaning of castings, Shot blasting, using pneumatic chippers and grinders,Salvaging , Heat treatment and painting of castings, Defects, inspection and testing of castings, Casting defects and their classification, rejection analysis, remedial measures; instrumentation, mechanization and automation, instrumentation, Safety aspects in foundries, Environmental issues and regulations, Possible hazards in foundries, Safety measures, Safety devices, Foundry mechanization and automation, Automatic Ladle System, industrial safety

Unit 6: Quality Control, Modernization , Mechanization and Productivity Improvement Techniques in Foundry	**7Hrs**

Quality specifications in respect of raw materials used in foundry sand, sand additives, furnace charging material, checklists maintained for raw materials, mould; Heat wise pouring reports, melting log sheets, test bars, calibration of testing equipments (U.T.M., Sand testing equipments); chemical analysis, mechanical properties, test reports, rejection report analysis, defect diagnosis, remedies, use

of cause - effect or fish- bone diagrams, S.Q.C. in foundries, control charts ,Auditing in foundries, optimization techniques, costing of castings; importance and implementation of TS, ISO and QS in foundries, KAIZEN, safety measures, pollution and its control (compliance to pollution control norms as specified by govt. authorities, Mechanization in Foundries: Conveying system, automated Pouring sand reclamation plants, foundry layout

Textbooks and reference books:

1. Advanced Pattern Making – Cox I.L. (The Technical Press, London.)
2. AFS and Control hand book – AFS.
3. ASM Handbook – Vol. 15 Castings.
4. Foundry Engineering – Taylor, Fleming & Wulff (John Wiley)
5. Fundamentals of Metal Casting – Flinn, Addison Wesley
6. Fundamentals of Metal Casting Technology - P.C. Mukherjee (Oxford, IBH)
7. Heineloper & Rosenthal, Principles of Metal Casting, Tata McGraw Hill, 2000.
8. IIF - Foundry Journal
9. Jain P.L., Principles of Foundry Technology,Tata McGrawHill Publishers, 2003
10. Mechanization of Foundry Shops – Machine Construction - P.N. Aeksenov (MIR)
11. Metal Castings – Principles & Practice - T.V. Ramana Rao. (New Age International Pvt. Ltd. Publishers.)
12. Principles of Foundry Technology - P.L. Jain (TMH)
13. Principles of Metal Castings - Heine, Loper and Rosenthal (TMH)
14. Principles of Metal Manufacturing Processes, J. Beddoes & M.J. Bibby (Elsevier, Butterworth, Heinemann) (2003)
15. The Foseco Foundryman's Handbook, -Foseco, CBS Publishers & Distributors
16. The New Metallurgy of Cast Metals Castings – Campbell, CBS Publishers & Distributors,

Reference books

1. Casting Technology And Casting Alloys by A.K.Chakrabarti, (PHL Learning Pvt Ltd.)
2. Iron and steel making by Ahindra Ghosh, Amit Chatterjee (PHL Learning Pvt Ltd.)
3. Complete Casting Handbook-Metal Casting Processes, Metallurgy, Techniques & Design by John Campbell (BH Publication
4. Casting simulation website ***www.efoundryiitb.ac.in***
5. The FOSECO Foundry man's handbook 10th edition by Butter Worth-Heinemann (BH Publication)
6. ASM Handbook on casting

Title of the Course: **Advanced Welding Technology** Course Code:PCCC0127	L	T	P	Credit
	3	1	-	4

Course Pre-Requisite:

Fundamental knowledge of basic science

Course Description:

Welding is the most economical and efficient way to join metals permanently. It is the only way of joining two or more pieces of metal to make them act as a single piece.

Course Objectives

1. To understand the basic principles of welding
2.To know the various types of advanced joining processes
3. To know about welding defects and remedial measures for it
4. To know the inspection Techniques of welding.
5 To know use of automation and Robotics in welding

Course Learning Outcomes:

CO	After the completion of the course the student should be able	Bloom's Cognitive	
		level	Descriptor
CO1	Develop welding techniques for various alloys	II	Knowledge
CO2	Develop welding application concepts	IV	Knowledge
CO3	Develop mechanized welding techniques	V	Skill
CO4	Develop welding electrodes and inspection techniques	V	Skill
CO5	Develop use of automation and robotics in welding	IV	Knowledge

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1	**2**		
CO2	**1**		
CO3	**1**		
CO4		**2**	**1**
CO5	**1**		**1**

1:low, 2:medium, 3:high

Assessments :

Teacher Assessment:
Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/Moodle quiz/Topic seminar/Group Discussions, Industrial case study etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1: Power sources	**6Hrs**
Classification of welding processes - heat sources, power sources, arc characteristics, V-I relationship, different types of electrodes, ingredients and function of electrode coverings, types of weld joints.	
Unit 2: Fusion welding processes	**5Hrs**

Shielded metal arc welding, gas welding, TIG welding, MIG welding, Submerged arc welding processes	
Unit 3: Solid state welding processes	**8Hrs**
Resistance, friction, friction stir, ultrasonic, induction pressure, diffusion welding processes, explosive welding .	
Unit 4: Special welding processes	**7Hrs**
Electron beam, laser beam welding, plasma arc processes; advantages, limitations, Introduction to Robotic welding, underwater welding	
Unit 5 Welding metallurgy and Inspection and Testing of Welds	**6Hrs**
Weld thermal cycles and their effects, effects of pre and post weld heat treatments, concept of HAZ, concept of weldability and its assessment. Welding of different materials, defects in welds, their causes and remedies. Destructive testing of weld – Tensile, Bend, Impact, Nick Break, Hardness, Etch Tests, Non Destructive Testing of Welds	
Unit 6:: Welding Automation and Robotics	**6Hrs.**
Introduction, Automation options, Simple Mechanization, Dedicated and Special Purpose Automation, Robotic welding, Modular Automation, Programmable control, Remote Control Slave and Automated Systems, Welding Fixtures:Introduction, welding fixtures, their characteristics, classification and selection considerations, Principles governing design of good welding fixtures, various types of welding fixtures. Estimation of Welding Cost: Introduction, main components costs of welding processes, factors involved in welding costs, basic costing procedure for arc welding, basic costing procedure for gas welding, factors affecting welding costs.	

Textbooks and reference books:

1. ASM Handbook vol.6, welding Brazing & Soldering, 2003
2. Carrry B., Modern Welding Technology, Prentice Hall Pvt Ltd., 2002
3. Cornu.J. Advanced welding systems – Volumes I, II and III, JAICO Publishers, 1994.
4. Iotrowski – Robotic welding – A guide to selection and application – Society of mechanical Engineers, 1987.
5. Lancaster.J.F. – Metallurgy of welding – George Alien & Unwin Publishers, 1980
6. Metallurgy of Welding Technology-D. Seferian, Chapman & Hall
7. Parmer R.S., Welding Engineering and Technology, Khanna Publishers,2002
8. Principles of Metal Manufacturing Processes, J. Beddoes & M.J. Bibby (Elsevier, Butterworth, Heinemann) (2003)
9. Schwariz, M.M. – Source book on innovative welding processes – American Society for Metals (OHIO), 1981
10. Srinivasan N.K., Welding Technology, Khanna Tech Publishers, 2002
11. Welding and Welding Technology- R.Little, TMH.
12. Advance Welding Technology by Sa Rizvi Wajahat Ali

Unit wise Measurable students Learning Outcomes:

Unit 1	Power sources	ULO1.1:To learn the basic concept of welding processes.
Unit 2	Fusion welding processes	ULO2.1: To learn different fusion welding processes
Unit *3*	Solid state welding processes	ULO 3.1 To learn different solid state welding process
Unit 4	Special welding processes	ULO4.1: To learn different special welding processes. .
Unit 5	Welding metallurgy and Inspection and Testing of Welds	ULO5.1To Analysis of stresses in welded structures ULO5.2: To identify and test welding defects and weldment
Unit 6	Welding Automation and Robotics	ULO 6.1: To use welding automation and robotics

Title of the Course: CAD/CAM Lab	L	T	P	Credit
Course Code:PCCC0131	-	-	2	1

Course Pre-Requisite:

1. Fundamentals of drawing
2. Fundamentals of metal cutting
3. Cutting machine information

Course Description:

This laboratory is aimed at providing an introduction to know how common processes used in industries for manufacturing parts by removal of material in a controlled manner. Auxiliary methods for machining to desired accuracy and quality will also be covered. The emphasis throughout the laboratory course will be on understanding the basic features of the processes carried out on CNC machine, or common practices in manufacturing or acquiring skill in the operation of machines. Evidently, acquaintance with the machine is desirable and the laboratory sessions will provide adequate opportunity for this.

Course Objectives:

1. Explain fundamental of computer aided manufacturing, computer numerical control and manual CNC programming
2. Develop manual CNC program for turning and milling operation
3. Select proper tool and machining parameters for operation like turning and milling operation on CNC machine
4. Carry out CNC program generation from CAD model
5. Perform turning and milling operation on CNC machine as per specified drawing

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Explain fundamental of computer aided manufacturing, computer numerical control and manual CNC programming	2	Explain
CO2	Develop manual CNC program for turning and milling operation	3	Develop
CO3	Select proper tool and machining parameters for operation like turning and milling operation on CNC machine	3	Select
CO4	Carry out CNC program generation from CAD model	5	Carry out
CO5	Perform turning and milling operation on CNC machine as per specified drawing	5	Perform

CO-PO Mapping:

CO	1	2	3
CO1	1	2	
CO2	1	2	
CO3	2		2
CO4	2		2
CO5	2		2

1: low, 2:medium, 3:high

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30

ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1:--- Introduction to Modeling software : - 2D drawing and drafting using sketcher workbench – 2 drawings - 3D modeling and drafting using 3D features – 5 models - Assembling and drafting of 2 assemblies with interference checking. - Surface modeling – 4 exercises	7 **Hrs.**
Unit 2:--- Computer aided manufacturing: - CNC Lathe – 4 exercises - CNC Machining Center – 4 exercises Generation of tool path, generation of NC code, Optimization of tool path (to reduce machining time) using any CAM software	7 **Hrs.**
Unit 3:--- Co-ordinate Measuring Machine: Case study: Inspection of a component using different probes, generation of report and interface (for example – Gears, Housings, Flywheels, Walls of machine structure, etc.)	**6 Hrs.**
Note- 1.The term- work will be accessed on the basis of completion of above assignments and submission of report. 2. Practical examination: Duration 3 hours, Candidate will carry out one exercise in modeling and one exercise in CNC part programming/ simulation/ manufacturing, followed by oral examination.	

Textbooks:

1. Jon Stenerson and Kelly Curran "Computer Numerical Control'', Prentice-Hall India Pvt. Ltd. New Delhi, 2008.
2. Ibrahim Zeid "CAD/CAM – Theory and Practice" Mc Hill, International edition, 1998.
3. P. N. Rao "CAD/Cam principles and operations", Tata McGraw Hill
4. Thomas M. Crandell "CNC Machining and Programming, Industrial Press ISBN-0-831-3118-7
5. Bedworth, Wolfe and Henderson-Computer aided design and manufacturing, McGraw Hill.
6. A. Ghosh and Malik "Manufacturing Science" Affiliated East West Press Pvt. Ltd.
7. Tilak Raj "CNC Technology and Programming", Dhanpat Rai Publication Company.
8. Robert Quesada, T. Jeyapoovan "Computer Numerical Control: Machining and Turning Centers", Pearson Education.
9. Programming Manuals of various CNC machines (Lathes and Machining Centers) e.g. FANUC, SINUMERIC, MAZAK etc.
10. Catalogs of Commercial Tool Manufacturers e.g. SANDVIK, KENNAMETAL, ISCAR, TAEGUTECH, MITSUBISHI etc.
11. Manuals of CNC Simulation and CAM Software.
12. Reference Manuals of controllers like FANUC, Siemens, Mazak, etc.

Title of the Course: DESIGN AND ANALYSIS LAB.I	L	T	P	Credit
Course Code: PCCC0132	-	-	2	1

Course Pre-Requisite:

1. Stiffness of spring
2. Material properties
3. Creation of nodes, elements
4. Global stiffness matrix

Course Description:

This laboratory is aimed to provide hoe FEA software can be used to solve simple solid mechanics, heat transfer problems.

Course Objectives:

1. To study steps used in FEA software for solving problems.
2. To study how number of nodes and elements are created.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Create nodes and elements for analyzing cluster of springs.	2	Explain
CO2	Develop elemental node connectivity to analyze 1D bar element	3	Develop
CO3	Develop elemental node connectivity to analyze 2D truss element	3	Select
CO4	Carry out heat transfer through composite wall	5	Carry out
CO5	Examine performance of material under coupled field loading conditions.	5	Perform

CO-PO Mapping:

CO	1	2	3
CO1	1		
CO2	1		
CO3		2	
CO4		2	
CO5			2

1: low, 2:medium, 3:high

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE	50
MSE	-
ESE	50

ISE is based on assignment/declared test/quiz/seminar/Group Discussions etc.

ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1:--- Introduction to FEA software : Pre-processing, types of Solvers, Post-processing	2 **Hrs.**
Unit 2:--- Analysis of cluster of springs	2 **Hrs.**
Unit 3:--- Analysis of 1D bar element	2Hrs
Unit 3:--- Analysis of 2D truss element	2Hrs
Unit 4:--- Heat transfer through composite wall	2Hrs
Unit 5:--- Fluid flow analysis	2Hrs
Unit 6: -- Modal analysis to calculate natural frequencies and to find mode shapes	2Hrs
Note- • Minimum two problems shall be solved with hand calculations. •Term work shall be assessed on the basis of completion of above assignments and submission of reports. • Practical examination: Duration 3 hours – Each candidate shall carry out analysis using suitable FEA software followed by oral examination.	

Textbooks:

1] Bathe K.J. Finite Element Procedures. Prentice Hall, 1996.
2] Belytschko, T. et al. Nonlinear Finite Elements for Continuum and Structures, John Wiley & Sons, 2000
3] Cook, R.D. et al. Concepts and Applications of Finite Element Analysis, John Wiley & Sons, 2004.
4] Zienkiewicz, O.C. and Taylor, R.L. The Finite Element Method, Butterworth 5. Heinemann, 2000.

1.

Title of the Course: Additive Manufacturing Course Code: PCCC0204	L	T	P	Credit
	3	1		4

Course Pre-Requisite: Knowledge of 3D Modeling is essential

Course Description: With explosive growth of AM along with consumer interests, so many unique and interesting application areas are being developed. The objective of the course is to develop an understanding of the principles of the current additive manufacturing processes that produce parts by a layer at a time from solid 3D computer model so that optimal geometry, machine, and material can be selected to satisfy the functional requirement of the designed shape. The course will conclude with a perspective in pushing the current envelop of AM spanning many technical domains such as biomedical, aerospace, biotechnology industries.

Course Objectives:

1. To describe the current available Additive Manufacturing systems, their fundamental operating principles, characteristics and limitations.
2 To Distinguish between traditional and Rapid Manufacturing process.
3. To Explain the principles and key characteristics of commonly used processes in additive manufacturing.
4.To Select the appropriate materials and rapid prototyping processes for a given prototyping task
5. To Apply criterion for selecting appropriate additive manufacturing process for any given application in the areas like automotive, aeronautics, tooling and biomechanics etc.
6. To Select appropriate Additive Manufacturing Process in the area of tooling.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Bloom's Cognitive Descriptor
CO1	Describe the current available Additive Manufacturing systems, their fundamental operating principles, and their characteristics along with its limitations.	2	Describe
CO2	Distinguish between traditional and Rapid Manufacturing process and assess impact of AM on DFMA.	4	Distinguish
CO3	Explain the principles and key characteristics of commonly used processes in additive manufacturing.	2	Explain
CO4	Select the appropriate materials and rapid prototyping processes for a given prototyping task	5	Select
CO5	Apply criterion for selecting appropriate additive manufacturing process for any given application in the areas like automotive, aeronautics, tooling and biomechanics etc.	5	Apply
CO6	Select appropriate Additive Manufacturing Process in the area of tooling.	5	Select

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1	1	1	
CO2	1	1	
CO3		1	
CO4			2
CO5			2
CO6			2

1:low, 2: medium, 3: high

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1: Introduction to Additive Manufacturing: Definition of additive manufacturing (AM), and rapid manufacturing, Introduction to Solid Freeform Fabrication, areas of application. Historical development, Fundamentals of Additive manufacturing, Advantages and Limitations of Additive manufacturing, Commonly used Terms, Classification,	6 **Hrs.**
Unit 2: Design Potential and management issues of Additive Manufacturing: Difference between conventional and Additive manufacturing process, Conventional design for manufacturing and assembly (DFM, DFMA), impact of AM on DFA and DFMA, Geometrical freedom, design complexity/ optimization, parts consolidation, body fitting customization and multiple assemblies manufactured as one, Customer input and customization, CAD environment for AM. Machine costs for AM, material cost, labor cost, comparison of cost of RM with cost of injection molding; Cost of manufacturing by AM,	6 **Hrs.**
Unit 3: Additive Manufacturing Processes: Liquid based processes, Powder based processes and Solid based processes; Process overviews, STL file Generation, File Verification & Repair, Part Construction, Part Cleaning and finishing, Process Strength & limitations, ▪ Liquid-Based Systems: (Stereolithography) ▪ Solid-Based Systems: (Fused Deposition Modeling, Laminated Object Manufacturing, Ultrasonic Consolidation, Polyjet) ▪ Powder-Based Systems: (Selective Laser Sintering, Laser Engineered Net Shaping, Electron Beam Melting) ▪ Bioprinting Construction, working principal, Applications, Benefits and Limitations of above processes	8 **Hrs.**
Unit 4: Materials in RM: viscous flow, photo-polymerization, sintering, infiltration, mechanical properties, Materials for AM processes, Prototype properties: Material properties, color, dimensional accuracy, stability, surface finish, machinability, environmental resistance, operational properties; Functionally graded materials (FGM composites), processing technologies for FGMs, thermal and mechanical properties of FGM, Deposition systems and applications,	6 **Hrs.**

Unit 5: Applications of AM: Design, Concept Models, Form and fit checking, Ergonomic Studies, Functional testing, Applications in Automotive, Aerospace industry, Construction industry, Archeology, Paleontology and forensic science, miniaturization, Biomechanics, Medical Field.	6 **Hrs.**
Unit 6: Rapid Tooling: Mold making, Metal spraying, Rapid tooling for die, squeeze and permanent mold casting, Rapid manufacturing of sheet metal forming tools, casting pattern plates by rapid tooling, RP for series production investment casting.	6 **Hrs.**

Textbooks:

1. Rapid Manufacturing: An Industrial Revolution for the Digital Age – Editors N. Hopkinson, R.J.M. Hague and P.M. Dickens, (2006) John Wiley & Sons, Ltd., ISBN-10 0-470-01613-2

2. A. Pereira, J.A. Pérez, J.L. Diéguez, G. Peláez and J.E. Ares, "Design and manufacture of casting pattern plates", by rapid tooling, Archives of Materials Science, Vol. 29, No. 1-2, 2008 63

References:

1] T. A. Grimm & Associates, Users Guide to Rapid Prototyping, Society of Manufacturing Engineers (SME) ISBN 0872636976

2] Frank W. Liou, Rapid Prototyping & engineering applications, CRC Press, ISBN 978-0-8493-3409-2

Unit wise Measurable students Learning Outcomes:

1. Students shall be able to describe the current available Additive Manufacturing systems, their fundamental operating principles, characteristics and limitations.

2 . Students shall be able to Distinguish between traditional and Rapid Manufacturing process.

3. Students shall be able to Explain the principles and key characteristics of commonly used processes in additive manufacturing.

4. Students shall be able to Select the appropriate materials and rapid prototyping processes for a given prototyping task

5. Students shall be able to Apply criterion for selecting appropriate additive manufacturing process for any given application in the areas like automotive, aeronautics, tooling and biomechanics etc.

6. Students shall be able to Select appropriate Additive Manufacturing Process in the area of tooling.

Title of the Course: Manufacturing System Design Course Code:PCCC0205	L 4	T 1	P	Credit 5

Course Pre-Requisite:
Basics of Production Management concepts, basics of operations research and network analysis

Course Description:
This course focuses on better understanding of different aspects of manufacturing systems, and improving manufacturing systems performance by modifying system characteristics.

Course Objectives:
The objectives of the course are:

1. To introduce the fundamental concepts of Manufacturing Systems.
2. To make the learners aware of the importance of optimizations in manufacturing systems and methods to improve efficiency of manufacturing systems.
3. To provide hands on experience of solving data management issues, forming cellular layouts and analyzing the networks in manufacturing systems.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	**Compare** and **contrast** different types of manufacturing systems.	II	Understanding
CO2	**Analyze** networks and process dependencies in manufacturing system.	IV	Analyzing
CO3	**Estimate** different costs involved in manufacturing systems.	V	Evaluating
CO4	**Make use of** databases for storing and retrieving different data in manufacturing systems.	III	Applying
CO5	**Explain** procedure to evaluate the manufacturing systems and decision makings based on evaluations.	II	Understanding
CO6	**Develop** the machine cells and layout for manufacturing processing resources.	III	Applying

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1			
CO2	1		1
CO3	1		1
CO4	1		1
CO5			
CO6			1

1=LOW, 2=MEDIUM, 3=HIGH

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1:--- **Fundamentals**: System concept and design, Hierarchical structure, Decision making procedure, System types in manufacturing environments; Manufacturing Systems: Structural aspects, transformational aspects, procedural aspects, integrated manufacturing systems; Modes of Production- Jobbing/Intermittent/ Continuous; Mass Production- Economies of Scale, Optimum production scale, Mass Customization; Multi-Product Small Batch Production- Economies of Scope with Diversification; Logistic Systems- Material flow: conversion / transportation / storage	7 **Hrs.**
Unit 2:--- **Product / Process Planning and Design**: Product Life Cycle, planning of a new product, Product Design Aspects, Design cost considerations, Concurrent Engineering; Process and Operation Design- Computer Aided Process Planning, Optimum routing analysis using Dynamic Programming and Network Techniques, Criteria for line balancing.	8 **Hrs.**
Unit 3:--- **Manufacturing Optimization**: Criteria for Evaluation, Optimization of single stage manufacturing- Unit production time and cost; Optimization of multistage manufacturing system- Scope, basic mathematical models; Cost Estimating- Classical metal cutting cost analysis, Industrial cost estimation practices, Estimating material, setup and cycle times.	7 **Hrs.**
Unit 4:--- **Information Systems in Manufacturing**: Database structures, hierarchical, network, Relational- concepts, keys, relational operations, query languages; Shop Floor Data Collection Systems- Types of data, on-line and off-line data collection, Automatic data collection systems.	6 **Hrs.**
Unit 5:--- **Computer Simulation in Manufacturing System Analysis**: Characteristics, Models, applications of probability and statistics; Design and evaluation methodology, General framework, Analysis of situation, Setting objectives, Conceptual modeling, Detailed design, Evaluation and Decision.	6 **Hrs.**
Unit 6:--- **Modern approaches in Manufacturing**: Cellular Manufacturing- Group Technology, Composite part, Rank Order Clustering Technique, Hollier method for GT cell layouts; Flexible Manufacturing- Concept, components, architecture; Lean Production concept, principles, Agile Manufacturing-	6 **Hrs.**

concept, principles and considerations for achieving agility.

Term Work:

Any six assignments out of the following:

1. Case Study of a manufacturing system in a small / medium organization.
2. Exercise on Concurrent Engg., Optimum routing analysis, Line Balancing
3. Exercise on Optimization of Single stage / Multi stage manufacturing system
4. Cost estimation of manufacturing a medium complex component of an assembly.
5. Creation of a relational database for a module of a manufacturing system, use of a suitable query language and generation of reports
6. Exercise on designing and analysis of GT Cell layouts
7. Simulation and performance testing of a manufacturing system

Textbooks:

1. Katsudo Hitomi, (1998), "Manufacturing Systems Engineering", Viva Low Priced Student Edition, ISBN 81-85617-88-0

References:

1. B. Wu, "Manufacturing Systems Design & Analysis: Context and Techniques" (2/e), Chapman & Hall, UK, ISBN 041258140X
2. Mikell P. Groover, (2002), "Automation, Production Systems and Computer Integrated Manufacturing", (2/e), Pearson Education, ISBN 81-7808-511-9
3. Radhakrishan P., Subramaniyan S. and Raju V., "CAD / CAM / CIM", (3/E), New Age International Publication
4. Luca G. Sartori,(1998), " Manufacturing Information Systems", Addison Wesley Publishing Co.
5. N. Viswanadhan & Y, Narhari, (1998), "Performance Modeling of Automated Manufacturing Systems", Prentice Hall of India
6. Phillip F. Ostwald, Jairo Munez, (2002), "Manufacturing Processes and Systems", John Wiley & Sons (Students' Edition), ISBN 9971-512-34-3
7. Sanjay B. Joshi, Jeffrey S. Smith, (1994), "Computer Control of Flexible Manufacturing Systems: Research and Development", Springer, ISBN 0412562006, 9780412562006
8. Manufacturing Systems Control Design: A Matrix-based Approach- Bogdan S., Lewis, S., Kovacic, Z., Mireles J.; Springer (2011), ISBN: 9788184898903

Unit wise Measurable Students Learning Outcomes:

After the completion of the course the student should be able to

1. **Compare** and **contrast** different types of manufacturing systems.
2. **Analyze** networks and process dependencies in manufacturing system.
3. **Estimate** different costs involved in manufacturing systems.
4. **Make use of** databases for storing and retrieving different data in manufacturing systems.
5. **Explain** procedure to evaluate the manufacturing systems and decision makings based on evaluations.
6. **Develop** the machine cells and layout for manufacturing processing resources.

Title of the Course: Product Lifecycle Management Course Code: PCCC0206	L 3	T 1	P	Credit 4

Course Pre-Requisite:

Course Description:

Course Objectives:

1. To introduce the students to concept, need and components of PLM.
2. To explain product development process and methodologies.
3. To introduce product modelling and product data management technology.
4. To demonstrate types of analysis tools.
5. To integrate PLM with other technologies.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Explain the concept, need, benefits and components of PLM.	2	Understanding
CO2	Explain product development process and methodologies.	2	Understanding
CO3	Illustrate concepts of product modelling and different analysis tools.	2	Understanding
CO4	Explain the PDM technology and integration of PLM with other applications	2	Understanding
CO5	Demonstrate the following skills ❖ presentation skills ❖ communication skills ❖ report writing	2	Understanding

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1			1
CO2			2
CO3			2
CO4			2
CO5		1	2

1:low, 2:medium, 3:high

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with 60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1:--- **Introduction** : Background, Overview, Need, Benefits, Concept of Product Life Cycle. Components / Elements of PLM, Emergence of PLM, Significance of PLM, Customer Involvement.	**5 hrs**
Unit 2:--- Product Life Cycle Environment : Product Data and Product Workflow, Company's PLM vision, The PLM Strategy, Principles for PLM strategy, Preparing for the PLM strategy, Developing a PLM strategy, Strategy identification and selection, Change Management for PLM.	**5 hrs**
Unit 3:--- Product Development Process & Methodologies : Integrated Product development process - Conceive – Specification, Concept design, Design – Detailed design, Validation and analysis (simulation), Tool design, Realize - Plan manufacturing, Manufacture, Build/Assemble , Test (quality check) , Service - Sell and Deliver , Use, Maintain and Support, Dispose. Bottom-up design, Top-down design, Front loading design workflow, Design in context, Modular design. Concurrent engineering – work structuring and team deployment - Product and process systemization - problem, identification and solving methodologies. Product Reliability, Mortality Curve. Design for Manufacturing, Design for Assembly. Design for Six Sigma	**8 hrs**
Unit 4:--- **Product Modelling** : Product Modelling - Definition of concepts – Fundamental issues - Role of Process chains and product models -Types of product models – model standardization efforts-types of process chains - Industrial demands.	**5 hrs**
Unit 5:--- **Types of Analysis Tools**: Design for manufacturing - machining - casting and metal forming - optimum design - Design for assembly and disassembly - probabilistic design concepts - FMEA - QFD - Taguchi Method for design of experiments -Design for product life cycle. Estimation of Manufacturing costs, Reducing the component costs and assembly costs, Minimize system complexity.	**6 hrs**
Unit 6:--- **Product Data Management (PDM) Technology** - Product Data Management – An Introduction to Concepts, Benefits and Terminology, CIM Data. PDM functions, definition and architectures of PDM systems, product data interchange, portal integration, PDM acquisition and implementation. **Integration of PLM system with other applications**: Different ways to integrate PLM system, transfer files, database integration, system roles, ERP, CAD, configurators	**6 hrs**
Textbooks: 1. Grieves, Michael. Product Lifecycle Management, McGraw-Hill, 2006. 2. Product Life Cycle Management - by Antti Saaksvuori, Anselmi Immonen, Springer, 1st Edition (2003) 3. Stark, John. Product Lifecycle Management: Paradigm for 21st Century Product Realisation, Springer-Verlag, 2004. ISBN 1852338105	
References books: 1. Product Design & Process Engineering, McGraw Hill – Kogalkusha Ltd., Tokyo, 1974. 2. Product Design & Development – by Kari Ulrich and Steven D. Eppinger, McGraw Hill International Edns, 1999. 3. Effective Product Design and Development – by Stephen Rosenthol, Business One	

Orwin, Homewood, 1992 ISBN 1-55623-603-4.
4. Burden, Rodger PDM: Product Data Management, Resource Pub, 2003. ISBN 0970035225
5. Clement, Jerry; Coldrick, Andy; & Sari, John. Manufacturing Data Structures, John Wiley & Sons, 1992. ISBN 0471132691
6. Clements, Richard Barrett. Chapter 8 ("Design Control") and Chapter 9 ("Document Control") in Quality Manager's Complete Guide to ISO 9000, Prentice Hall, 1993. ISBN 013017534X
7. Crnkovic, Ivica; Asklund, Ulf; & Dahlqvist, Annita Persson. Implementing and Integrating Product Data Management and Software Configuration Management, Artech House Publishers, 2003. ISBN 1580534988
8. Garwood, Dave. Bills of Materials for a Lean Enterprise, Dogwood Publishing Co., 2004. ISBN 0962111848
9. Anti Saaksvuori, Anselmi Immonen, Product Lifecycle Management, Springer

Unit wise Measurable students Learning Outcomes:

1. To explain overview and concept of PLM.
2. To explain strategies and principles of PLM.
3. To explain the product development process and methodologies.
4. To explain the concept of product modeling and types of product model.
5. To explain different analysis tools for product design.
6. To explain product data management technology and integration of PLM with other applications.

Title of the Course: Industrial Automation and Robotics Course Code:PCCC0221	L	T	P	Credit
	3	1	-	4

Course Pre-Requisite:
Basic knowledge of manufacturing
Basics of Hydraulics and Pneumatics
Basics of Programming

Course Description:
This course is an introduction to fixed and flexible automation equipment. An emphasis is placed upon flexible equipment components such as the industrial robot. Robot topics includes fundamentals of robots, robot control system, end effectors and sensors, robot programming and kinematics

Course Objectives:
1. To be familiar with the automation and brief history of robot and applications.
2. To give the student familiarities with the kinematics of robots.
3. To give knowledge about robot end effectors and their design.
4. To learn about Robot Programming methods & Languages of robot.
5. To give knowledge about various Sensors and their applications in robots.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Bloom's Cognitive Descriptor
CO1	Distinguish the types of automation	4	Distinguish
CO2	Identify robot configurations	3	Identify
CO3	Select a sensor for given application	3	Select
CO4	Select an appropriate programming language for given application	3	Select

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1	1	2	
CO2	2		
CO3	2		2
CO4	2		2

1:low, 2:medium, 3:high

Assessments :
Teacher Assessment:
Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.

MSE: Assessment is based on 50% of course content (Normally first three modules) ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.	
Course Contents:	
Unit 1:--- **Introduction:** Automated manufacturing systems, fixed /programmable /flexible automation, need; Basic elements of automated systems- power, program and control; Advanced automation functions, Levels of automation; Industrial control systems in process and discrete manufacturing industries, Continuous and discrete control; Low cost automation, Economic and social aspects of automation.	6 **Hrs.**
Unit 2:--- **a)Transfer Lines:** Fundamentals, Configurations, Transfer mechanisms, storage buffers, control, applications; Analysis of transfer lines without and with storage buffers. **b)Assembly Automation:** Types and configurations, Parts delivery at workstations-Various vibratory and non-vibratory devices for feeding and orientation, Calculations of feeding rates, Cycle time for single station assembly machines and partially automated systems; Product design for automated assembly.	6 **Hrs.**
Unit 3:--- **Fundamentals of Industrial Robots and Control System:** Specifications and Characteristics, Basic components, configurations, Criteria for selection, various industrial applications. Drives, Robot Motions, Actuators, Power transmission systems; Robot controllers, Dynamic properties of robots- stability, control resolution, spatial resolution, accuracy, repeatability, compliance	6**Hrs.**
Unit 4:--- **Robotic End Effectors and Sensors:** Transducers and sensors- sensors in robotics and their classification, Touch (Tactile) sensors, proximity and range sensors, force and torque sensing, End Effectors- Types, grippers, Various process tools as end effectors; Robot-End effectors interface, Active and passive compliance, Gripper selection and design.	7 **Hrs.**
Unit 5:--- **Robot Programming:** Lead through method, Robot program as a path in space, Methods of defining positions in space, Motion interpolation, branching; Textual robot programming languages **Robot Kinematics:** Introduction, forward, reverse & homogeneous transformations, manipulator path control, introduction to robot dynamics configuration of a robot controller.	7 **Hrs.**
Unit 6:- Modeling and Simulation for manufacturing Plant Automation:- Introduction, need for system Modeling, Building Mathematical Model of a	6 Hrs

manufacturing Plant, Modern Tools- Artificial neural networks in manufacturing automation, AI in manufacturing, Fuzzy decision and control, robots and application of robots for automation. **Artificial Intelligence**:- Introduction to Artificial Intelligence, AI techniques, Need and application of AI. Other Topics in Robotics:- Socio-Economic aspect of robotisation. Economical aspects for robot design, Safety for robot and associated mass, New Trends & recent updates in robotics.	

Textbooks:

1. Groover, M.P., (2004), "Automation, Production Systems & Computer Integrated Manufacturing" 2/e, (Pearson Edu.) ISBN: 81-7808-511-9

2. Morris, S.Brian (1994), "Automated Manufacturing Systems", (McGraw Hill) ISBN: 0-07-113999-0

3. Pessen, David W.(1990), "Industrial Automation, Circuit Design & Components", (John Wiley & Sons, Singapore)

4. Groover, M.P.; Weiss, M.; Nagel, R.N. & Odrey, N.G. "Industrial Robotics, Technology, Programming & Applications", (McGraw Hill Intl. Ed.) ISBN:0-07-024989-X

5. Fu, K.S.; Gonzalez, R.C. & Lee, C.S.G. "Robotics-Control, Sensing, Vision and Intelligence", (McGraw Hill Intl. Ed.) ISBN:0-07-100421-1

References:

1. Keramas, James G. (1998), " Robot Technology Fundamentals",(CENGAGE) ISBN:981-240-621-2 7. Noff, Shimon Y. "Handbook of Robotics", (John Wiley & Sons)

2.Niku, Saeed B. (2002), "Introduction to Robotics, Analysis, Systems & Applications", (Prentice Hall of India)

3. Koren, Yoram "Robotics for Engineers", (McGraw Hill)

4.Schilling, Robert J.(2004), "Fundamentals of Robotics, Analysis & Control", (Prentice Hall of India), ISBN: 81-203-1047-0

5. Dan W. Patterson(1990),Introduction to Artificial Intelligence and Expert Systems
ISBN 0134771001, 9780134771007

Unit wise Measurable students Learning Outcomes:

1. The student shall be able to understand different types of automation
2. The student shall be able to understand the concept of transfer line
3. The student shall be able to understand basics of robotics
4. The student shall be able to understand robotic control system
5. The student shall be able to select appropriate end effectors
6. The student shall be able to write a robot program using suitable programming language

Title of the Course: Mechatronic System Design Course Code: PCCC0222	L	T	P	Credit
	3	1	-	4

Course Pre-Requisite:

1. Fundamentals of Electronics
2. Electrical Machines and Electronics

Course Description:

Mechatronics refers to a flexible, multi-technological approach for integration of mechanical engineering, computer engineering, electronics and information sciences. Mechatronics is essential in the design of intelligent products. It allows engineers to transform their virtual concepts into real life applications. It is a relatively new concept relating to the design of systems, devices and products aimed at achieving an optimal balance between basic mechanical structure and its overall control.

Course Objectives:

1. Apply mechanical engineering and electrical engineering knowledge and skills to problems and challenges in the areas of mechatronic engineering.
2. Integrate and use systems or devices incorporating modern microelectronics, information technologies and modern engineering tools for product design, development and manufacturing.
2. To demonstrate team-oriented skills within the field of mechatronics.
3. Interface common sensors and actuators to PCs or microcontrollers
4. To demonstrate knowledge of electrical circuits and logic design.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Demonstrate the knowledge of sensors and actuators effectively using working models	2	Demonstrate
CO2	Develop PLC program for given application by using suitable software	3	Develop
CO3	Identify appropriate signal conditioning method for given application	3	Identify
CO4	Design a simple mechatronic system for given application	6	Design

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1	2	1	
CO2	2	1	
CO3	2		2
CO4	2		2

1:low, 2:medium, 3:high

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30

ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1:--- A) I**ntroduction**: Introduction to mechatronic system, evolution, scope and components of mechatronic systems, mechatronics in product and measurement system, control system and modes of control, traditional design and mechatronic design. B) Actuators, Sensors and Transducers: Hydraulic, pneumatic and electrical actuators and their system modeling, performance terminology, system modeling of sensors; displacement, position and proximity sensors, velocity and acceleration sensors, flow sensors, force sensors, temperature sensors, ultrasonic and fibre-optic sensors, selection of sensor, piezo-electric sensors.	9 **Hrs.**
Unit 2:--- **Hardware Components:** Number systems in Mechatronics, binary logic, Karnaugh map minimization, transducer signal conditioning process, principals of analogue and digital signal conditioning, protection, filtering, operational and instrumentation amplifiers and their gains, analogue to digital and digital to analogue conversion, multiplexers, pulse modulation.	6 **Hrs.**
Unit 3:--- **Programmable Logic Controller:** Review of logic gates, basic structure, features, input/output processing, programming, functional block diagram (FBD), ladder diagram, logic functions, latching, sequencing, jumps, internal relays, counters, shift registers, master and jump control, data handling, data movement, data comparison, arithmetic operations, code conversion, analog input and output, applications for automation, diagnostics and condition monitoring.	4 **Hrs.**
Unit 4:--- **Microcontroller:** Comparison between microprocessor and microcontroller, organization of microcontroller system, architecture of MCS 51 controller, pin diagram of 8051, addressing modes, programming of 8051, introduction to Proteus and Keil software, programming of 8051 for simple applications using Proteus and Keil,interfacing input and output devices, interfacing D/A converters and A/D converters, Various applications for automation and control purpose.	8 **Hrs.**
Unit 5:--- **Real-Time Interfacing:** Introduction, Elements of Data Acquisition and Control System, Overview of I/O Process, Installation of the I/O Card and Software, Installation of the application Software, Examples, Over framing.	4 **Hrs.**

Unit 6:--- **Advanced Applications in Mechatronics:** Mechatronic control in automated manufacturing, Artificial Intelligence in mechatronics, Introduction to Fuzzy logic,Fuzzy Logic application in Mechatronics, Micro sensors in Mechatronics, and case studies of Mechatronic systems.	5 **Hrs.**

Textbooks:

1. Mechatronics, 3/e --- W. Bolton (Pearson Education)
2. Mechatronics -Dan Necsulescu (Pearson Education)
3. The 8051 Microcontroller: Architecture, Programming and Applications, 2/e—Kenneth J.Ayala (Penram International)
4. Mechatronics: Principles, Concepts and Applications - N.P.Mahalik (TMH)
5. Introduction to Mechatronics & Measurement Systems – David G. Alciatore& Michael B.Histand (TMH)
6. Process Control & Instrumentation Technology –Critis D. Johnson (Pearson Education)
7. Mechatronics System Design – DevdasShetty, Richard A. Kolk (Thomson)
8. Computer Control of Manufacturing Systems - YoramKoren (McGraw Hill)
9. Automated Manufacturing Systems: Sensors, Actuators - S. Brain Morriss (McGraw Hill)
10. Industrial Automation – David W. Pessen (John Wiley & Sons)
11. 99 Examples of Pneumatic Applications – FESTO Controls Pvt. Ltd. Bangalore.
12. Modular Pick and Place Device– FESTO Controls Pvt. Ltd. Bangalore.
13. Rationalization with Handling Technology– FESTO Controls Pvt. Ltd. Bangalore.
14. Rationalization with Small Work piece Feeding- FESTO Controls Pvt. Ltd. Bangalore.
15. Sensors for Handling & Processing Pechnology- FESTO Controls Pvt. Ltd. Bangalore.
16. Sensors in Production Engg. - FESTO Controls Pvt. Ltd. Bangalore.
17. Handbook of Industrial Automation – Richard L. Shell & Ernest L. Hall (Marcel Decker Inc.)
18. Programmable Logic Controllers"Programming Methods and Applications" (with CD Rom) –Jack R. Hackworth & Fredrick D. Hackworth,Jr.(Pearson Education).

References:

1] Mechatronics – Dan Necsulescu (Pearson Education) ISBN 81-7808 -676 – X. 8. The 8051 Microcontroller: Architecture, Programming & Applications, 2/e – Kenneth J. Ayala (Penram International) ISBN – 81-900828-7

2] Introduction to Mechatronics & Measurement System – David G. Alciatore & Michael B. Histand (TMH) ISBN 0-07-052908

Unit wise Measurable students Learning Outcomes:

1. The student shall be able to select appropriate sensor and controller for given application
2. The student shall be able to understand different signal conditioning tech
3. The student shall be able to construct PLC ladder program
4. The student shall be able to understand the concept of microprocessor and microcontroller
5. The student shall be able to understand interfacing techniques
6. The student shall be able to understand the applications of Mechatronics

Title of the Course: MICROELECTROMECHANICAL SYSTEMS AND NANO TECHNOLOGY Course Code: PCCC0223	L	T	P	Credit
	3	1		4

Course Pre-Requisite:

1. Fundamentals of Electronics
2. Electrical Machines and Electronics

Course Description:

Microelectromechanical systems (mems) refers to a flexible, multi-technological approach for integration of mechanical engineering, computer engineering, electronics and information sciences. Mechatronics is essential in the design of intelligent products. It allows engineers to transform their virtual concepts into real life applications. It is a relatively new concept relating to the design of systems, devices and products aimed at achieving an optimal balance between basic mechanical structure and its overall control.

Course Objectives:

1. Apply mechanical engineering and electrical engineering knowledge and skills to problems and challenges in the areas of MEMS.
2. Integrate and use properties of systems or devices incorporating modern microelectronics, information technologies and modern engineering tools for product design, development and manufacturing.
3. To demonstrate team-oriented skills within the field of MEMS processes.
4. Interface common MEMS sensors and actuators to PCs or microcontrollers
5. To demonstrate knowledge of microsystem packaging

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive	
		level	Descriptor
CO1	Explain MEMS, microsystem and applications of MEMS	2	Demonstrate
CO2	Explain the properties of different materials used for MEMS	3	Develop
CO3	Explain the various types of micromachining processes, etching methods and their applications	3	Identify
CO4	Explain various types of MEMS sensors and actuators	6	Design
CO5	Select the materials, manufacturing process, signal transduction technique, for microsystem design		Evaluate
CO6	Discuss microsystem packaging and packaging technology	6	Create

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1	2	1	
CO2	2	1	
CO3		1	
CO4			2
CO5	1	1	

1:low, 2:medium, 3:high

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1:--- **Introduction:** Micro-Electro-Mechanical Systems (MEMS), Microsystems and their products, miniaturization, applications, mechanical MEMS, thermal MEMS, micro-opto electro-mechanical systems, magnetic MEMS, radio frequency (RF) MEMS	**5 Hrs.**
Unit 2:--- **Materials:** Materials for MEMS – substrate and wafers, silicon as a substrate material, crystal structure, single crystal and polycrystalline, mechanical properties, silicon compounds, silicon piezo-resistors, gallium arsenide, quartz, piezo-electric crystals, polymers, packaging materials;	**10 Hrs.**
Unit 3:--- **Fabrication Processes** – Bulk micro-manufacturing, photolithography, photoresists, structural and sacrificial materials, X-ray and electron beam lithography, Thin film deposition – spin coating, thermal oxidation, chemical vapour deposition (CVD), electron beam evaporation, sputtering; Etching – wet etching, dry etching; Surface micromachining, bulk vs. surface micromachining; LIGA process and applications	**8 Hrs.**
Unit 4:--- **Microsensors and Actuators:** Sensing and actuation, Chemical sensors, Optical sensors, Pressure sensors, Thermal sensors – thermopiles, thermistors, micromachined thermocouple probes, thermal flow sensors, MEMS magnetic sensor, magnetic actuators – optical switches and bidirectional microactuators, Piezoelectric material as sensing and actuating elements – capacitance, piezomechanics, Piezoactuators as grippers, microgrippers, micromotors, microvalves, microaccelerometers, shape memory	**6 Hrs.**

alloy based optical switch, thermally activated MEMS relay, microspring thermal actuator, data storage cantilever.	
Unit 5:--- **Nanomaterials:** Molecular building blocks to nanostructures – fullerenes, nanoscaled biomolecules, chemical synthesis of artificial nanostructures, molecular switches and logic gates, nanocomposites; Carbon nanotubes - structure, single walled, multi walled, properties of carbon nanostructures and their synthesis, Potential applications of nano-structures.	**6 Hrs.**
Unit 6:--- **Nanofinishing Techniques**: Abrasive flow machining, magnetic abrasive finishing, magnetorheological finishing, elastic emission machining, ion beam machining, chemical mechanical polishing, Nanomanipulation, Nanolithography, Top-down versus bottom –up assembly, Visualisation, manipulation and characterization at the nanoscale; Applications - in Energy, Tribology, Informatics, medicine, etc	**5 Hrs.**

Text Books

1. "MEMS and MICROSYSTEMS: Design and Manufacture", Hsu, Tai-Ran, TMH, ISBN:0-07-048709-X, (2003).

2. "MEMS", Mahalik, N. P., TMH, ISBN: 0-07-063445-9, (2007).

3. "Micromanufacturing and Nanotechnology", Mahalik, N.P., Springer India Pvt. Ltd., ISBN: 978-81-8128-505-8 (Distributed by New Age International, New Delhi) (Ed.),(2006)

4. "Handbook of Microlithography, Micromachining and Microfabrication", P.Rai-Choudhury,SPIE, (1997).

5. "Introduction to Microelectronic Fabrication", Richard C. Jaeger, Prentice Hall, 2nd Edition, Volume V, ISBN: 0-201-44494-7, (2002).

6. "Nanosystems: Molecular Machinery, Manufacturing and Computation", K E Drexler, Wiley, ISBN 0471575186 ,(1992).

7. "Microsystem Design", Stephen D. Senturia, Kluwer Academic Publishers, Boston, (2001),

References:

1] Mechatronics – Dan Necsulescu (Pearson Education) ISBN 81-7808 -676 – X. 8. The 8051 Microcontroller: Architecture, Programming & Applications, 2/e – Kenneth J. Ayala (Penram International) ISBN – 81-900828-7

2] Introduction to Mechatronics & Measurement System – David G. Alciatore & Michael B. Histand (TMH) ISBN 0-07-052908

Unit wise Measurable students Learning Outcomes:

1. The student shall be able to select appropriate sensor and controller for given application
2. The student shall be able to understand different signal conditioning tech
3. The student shall be able to construct PLC ladder program

4. The student shall be able to understand the concept of microprocessor and microcontroller
5. The student shall be able to understand interfacing techniques
6. The student shall be able to understand the applications of Mechatronics

Title of the Course: Product Design and Development (Professional Elective-III) Course Code: PCCC0224	L	T	P	Credit
	3	1		4

Course Pre-Requisite: --Knowledge of 3D modeling is essential

Course Description: Product Design and Development is a course that covers modern tools and methods for product design and development. Topics include identifying customer needs, concept generation, product architecture, industrial design, design-for-manufacturing and product lifecycle management

Course Objectives:

1.To explain the concept and general process of product design and development
2. To analyze the customer needs and generate appropriate product concepts.
3.To Select the appropriate Product concept out of few generated and test these product concepts for intended function
4.To tear down the existing product and carry out benchmarking process.
5.To design the product for Manufacturing, assembly and environment concerns.
6.To Explain the concept of product lifecycle management, intellectual property rights and patents.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Bloom's Cognitive Descriptor
CO1	Explain Product Design & Development process from its first stage of customer needs to last stage.	2	Explain
CO2	Develop the appropriate product concept after analyzing customer need.	3	Develop
CO3	Select the appropriate concept and test the concept for intended function of the product.	5	Select
CO4	Dissect the existing product to analyze the function .	4	Dissect
CO5	Design the product for Manufacturing, assembly and environment concerns.	6	Design
CO6	Explain the concept of product lifecycle management, intellectual property rights and patents	2	Explain

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1	2	1	
CO2			2
CO3			
CO4	1		
CO5			2
CO6	1	1	

1:low, 2:medium, 3:high

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks

ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1:--- Introduction to Product Design & Development: Definition Of Product Design, Design By Evolution And Innovation, Factors In Product Design, Morphology Of Product Design (Seven Phases), Standardization, Simplification and Specialization In Product Design, Modern Product Development Process. Technology Forecasting and Technology S-Curve (Technology Stage),	6 **Hrs.**
Unit 2: Customer Needs and Concept Generation, Customer Needs and Satisfaction, KANO model, Customer Population and Market Segmentation, Customer Needs-Types and Models, Gathering Customer Needs Information, Establishing product function, Generating concepts, information gathering, brainstorming, Five step concept generation method, morphological analysis,	6 **Hrs.**
Unit 3: Concept Selection, testing and Concept Embodiment: concept selection process, Pugh's concept, numerical concept scoring, Methods of concept testing, process of concept embodiment, system modeling, FMEA, functional modeling and decomposition, fast method, subtract and operate procedure, establishing system functionality, augmentation and aggregation.	6 **Hrs.**
Unit 4:--- Product Teardown and benchmarking process: Product Teardown Process, Tear Down Methods - Force Flow Diagrams, Measurement and Experimentation, Applications of Product Teardown, Benchmarking Approach and Detailed Procedure, Tools Used In Benchmarking - Indented Assembly Cost Analysis, Function -Form Diagrams, Trend Analysis, Setting Product Specifications, Introduction to Product Portfolio and Architecture. Reverse Engineering.	6 **Hrs.**
Unit 5: Design for Manufacture, Assembly and Environment: Design for Manufacture and its guidelines, design for assembly and guidelines, manufacturing cost analysis, need and importance of design for environment and its guidelines, global, local and regional issues, life cycle assessment - basic method, weighed sum assessment method,	6 **Hrs.**
Unit 6:--- Introduction to Product Life Cycle Management, Intellectual Property Rights and patents : Background, Overview, Need, Benefits, and Concept of Product Life Cycle, Components/Elements of PLM, Emergence and Significance of PLM, Customer Involvement, Product Data and Product Workflow, Different Phases of Product Life Cycle and corresponding technologies. Concept of Intellectual Property Rights, Patents	6 **Hrs.**

Textbooks: 1. "Product Design and Development",Karl T. Ulrich, Steven G. Eppinger; Irwin Tata McGraw Hill, 3 rd Edition. 2. "Product Design and Manufacturing",A.C. Chitale and R.C. Gupta, Prentice Hall of India, 3 rd Edition. 3. "Product Design Techniques in Reverse Engineering and New Product Development" Kevin Otto and Kristin Wood, Pearson Education Inc. 4. "Product Lifecycle Management: Paradigm for 21st Century Product Realisation" Stark, John, Springer-Verlag, 2004. ISBN 1852338105 .	
References: 1] "New Product Development", Tim Jones, Butterworth, Heinemann, Oxford, (1997). 2] "Industrial Design for Engineers",Mayall W.H, London, Hiffee books Ltd. 3] " Handbook of Product Design for Manufacturing", Bralla, James G, McGraw Hill Pub.1986 ..	
Unit wise Measurable students Learning Outcomes: 1.Students shall be able to explain Product Design & Development process. 2.Students shall be able to Develop the appropriate product concept after analyzing customer need 3.Students shall be able to Select the appropriate concept and test the concept for intended function of the product. 4.Students shall be able to Dissect the existing product to analyze the function 5.Students shall be able to Design the product for Manufacturing, assembly and environment concerns. 6.Students shall be able to Explain the concept of product lifecycle management, intellectual property rights and patents.	

Title of the Course: COMPUTATIONAL FLUID DYNAMICS	L	T	P	Credit
Course Code: PCCC0225	3	1		4

Course Pre-Requisite:
Engineering Mathematics, Numerical Methods, Fluid Mechanics, Heat Transfer.

Course Description:
Computational fluid dynamics (**CFD**) is a branch of fluid mechanics that uses numerical analysis and data structures to solve and analyze problems that involve fluid flows. Computers are used to perform the calculations required to simulate the interaction of liquids and gases with surfaces defined by boundary conditions.

Course Objectives:
1. Equip students with the knowledge base essential for application of computational fluid dynamics to engineering flow problems.
2. Provide the essential numerical background for solving the partial differential equations governing the fluid flow.
3. Develop students' skills of using a commercial software package.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Outline an understanding for the major theories, approaches and methodologies used in CFD.	2	Understanding
CO2	Build up the skills in the actual implementation of FDM and FVM using C / C^{++} programming language.	4	Build
CO3	To apply CFD analysis to real engineering designs.	3	Apply

CO - PO Mapping:

CO	PO1	PO2	PO3
CO1	1	2	
CO2	1		1
CO3	1		2

1:low, 2:medium, 3:high.

Assessments :

Teacher Assessment:
Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with 60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1:- Introduction to CFD and Principles of Conservation Computational Fluid Dynamics: What, When, and Why?, CFD Applications, Numerical v/s Analytical v/s Experimental, Modeling v/s Experimentation, Fundamental principles of conservation, Reynolds transport theorem, Conservation of mass, Conservation of linear momentum, Navier-Stokes equation, Conservation of Energy, General scalar transport equation. Mathematical classification of Partial Differential Equation, Illustrative examples of elliptic, parabolic and hyperbolic equations, Physical examples of elliptic, parabolic and hyperbolic partial differential equations.	06 **Hrs.**
Unit 2:-Fundamentals of Discretization and Finite Volume Method Discretization principles: Pre-processing, Solution, Post-processing, Finite Element Method, Finite difference method, Well posed boundary value problem, Possible types of boundary conditions, Finite Volume Method: Finite volume method (FVM), Illustrative examples: 1-D steady state heat conduction without and with constant source term Some Conceptual Basics and Illustrations through 1-D Steady State Diffusion Problems: Physical consistency, Overall balance, FV Discretization of a 1-D steady state diffusion type problem, Four basic rules for FV Discretization of 1-D steady state diffusion type problem, Source term linearization, Implementation of boundary conditions. Discretization of 1-D unsteady state diffusion problems: implicit, fully explicit and Crank-Nicholson scheme.	08 **Hrs.**
Unit 3:- Important Consequences of Discretization of Time Dependent Diffusion Type Problems: Consequences of time-discretization in finite discretization, Consistency, Stability, Convergence, LAX Equivalence theorem, Grid independent and time independent study, Stability analysis of parabolic equations (1-D unsteady state diffusion problems): FTCS (Forward time central space) scheme, Stability analysis of parabolic equations (1-D unsteady state diffusion problems): CTCS scheme (Leap frog scheme), Stability analysis of hyperbolic equations: FTCS, FTFS, FTBS and CTCS Schemes. Finite Volume Discretization of 2-D unsteady State Diffusion type	06 **Hrs.**
Unit 4:- Discretization of Convection-Diffusion Equations: A Finite Volume Approach: Finite volume discretization of convection-diffusion problem: Central difference scheme, Upwind scheme, Exponential scheme and Hybrid scheme, Power law scheme, Generalized convection-diffusion formulation, Finite volume discretization of two-dimensional convection-diffusion problem, The concept of false diffusion, QUICK scheme. Discretization of Navier Stokes Equations: Discretization of the Momentum Equation: Stream Function-Vorticity approach and Primitive variable approach, Staggered grid and Collocated grid, SIMPLE Algorithm, SIMPLER Algorithm.	06 **Hrs.**
Unit 5:- Solution of Systems of Linear Algebraic Equations: Criteria for unique solution, infinite number of solutions and no solution, Solution techniques for systems of linear algebraic equations: Elimination, Iteration and Gradient Search method, Tridiagonal matrix algorithm (TDMA): Thomas algorithm, Illustrative examples, Error analysis of elimination methods, Iteration methods: Jacobi's method and Gauss Siedel method, Generalized analysis of the iterative methods, Sufficient condition for convergence, Rate of convergence, Scarborough criteria of sufficient condition for convergence in Gauss Siedel Method, Illustrative examples of Jacobi's method and Gauss-Siedel method, Relaxation methods, Preferential characteristics of iterative methods, Multigrid method, Line by line TDMA, ADI (Alternating direction implicit) method.	08 **Hrs.**
Unit 6:- Introduction to Turbulence Modeling Important features of turbulent flow, Vorticity transport equation, Statistical representation of turbulent flows: Homogeneous turbulence and isotropic turbulence, General Properties of turbulent quantities, Reynolds average Navier stokes (RANS) equation, Closure problem in turbulence: Necessity of turbulence modeling, Different types of turbulence model: Eddy viscosity models, Mixing length model, Turbulent	06 **Hrs.**

kinetic energy and dissipation, The κ-ε model, Advantages and disadvantages of κ-ε model, More two-equation models: RNG κ-ε model and κ-ω model, Reynolds stress model (RSM), Large eddy Simulation (LES), Direct numerical simulation (DNS).	

Textbooks:

1. H. K. Versteeg & W. Malalasekera, An Introduction to Computational Fluid Dynamics, Longman Scientific & Technical.
2. John D. Anderson Jr., Computational Fluid Dynamics, McGraw Hill Book Company.
3. J. Blazek, Computational Fluid Dynamics: Principles and Applications, Elsevier.

References:

1] S. V. Patankar, Numerical Heat Transfer and Fluid Flow, McGraw-Hill.
2] T. J. Chung, Computational Fluid Dynamics, Cambridge University Press.
3] J. H. Ferzier and M. Peric, Computational Methods for Fluid Dynamics, Springer.
4] John C. Tannehill, Dale A. Anderson and Richard H. Pletcher, Computational Fluid Mechanics and Heat Transfer, Taylor & Francis.

Unit wise Measurable students Learning Outcomes: The students will be able to

1. Explain fundamentals of CFD and governing equations
2. Demonstrate the method of discretisation using FDM and FVM
3. Explain Discretisation of Time Dependent Diffusion Type Problems
4. Demonstrate Discretisation of Convection-Diffusion Equations using Finite Volume Approach
5.Solve Systems of Linear Algebraic Equations
6. Explain fundamentals of turbulence modeling

Title of the Course: CAD/CAM/CAE PRACTICES IN METAL FORMING Course Code:PCCC0226	L	T	P	Credit
	3	1		4

Course Pre-Requisite:

1. Fundamentals of Strength of material
2. Fundamentals of material
3. Fundamentals of FEA

Course Description:

FEA tool use to show severity of stresses develop in metal forming product

Theories of forming processes are good application of theory of plasticity like yielding criteria, application of two and three dimensional problem.

forming processes use to produce different forming product for industrial application

Course Objectives:

1. Understand the analysis of flow of stresses in forming product
2. Gain the fundamental knowledge of metal working and formability.
3. Understand the analysis of flow of material and it's properties during the processes
4. Selection the process of metal forming as per the applications such as wire drawing, extrusion, rolling forging etc.
5. To introduce the students to the theory and practices of metal forming

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Explain concepts of deformation in forming process	1	Remember
CO2	Demonstrate the knowledge of stresses in metal forming process.	2	Demonstrate
CO3	Interpret the analysis of flow of material and it's properties during the processes	4	Analyze
CO4	Select process parameter of different metal forming process	3	Apply
CO5	Select the process of metal forming as per the applications	3	Apply

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1	1	1	
CO2	1		
CO3	1	1	
CO4			2
CO5			2

1:low, 2:medium,3:high.

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks

ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1:--- Introduction:-Process Modeling, The finite element method, Solid formulation and hollow formation, metal forming and FEM **Metal forming Processes**:-Introduction, Metal forming operations as a system, Classification and Description of metal forming processes, Casting process	6 **Hrs.**
Unit 2:--- Analysis and Technology in Metal Forming:- Introduction, Flow stress of metals, Friction in metal forming, Temperatures in metal forming, Impression and closed die forging, Hot extrusion of Rods and Shapes, Cold forging and extrusion, Rolling of strip, plate and shapes, Drawing of Rod, wire, shapes and Tubes, Sheet metal forming, fine blanking	6 **Hrs.**
Unit 3:--- Plasticity and Visco-plasticity: Introduction, Stress, strain and strain rate, The yield criteria, Equilibrium and Virtual work rate principle, Plastic potential and flow rate, Strain Hardening, Effective stresses and Effective strain, Visco-plasticity **Method of Analysis:** Introduction, Upper Bound method, Hills General Method, FEM	6 **Hrs.**
Unit 4:--- Workability: Overview at the workability, workability in sheet metal forming, forging, rolling, and in extrusion and wire drawing plastic work, work hardening, strain rate and temperature, deformation zone geometry, formability, forming limit diagrams	6 **Hrs.**
Unit 5:--- **Axi-symmetric Isothermal Forging:** Introduction, Finite Element formation, Pre-form design method, Die design, Shell nosing at room temperature, Plane strain rolling, Axially Symmetric forging **Steady State Processes of Extrusion and Drawing:** Introduction, Method of Analysis, Bar Extrusion, Bar Drawing, Multi pass bar drawing and Extrusion, Applications to process design **Sheet Metal Forming:** Introduction, Plastic Anisotropy, In-plane deformation process, Axi-symmetric but of plane deformation, Axi-symmetric Punch stretching and deep drawing process, Sheet metal forming of General shapes, Square – cup drawing process	6 **Hrs.**
Unit 6:--- **Finite Element Method:** Introduction, Finite Element Procedures, Elements and shape function, Element strain rate matrix, Elemental stiffness equation, Numerical integrations, Assemblage and Linear matrix solver, Boundary conditions, Direct / Iteration method, Time investment and Geometry updating, Rezoning **Plane – Strain Problems:** Introduction, Finite Element formulation, Closed die forging with flash, Sheet Rolling, Plate Bending, Side pressing	6**Hrs.**

Textbooks:

1. George E. Dieter - Mechanical Metallurgy, McGrew Hill, London, 1988

2. R. Sharan, S.N. Prasad - Forging Design and Practice
3. Forging Equipment, Material and Processes, J. Altan, F. W. Boulger - Metals Ceramic Information Center, Columbus 1973.
4. Metal Forming Fundamentals & Applications – Alan T, American Society of Metals, Metal Park 1983
5. Metal Forming Mechanics & Metallurgy, Hosford WF and Cadell R.M. , Prentice Hall, Englewood Cliffs, 1993
6. Metal Forming & Finite Element Method – by Shiro Kobjashi Oxford University
7. Theory of Plasticity- Amitav Chakraborty, McGraw Hill

References:

11] G. E. Dieter - Workability Testing Techniques, American Society for Metals, Metals Park, 1984
2] Metal Forming Handbook, -Schuler, Springer-Verlag Berlin Heidelberg New York, (2008) ISBN 3- 540-61185-1
3)Roll Forming Handbook, - Geotge T. Halmos, (CRC Press, Taylor & Francis), (2006) ISBN 0-8247- 9563-6
4] ASM Hand Book - Forming and Forging, 9/e, Volume 14, (1998

Title of the Course: Mechanical Vibrations Course Code:PCCC0227	L 03	T -	P 02	Credit 03

Course Pre-Requisite: Fundamental of Dynamics of machines

Course Description:

Free and forced vibrations of one-degree-of-freedom systems with and without viscous damping. Introduction to torsional vibration. Vibration of single -degree--of-freedom systems with and without damping. Two degree of freedom systems, Multi degree vibrations. Numerical methods for multi degree vibration analysis. Introduction to Acoustics and Noise effects.

Course Objectives:

1. Overview of basic concepts of vibration analysis.
2. Study vibration analysis of multi degree of freedom systems
3. Acquaint with the principles of vibration measuring instruments.
4. Acquaint with Acoustic parameters and noise measurement.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Define various terminology related to vibration.	3	Applying
CO2	Develop mathematical model of simple vibration system.	3	Applying
CO3	Apply analytical formulae to simple vibratory systems to calculate vibration parameters.	3	Applying
CO4	Measure vibrations of various systems.	3	Applying
CO5	Analyze dynamics of simple vibratory system.	4	Analyze
CO6	Assess dynamic behavior of two degree and multi degree vibration systems.	5	Evaluation

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1	1	1	
CO2	1	1	
CO3	1		
CO4	1		2
CO5	1		2
CO6	1		2

1:low, 2:medium,3: high

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with60-70% weightage for course content

(normally last three modules) covered after MSE.	
Course Contents:	
Unit 1- Fundamentals of vibrations: Basic concepts and definitions, vibration measuring parameters, Free vibrations, Forced vibrations.	04 **Hrs.**
Unit 2 :- Single Degree of Freedom Systems: Free vibrations with and without damping (Rectilinear, Torsional & Transverse), degree of damping. Logarithmic decrement, equivalent viscous damping, Coulomb damping. Forced vibrations with viscous damping, magnification factor, frequency (06) response curves, vibration isolation and transmissibility, forced vibrations due to support excitation.	
Unit 3:- Two Degrees of Freedom: a) Free un damped vibrations – Principal modes and natural frequencies, Co-ordinate coupling and principal co-ordinates. b) Forced vibrations (Un damped) – Harmonic excitation, Vibration Dampers and absorbers, Dynamic vibration absorber – Tuned and Un tuned type, Two rotor system	08 **Hrs.**
Unit 4:- Introduction to Multidgrees of Freedom : Free vibrations of Multi DOF System-Flexibility and stiffness influence coefficient matrix, Equation of motion , Rayleigh's method, Matrix Method, Matrix iteration method .	08 **Hrs.**
Unit 5: Continuous System: Mode shapes and natural frequencies,. Numerical methods in vibrations: Dunkerley's Method, Rayleigh, Rayleigh-Ritz, Stodola and Holzer's method.	08 **Hrs**
Unit 6:- Vibration Measurement and Applications - Instruments for measurement of displacement, velocity, acceleration and frequency of vibration, Sensors and Actuators, Introduction of X – Y plotter, Spectral analyzers, Exciters FFT analyzer. Introduction to Condition Monitoring and Fault Diagnosis.	06**Hrs.**

Textbooks:

1. "Mechanical Vibrations", Singiresu S.Rao , Pearson Education, ISBM –81-297-0179-0 - (2004).
2. "Mechanical Vibrations", G. K. Grover, Published by Nemchand and Brothers, Roorkee.
3. "Mechanical Vibrations", Dr. V. P. Singh, Published by S. Chand and Sons New Delhi.
4. "Noise and Vibration Control", Leo L. Bernack, Tata Mc- Graw Hill Publication.
5. "Mechanical Vibration and Noise Engineering",A. G. Ambekar, Prentice Hall of India.
6. "Fundamentals of Vibrations", Balchandran Magrab ,Cengage Learning.
7. "Theory of Vibrations with Applications", W. Thomson, Pearson Education,2nd Edition.
8. "Mechanical Vibration",Dr Debabrata Nag, Wiley India Pvt. Ltd ,ISBN 978-81-265-3090-8.

References:

1. "Mechanical Vibration",Austin Church, Wiely Eastern. 2nd Edition.
2. "Schaumm's Outline series in Mechanical Vibration", S. Graham Kelly, 6th Edition.
3. "Kinematics, Dynamics and Design of Machinery",Waldron, Willey India, 2nd Edition.
4. "Mechanical Vibrations", J.P. Den Hartog, Tata McGrawhill Book Company Inc., 4th Edition.
5. "Introduction to Dynamics and Control", Leonard Meirovitch, J. Wiley, New York.
6. "Elements of Vibration Analysis" Leonard Meirovitch, Tata McGrmv-Hill, New York. 2nd Edition.
7. "Principles of Vibration",Benson H. Tongue,Oxford University Press., 4th Edition.
8. "Vibrations and Noise for Engineers", Kewal Pujara Dhanpat Rai and Sons, (1992).
9. "Mechanical vibration", William J Palm III Wiley India Pvt. Ltd., ISBN 978-81-265-3168-4, 1st Edition.
10. "Fundamentals of vibrations", Leonard Meirovitch, McGraw Hill International Edition.
11 "Principles of Vibration Control", . Asok Kumar Mallik, Affiliated East-West Press.
12 "Mechanical Vibrations", A.H. Church, John Wiley and Sons, Inc, New York, 1994.

Unit wise Measurable students Learning Outcomes:

1. **Identify types of vibratory system as Undamped, Damped, SDOF, MDOF**

2. **Model the vibratory system for analysis purpose.**
3. **Evaluate natural frequencies and mode shapes of SDOF systems.**
4. **Evaluate natural frequencies and mode shapes of MDOF systems.**
5. **Measure the vibration parameters of system using instruments.**

Title of the Course: Tribology Course Code: PCCC0228	L	T	P	Credit
	3	1		4

Course Pre-Requisite:

Course Description: Fundamentals of surface contact: surface topography, asperity contact, interfacial phenomena. Friction theories and wear mechanisms. Temperatures in sliding contacts. Hydrodynamic, hydrostatic, elasto-hydrodynamic and boundary lubrication.

Course Objectives:

1. To introduce concept of tribology along with its practical objectives.
2. To explain and illustrate friction, wear and lubrication in context of tribology.
3. To provide preliminary knowledge of micro-nano trobology and green tribology.
4. To list various areas of application of tribology.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Explain industrial and practical objectives of tribology considering parameters of tribology triangle.	2	Understanding
CO2	Explain mechanisms of friction and wear for metals, alloys, ceramics and polymers.	2	Understanding
CO3	Demonstrate various wear measurement methodologies and apparatus.	2	Understanding
CO4	Illustrate different types of lubrication system	2	Understanding
CO5	Explain concept of micro-nano tribology and green tribology.	2	Understanding
CO6	Identify tribological components and tribology applications.	3	Applying

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1	**1**	**2**	**3**
CO2			1
CO3			2
CO4			2
CO5			1
CO6			2

1:low, 2:medium,3: high

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar/Group Discussions etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with 60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:	
Unit 1:--- Introduction to Tribology Definition and History of Tribology, Industrial Significance of Tribology, Practical objectives of tribology: wear, friction, lubrication, Physical properties of lubricant: viscosity, density, specific gravity, thermal properties, lubricant impurities and contaminations, Solubility of gases in oils, measurement of surface roughness	**5 Hrs.**
Unit 2:---Friction Rules of Sliding Friction, Basic Mechanisms of Sliding Friction, Other Mechanisms of Sliding Friction, Friction Transitions During Sliding, Static Friction, Stick-Slip, Rolling Friction, Friction of Metals and Alloys, Friction of Ceramics, Friction of Polymers, Friction of Solid Lubricants.	**5 Hrs.**
Unit 3:---Wear Adhesive Wear, Abrasive Wear (by Plastic Deformation and Fracture), Fatigue Wear, Impact Wear, Chemical (Corrosive) Wear, Electrical-Arc-Induced Wear, Fretting and Fretting Corrosion, Wear of Metals and Alloys, Wear of Ceramics, Wear of Polymers, Measurement of wear: Sliding Friction and Wear Tests, Abrasion Tests, Rolling-Contact Fatigue Tests, Solid-Particle Erosion Test, Corrosion Tests.	**9 Hrs.**
Unit 4:---Lubrication Fluid Film Lubrication: Regimes of Fluid Film Lubrication, Hydrostatic Lubrication, Hydrodynamic Lubrication, Elasto-hydrodynamic Lubrication, Mixed Lubrication, Boundary Lubrication, Effect of Adsorbed Gases, Effect of Monolayers and Multilayers, Effect of Chemical Films, Effect of Chain Length (or Molecular Weight).	**8 Hrs.**
Unit 5:---Micro-Nano Tribology Introduction to micro-nano tribology, Surface Force Apparatus (SFA) studies, Description of an SFA, Static (Equilibrium), Dynamic and Shear Properties of Molecularly Thin Liquid Films, AFM/FFM Studies, Description of AFM/FFM and Various Measurement Techniques, Atomic-Scale Computer Simulations.	**7 Hrs.**
Unit 6:--- **Tribological Components and Applications**: Bearing, seals, gears, cam, piston rings, MEMS, NEMS, cutting tools, grinding, industrial applications, bio-tribology **Green tribology**: Twelve Principles of Green Tribology, Areas of Green Tribology.	**6 Hrs.**
Textbooks: 1. Engineering Tribology, Gwidon W. Stachowiak, Andrew W. Batchelor, Butterworth-Heinemann. 2. Introduction to Tribology, Bharat Bhushan, A John Wiley & Sons, Ltd., Publication 3. Introduction to Tribology of Bearings, B. C. Mujumdar, S. Chand publication	
References books: 1. Principles of Tribology, Halling J., McMillan Press Ltd. 2. Handbook of Tribology: materials, coatings and surface treatments, B. Bhushan, B. K. Gupta McGraw-Hill. 3. Design of Machine Elements, V.B. Bhandari, Tata McGraw Hill Pvt Ltd 4. Fundamentals of Tribology, S. K. Basu, S. N. Sengupta & B. B. Ahuja	
Unit wise Measurable students Learning Outcomes: 1. Summarize industrial and practical aspects of tribology. 2. Explain mechanisms of friction for metals, alloys, ceramics and polymers. 3. Illustrate various types of wear and wear measurement equipment. 4. Explain various mechanisms of lubrication with its significance.	

5. Tell concept of micr-nano tribology and green tribology
6. Identify the areas of applications for tribology

Title of the Course: Automation and Simulation Lab	L	T	P	Credit
Course Code: PCCC0233	0	0	2	1

Course Pre-Requisite:

1. Hydraulic and Pneumatic Circuits
2. Micro Processor
3. PLC
4. Industrial Robots

Course Description:

This laboratory is aimed to study automation and simulation for Mechanical Systems.

Course Objectives: This subject provides students with

1. Basics of simulations and model building activity.
2. Analyzing performance of simulated model of manufacturing system.
3. Hands on experiences in different simulation software, robot, PLC programming.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	**Develop** Model and **analyze** a given manufacturing scenario using simulation.	III IV	Develop Analyze
CO2	**Develop** PLC programs for control of traffic lights, water level, lift and conveyor belt	III	Develop
CO3	**Develop** microcontroller program to guide a robot in a given arena.	III	Develop
CO4	**Develop** pneumatic and hydraulic circuits using Automaton studio.	III	Develop

CO-PO Mapping:

CO	PO1	PO2	PO3
CO1	2	1	3
CO2	1		1
CO3	1		1
CO4	1		

1:low, 2: medium, 3:high

Assessments :

Teacher Assessment:

One component of In Semester Evaluation (ISE) and one End Semester Examination (ESE) having 50%, and 50% weights respectively.

Assessment	Marks
ISE	25
ESE	25

ISE are based on practical performed/ Quiz/ Mini-Project assigned/ Presentation/ Group Discussion/ Internal oral etc.

ESE: Assessment is based on oral examination	
Course Contents:	
Experiment No. 1: - Study, design / simulation of automation projects in material handling/packaging using manufacturing simulation software.	**6 Hrs.**
Experiment No. 2: - Exercise on flexible automation using PLC, different sensors and actuators	4 **Hrs.**
Experiment No. 3: - Simulation of Robotic system for automation using a suitable software	2 **Hrs.**
Experiment No. 4: - Simulation of Electrohydraulic / Electro pneumatic circuits using a suitable software -like FESTO PneuSim & HydroSim (Demo versions available on Internet) or Automation Studio or similar simulation software	4 **Hrs.**
Experiment No. 5: - Exercise on control of electrical motors using microcontroller / microprocessor.	4 **Hrs.**
Note- • Term work shall be assessed on the basis of completion of above assignments and submission of reports. • Practical examination: Duration 3 hours – The candidate shall carry out the practical exercise on one of the above topics. It will be followed by an oral examination.	

Title of the Course: DESIGN AND ANALYSIS LAB.II	L	T	P	Credit
Course Code:	-	-	2	1

Course Pre-Requisite:

1. Stiffness of spring
2. Material properties
3. Creation of nodes, elements
4. Global stiffness matrix

Course Description:

This laboratory is aimed to provide hoe FEA software can be used to solve non-linear analysis problems.

Course Objectives:

1. To study steps used in FEA software for solving non-linear problems.
2. To study how FEA software can be used for optimization.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Bloom's Cognitive Descriptor
CO1	Develop steps in Transient Thermal analysis.	2	Explain
CO2	Develop solution for non-linear FEA	3	Develop
CO3	Develop optimized results by using FEA software.	3	Select

CO-PO Mapping:

CO	1	2	3
CO1	2		
CO2	2		
CO3	1	1	3
CO4	2	2	3

1:low, 2:medium, 3:high

Assessments :

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one EndSemester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE	50
MSE	-
ESE	50

ISE is based on assignment/declared test/quiz/seminar/Group Discussions etc.

ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Unit 1:--- Steady State Thermal analysis, Transient Thermal analysis	2 **Hrs.**
Unit 2:---	2 **Hrs.**

Non-linear analysis – Material Non-linearity	
Unit 3:--- Non-linear analysis – Geometric Non-linearity	2Hrs
Unit 4:--- Buckling Analysis	2Hrs
Unit 5:--- Optimization of Component using FEA software.	2Hrs
Unit 6:--- Mini project based on Design and Analysis Lab I and Lab II.	2Hrs
Note- •Term work shall be assessed on the basis of completion of above assignments and submission of reports. • Practical examination: Duration 3 hours – Each candidate shall carry out analysis using suitable FEA software followed by oral examination. • At least one assignment shall be based on validation of FEA results.	

Textbooks:

1] Bathe K.J. Finite Element Procedures. Prentice Hall, 1996.
2] Belytschko, T. et al. Nonlinear Finite Elements for Continuum and Structures, John Wiley & Sons, 2000
3] Cook, R.D. et al. Concepts and Applications of Finite Element Analysis, John Wiley & Sons, 2004.
4] Zienkiewicz, O.C. and Taylor, R.L. The Finite Element Method, Butterworth 5. Heinemann, 2000.

1.

Course Title:	Industrial Ethics & Human Values (Audit Course)	L	T	P	Credit
Course Code:	PCCC0262	3	1	-	4

Course Pre-requisites

Course Description

Course Objectives

1. To identify and analyse an ethical issue in the subject matter under investigation or in a relevant field.

2. To identify the multiple ethical interests at stake in a real-world situation or practice.

3. articulate what makes a particular course of action ethically defensible & assess their own ethical values and the social context of problems.

4. To identify ethical concerns in research and intellectual contexts, including academic integrity, use and citation of sources, the objective presentation of data, and the treatment of human subjects.

5. To demonstrate knowledge of ethical values in non-classroom activities, such as service learning, internships, and field work.

6. To integrate, synthesize, and apply knowledge of ethical dilemmas and resolutions in academic settings, including focused and interdisciplinary research.

Course Learning Outcomes

CO	After the completion of the course the student should be able to	Bloom's Cognitive	
		Level	Descriptor
CO1	Identify and analyse an ethical issue in the subject matter under investigation or in a relevant field	3	Identify
CO2	Identify the multiple ethical interests at stake in a real-world situation or practice	3	Identify
CO3	Articulate what makes a particular course of action ethically defensible & assess their own ethical values and the social context of problems		
CO4	Identify ethical concerns in research and intellectual contexts, including academic integrity, use and citation of sources, the objective presentation of data, and the treatment of human subjects	3	Identify
CO5	Demonstrate knowledge of ethical values in non-classroom activities, such as service learning, internships, and field work and apply knowledge of ethical dilemmas.	2	Understanding

CO-PO Mapping

CO	PO1	PO2	PO3
CO1	2		1
CO2	1		2
CO3	2		1
CO4	2	2	
CO5	3		3

Teacher Assessment

One End Semester Examination (ESE) having 100% weight.

Assessment	Marks
ESE	50

ESE: Assessment is based on 100% course content.

Course Contents

Unit	Unit Contents	Hours
1	Ethics and Human Values: Ethics and Values, Ethical Vision, Ethical Decisions, Human Values – Classification of Values, Universality of Values.	**6 Hrs.**
2	Engineering Ethics: Nature of Engineering Ethics, Profession and Professionalism, Professional Ethics, Code of Ethics, Sample Codes – IEEE, ASCE, ASME and CSI.	6 **Hrs.**
3	Engineering as Social Experimentation: Engineering as social experimentation, Engineering Professionals – life skills, Engineers as Managers, Consultants and Leaders, Role of engineers in promoting ethical climate, balanced outlook on law.	6 **Hrs.**
4	Safety Social Responsibility and Rights: Safety and Risk, moral responsibility of engineers for safety, case studies – Bhopal gas tragedy, Chernobyl disaster, Fukushima Nuclear disaster, Professional rights, Gender discrimination, Sexual harassment at work place.	6 **Hrs.**
5	Global Issues: Globalization and MNCs, Environmental Ethics, Computer Ethics, Cyber Crimes, Ethical living, concept of Harmony in life.	**6Hrs.**

Text Books

1. Govindharajan, M., Natarajan, S. and Senthil Kumar, V.S., Engineering Ethics, Prentice Hall of India, (PHI) Delhi, 2004.

Reference Books

1. Charles D, Fleddermann, “Engineering Ethics”, Pearson / PHI, New Jersey 2004 (Indian Reprint)

2. Subramainam, R., Professional Ethics, Oxford University Press, New Delhi, 2013.