Curriculum & Syllabi

of

Master of Technology

In

Computer Integrated Manufacturing

(w.e.f. 2018-19)

Vision

Mission

Program Educational Objectives

Program Outcomes

Program Specific Outcomes

Overall Credit Structure

Curriculum

Syllabus

Offered By

MECHANICAL ENGINEERING DEPARTMENT
M. M. M. UNIVERSITY OF TECHNOLOGY,
GORAKHPUR-273010, UP
August 2021

Department of Mechanical Engineering
Madan Mohan Malaviya University of Technology Gorakhpur

M.Tech: Computer Integrated Manufacturing

VISION:

To become an Internationally Acclaimed Department of Higher Learning, Research, Innovation, and Incubation inMechanicalEngineeringby2035.

MISSION:

1. To provide quality education to the students in order to make them globally competitive Mechanical Engineers.
2. To enhance the skills of students using modern engineering tools and experimental techniques to solve real life mechanical engineering problems.
3. To make them work in groups with high level of societal, environmental, and professional ethics with the self-learning attitude.
4. To establish linkages with the Industries, R&D organizations, and educational institutions in India and abroad for excellence in teaching, research, and innovation.

PROGRAMME EDUCATIONAL OBJECTIVES (PEO)

PEO-1: To prepare students in the area of mechanical engineering for successful careers in industries, academia, and research organizations through state-of-the-art education

PEO-2: To provide students with a sound foundation in science and engineering fundamentals necessary to formulate, analyze and solve mechanical engineering problems and to prepare them for research activities.

PEO-3: To develop ability in the field of machine design, thermal engineering, manufacturing, and industrial engineering so as to design and create novel products, processes and solutions for the real-life problems

PEO-4: To inculcate in students professional and ethical attitude, effective communication & teamwork skills, and ability to apply multidisciplinary knowledge to relate mechanical engineering problems to broader environmental and social context.

PEO-5: To engage students in professional development through the self-learning and keep abreast with the state-of-the-art technology needed for a successful professional career.

PROGRAMME OUTCOME (POS)

PO-1 Apply knowledge of mathematics, science, and mechanical engineering fundamentals to solve real life problems.

PO-2 Identify, formulate, apply engineering knowledge, and conduct research to solve real life mechanical engineering problems.

PO-3 Ability to design a system, component, or process by applying the knowledge of Machine Design, Thermal Engineering, Manufacturing to meet desired needs within realistic constraints such as economic, environment, cultural, societal, health and safety and sustainability.

PO-4 Ability to design and conduct experiments, as well as to analyze and interpret data and synthesis of information to reach out to solutions.

PO-5 Select, create, and apply modern engineering and IT tools, including CAD, CAM to solve complex engineering problems.

PO-6 Apply reasoning to assess the impact of engineering solutions and practices in a global, societal, health, safety, legal and cultural context.

PO-7 Understand the impact of engineering solutions in societal and environmental contexts and demonstrate knowledge of and need for sustainable development.

PO-8 Apply ethical principle, inculcate moral values and commit to professional ethics, responsibility and norms of engineering practice.

PO-9 Function effectively as member or leader in diverse teams and in multi-disciplinary settings.

PO-10 Communicate effectively on complex engineering activities with engineering fraternity and society at large such as being able to understand and write effective reports, documents, presentations and give and take instructions clearly.

PO-11 Apply knowledge and understanding of industrial engineering and management principles and function in multidisciplinary teams as a member or leader to manage projects.

PO-12 Recognition of the need for and an ability to engage in life-long self-learning in state-of-the-art technology.

PROGRAMME SPECIFIC OUTCOME (PSOS)

PSO-1. Graduate will be able to identify, analyze and solve engineering problems relating to mechanical systems together with allied engineering streams.

PSO-2. Graduates will learn managerial skills and interdisciplinary technologies to work effectively in a team and in a society by following ethical and environmental practices.

MECHANICAL ENGINEERING DEPARTMENT
M. M. M. UNIVERSITY OF TECHNOLOGY
GORAKHPUR

Overall Credit Structure for M.Tech. Programme

Credit Courses			
Postgraduate Core (PC)		**Postgraduate Electives (PE)**	
Category	**Min. Credits**	**Category**	**Min. Credits**
Maths (M)	4	Program Electives (PE)	16
Program Core (PC)	22		
Minor Project (MP)	4		
Dissertation (D)	18		
Seminar (S)	2		
	50		**16**
Total		**66 (min.)**	
Audit Courses			
Audit Courses (Other Departments)	**6** (min.)		
Grand Total	**6 (min.)**		

Credit Structure M.Tech. (Computer integrated Manufacturing)

Category Semesters	**I**	**II**	**III**	**IV**	**Total**
Maths (M)	5	-	-	-	5
ProgrammeCore (PC)	13	9	-	-	22
Program Electives (PE)	-	8	8	-	16
Minor Project (MP)	-	-	4	-	4
Dissertation (D)			4	14	18
Seminar (S)	-	-	-	2	2
Total	**18**	**17**	**16**	**16**	**67**

Curriculum of M.Tech. (Computer integrated Manufacturing)

Junior Year, Semester-I

S.N	**Category**	**Paper Code**	**Subject Name**	**L**	**T**	**P**	**Credit**
1.	M	MAS-101	Numerical Methods & Engineering Optimization	3	1	2	5
2.	PC	MME-101	Advanced Computer Aided Design	3	1	2	5
3.	PC	MME-102A	Computational Methods in Engineering	3	1	0	4
4.	PC	MME-103	Machining Science	3	1	0	4
5.	AC		Audit subject				
			Total	**12**	**4**	**4**	**18**

Junior Year, Semester-II

S.N.	Category	Paper Code	Subject Name	L	T	P	Credit
1.	PC	MME-104	Advanced Computer Aided Manufacturing	3	1	2	5
2.	PC	MME-105	Advance Machining Processes	3	1	0	4
3.	PE1	MME-1**	Program Elective-1	3	1	0	4
4.	PE2	MME-1**	Program Elective-2	3	1	0	4
5.	AC		Audit subject				
			Total	**12**	**4**	**2**	**17**

Senior Year, Semester-III

S.N.	Category	Paper Code	Subject Name	L	T	P	Credit
1.	PE3	MME-1**	Program Elective-3	3	1	0	4
2.	PE4	MME-1**	Program Elective-4	3	1	0	4
3.	MP	MME-120	Minor Project	0	0	8	4
4.	D	MME-130	Dissertation Part-I	0	0	8	4
			Total	**6**	**2**	**16**	**16**

Senior Year, Semester-IV

S.N.	Category	Paper Code	Subject Name	L	T	P	Credit
1.	S	MME-140	Seminar	0	0	4	2
2.	D	MME-150	Dissertation Part-II	0	0	28	14
			Total	**0**	**0**	**32**	**16**

Program Core(Computer Integrated Manufacturing)

S.N.	Paper Code	Subject	Prerequisite Subject	L	T	P	Credits
1.	MMS 601/ MAS-101	Numerical Methods & Engineering Optimization	-	3	1	2	5
2.	MME-101	Advanced Computer Aided Design	-	3	1	2	5
3.	MME-102A	Computational Methods in Engineering	-	3	1	0	4
4.	MME-103	Machining Science	-	3	1	0	4
5.	MME-104	Advanced Computer Aided Manufacturing	-	3	1	2	5
6.	MME-105	Advance Machining Processes	-	3	1	0	4
7.	MME-120	Minor Project	-	0	0	8	4
8.	MME-130	Dissertation Part-I	-	0	0	8	4
9.	MME-140	Seminar	-	0	0	4	2
10.	MME-150	Dissertation Part-II	Dissertation Part-I	0	0	28	14

Program Electives (Computer Integrated Manufacturing)

S.N.	Paper Code	Subject	Prerequisite Subject	L	T	P	Credits
		PE-1& PE-2 (Semester-II)					
1.	MME-151	Machine Tool Design	-	3	1	0	4
2.	MME-152	Design for Manufacture and Assembly	-	3	1	0	4
3.	MME-154A	Robotic Engineering	-	3	1	0	4
4.	MME-159	Design of experiments	-	3	1	0	4
5.	MME-155	Micro-Machining and Precision Engineering	-	3	1	0	4
6.	MME-156	Production and Operations Management	-	3	1	0	4
7.	MME-157	Additive Manufacturing	-	3	1	0	4
		PE-3 & PE-4 (Semester-III)					
1.	MME-161	Finite Element Method	-	3	1	0	4
2.	MME-169	Advance Material and Characterization	-	3	1	0	4
3.	MME-163	Industrial Automation	-	3	1	0	4
4.	MME-164	Flexible Manufacturing System	-	3	1	0	4
5.	MME-165	Concurrent Engineering & Product Lifecycle Management	-	3	1	0	4
6.	MME-166	Advanced Strength of materials	-	3	1	0	4

Audit Courses for M.Tech. (Computer Integrated Manufacturing)

S.N.	Paper Code	Subject		L	T	P	Credits
		Semester-I					
1.	MAS-105	Applied Probability and Statistics	-	3	1	0	4
2.	BOE-04	Principles of Remote Sensing		2	1	0	3
3.	BOE-07	Introduction to Data and File Structures	-	2	1	2	4
4.	MBA-109	Research Methodology	-	3	1	0	4
		Semester-II					
1.	BAS-27	Discrete Mathematics	-	3	1	0	4
2.	BCE-21	Environmental Impact Assessment & Management	-	3	1	0	4
3.	BCS-73	Neural Network & Fuzzy Systems	-	3	1	0	4
4.	BEE-15	Introduction to Microprocessors	-	3	1	2	5
5.	MBA-106	Human Resource Management	-	3	1	0	4

Department of Mechanical Engineering

Madan Mohan Malaviya University of Technology, Gorakhpur-273 010, India

M. Tech. (Computer Integrated Manufacturing) Syllabus

MMS 601/ MAS-101 NUMERICAL METHODS AND ENGINEERING OPTIMIZATION

Course category	:	Basic Sciences & Maths (BSM)
Pre-requisites	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial: 1 , Practical: 2
Number of Credits	:	5
Course Assessment methods	:	Continuous assessment through tutorials, assignments, quizzes, One Minor and one Major Theory & Practical Examination
Course Outcomes	:	The students are expected to be able to demonstrate thefollowing knowledge, skills and attitudes after completing this course

1. To find the root of a curve using iterative methods
2. To interpolate a curve using Gauss, Newton's interpolation formula.
3. Use the theory of optimization methods and algorithms developed for various types ofoptimization problems.
4. To apply the mathematical results and numerical techniques of optimization theory toEngineering problems.

Topics Covered

UNIT-I 9

Numerical Methods I: Solution of algebraic and transcendental equations by Bisection, Regula- Falsi and Newton-Raphson methods. Interpolation: Newton's forward and backward interpolation formulae, Lagrange's formula and Newton's divided difference formula.

UNIT-II 9

Numerical Methods II: Solution of system of linear equations by Gauss Jacobi method, Guass- Siedel method, Relaxation method and LU decomposition method, Cholesky method. Numerical differentiation, Numerical Integration: Trapezoidal Rule, Simpson's one-third and three-eight rules.

UNIT-III 9

Classical Optimization Techniques: Introduction, Review of single and multi-variable optimization methods with and without constraints, Non-linear one-dimensional minimizationproblems, Examples.

UNIT-IV 9

Constrained Optimization Techniques: Introduction, Direct Methods, Cutting plane method,Indirect methods, Convex programming problems, Exterior penalty function method, Examples and problems. Unconstrained optimization techniques: Introduction, Descent methods, Steepest Descentmethods Newton's method, Quasi-Newton's method.

Experiments:

1. To implement Regula Falsi method to solve algebraic equations.
2. To implement numerical integration to solve algebraic equations.
3. To implement Gauss-Siedel method for solution of simultaneous equations.
4. To implement Runge-Kutta method of order four to solve differential equations.
5. To implement Euler's method to find solution of differential equations.
6. To find optimum solution to problem parameters.
7. To find derivatives of static displacements and stresses.
8. To write Computer based algorithm and program for solution of Eigen-value problems.
9. Reduction of size of an optimization problem using Reduced basis technique.
10. To find Derivatives of Eigen-values and Eigen vectors.

Books & References

1. S.S.Rao; Engineering Optimization, New Age International.
2. E.J. Haug and J.S. Arora, Applied Optimal Design; Wiley New York.
3. P. Kandasamy, K.Thilagavathy & K.Gunavathy,Numerical Methods, S. chandPubl.

MAS-101 NUMERICAL METHODS & ENGINEERING OPTIMIZATION

Course category	:	Program Core (PC)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture : 3, Tutorial : 1 , Practical: 2
Number of Credits	:	5
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, practical work, record, viva voce and One Minor tests and One Major Theory & Practical Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

Topics Covered

UNIT-I

Numerical Methods: Solution of algebraic and transcendental equations by Bisection, Regula-Falsi and Newton-Raphson methods. Interpolation: Newton's forward and backward interpolation formulae, Lagrange's formula andNewton's divided difference formula. Solution of system of linear equations by Guass-Siedel method and Crout'smethod, Numerical Integration: Trapezoidal Rule, Simpson's one-third and three-eight rules. 9

UNIT-II

Classical Optimization Techniques: Introduction, Review of single and multi-variable optimization methodswith and without constraints, Non-linear one-dimensional minimization problems, Examples. 9

UNIT-III

Constrained Optimization Techniques: Introduction, Direct Methods, Cutting plane method and method offeasible directions, Indirect methods, convex programming problems, Exterior penalty function method, Examples and problems. 9

UNIT-IV

Unconstrained optimization techniques: Introduction: Direct search method, Random, Univariate andPattern search methods, Rosenbrock's method of Rotating co-ordinates, Descent methods, Steepest Descent methods, Quasi-Newton's and variable metric method 9

EXPERIMENTS

Minimum Eight experiments are to be performed

1. To implement numerical integration using Simpson's one-third and Simpson's three-eight rules.
2. To implement Gauss-Siedel method for solution of simultaneous equations.
3. To implement Relaxation method for solving simultaneous equations.
4. To implement Runge-Kutta method of order four to solve differential equations.
5. To implement Euler's method to find solution of differential equations.
6. To find optimum solution to problem parameters.
7. To find derivatives of static displacements and stresses.
8. To write Computer based algorithm and program for solution of Eigen-value problems.
9. Reduction of size of an optimization problem using Reduced basis technique.10.To find Derivatives of Eigen-values and Eigen vectors.

Books & References

1. Engineering Optimization
2. Applied Optimal Design
3. Optimization for Engineering Design
4. Engineering Mathematics

MME-101	**ADVANCED COMPUTER AIDED DESIGN**	
Course category	:	Program Core (PC)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture : 3, Tutorial : 1 , Practical: 2
Number of Credits	:	5
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, practical work, record, viva voce and one Minor test and One Major Theory & Practical Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. The knowledge of computer graphics system and its hardware such as graphics input, display and output devices.
2. The ability to generate circle and ellipse using Bresenham's algorithm and understand the mathematics behind 3D geometric transformations.
3. Understand analytical representations of different types of parallel such as orthographic, oblique and axonometric projections as well as non parallel such as perspective and stereographic projections.
4. The analytical representations of parametric planar curves and synthetic space curves such as Hermite, Bezier, non rational& rational B-spline curves and their properties.
5. The synthetic surfaces and their parametric representations, different solid modeling techniques and skill of generating 3D geometric models in CAD software.

Topics Covered	
UNIT-I	
Graphic Systems Introduction, Graphics systems, Graphics hardware input devices, Display devices, Color displays, Solid state monitors, Output devices, Software configuration and functions, Graphics software standards **Output Primitives** Scan conversion of primitives, Bresenham's Circle generating algorithm and Ellipse generating algorithms, problems.	9
UNIT-II	
3D Transformation Linear transformations, translation, rotation, scaling, reflection and shear, Matrix representation, Overall scaling, Composite transformations, Rotation about local axes parallel to global axes, Rotation about an arbitrary axis, Scaling with respect to fixed point, Reflection through an arbitrary plane **Projections** Plane geometric projection, Parallel projections–Matrix equations for Orthographic projection, Oblique projection-Cavalier and Cabinet projections, Axonometric projections-isometric, diametric and trimetric	9

projections, Perspective projections-vanishing point, Equation for one point, two point and three point perspective projections, Stereographic projections-monocular and binocular depth perceptions	
UNIT-III	
Curves Classical representation of curves, Parametric analytic curves, Space curves, Hermite curves-Blending functions, properties, Bezier curves-Blending functions, properties, Composite Bezier curves and drawbacks, Non-rational B-spline curves-spline blending functions, blending function formulation, knot vector, uniform, open uniform and non uniform non rational spline blending functions, B-splines curve generation for various control points, Shape control of spline curves, properties, Rational B-spline curves-open uniform, periodic uniform and non uniform knot vector, Conic sections generation	9
UNIT-IV	
Surface Description and Generation Parametric representation, Surfaces of revolution, Sweep surfaces, Bilinear surface, Ruled and developable surfaces, Coons bicubic surfaces, Bezier and B-spline surfaces **3D Graphics** Polygon surfaces-polygon meshes, Wire frame and Solid models-Regularized Boolean set operations, Sweep and boundary representations, Constructive Solid Geometry- unbounded and bounded primitives	9

EXPERIMENTS

Minimum Eight experiments are to be performed

1. Understanding and use of drafting software AutoCAD
2. Sketching and solid modeling of a machine component in CAD software such as ProE/ Solidworks etc.
3. Writing and validation of circle drawing algorithm
4. Writing and validation of ellipse drawing algorithm
5. Writing and validation of computer program for individual geometric transformation such as translation/ rotation/ scaling
6. Writing and validation of computer program for combined geometric transformations such as translation/ rotation/ scaling
7. Writing and validation of computer program for design of shaft under the combined bending and torsional loading
8. Experiments on generation of analytic curves
9. Experiments on generation of space curves
10. Experiments on generation of surfaces
11. Experiments on generation of solid models in CAD software
12. Experiments on projection of an object

Books & References

1. Computer Graphics-Hearn & Baker, Prentice Hall of India
2. Computer Aided Engineering Design-Anupam Saxena & B. Sahay, Anamaya Publishers
3. CAD/CAM Theory and Practice- Ibrahim Zeid& R Sivasubramaniam, McGraw Hill
4. Mathematical Elements for Computer Graphics- DF Rogers & JA Adams, McGraw Hill
5. CAD/CAM-HP Groover & EW Zimmers Jr, Prentice Hall India Ltd
6. Computer Aided Design-S.K. Srivastava, IK International Publications
7. Computer Aided Design-R.K. Srivastava, Umesh Publications

MME-102A	**Computational Methods in Engineering**	
Course Category	:	Program Core (PC)
Pre-requisites	:	NIL
Contact Hours/Week	:	Lecture: 3, Tutorial: 1, Practical: 0
Number of Credits	:	4
Course Assessment Methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, one minor test and one major examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge and skills after completing this course

1. Demonstrate understanding of common numerical methods and how they are used to obtain approximate solutions
2. Derive numerical methods for various mathematical operations and tasks, such as interpolation, differentiation, integration, the solution of linear and nonlinear equations, and the solution of differential equations.
3. Ability to select appropriate numerical methods for various types of problems in engineering.
4. Analyse and evaluate the accuracy of common numerical methods.

Topics Covered

UNIT-I	
Introduction to Linear Algebraic Equation, Roots of Equation, Numerical differentiation and Integration, Initial and boundary value problems. **Systems of Linear Algebraic Equations:** Gauss Elimination Method, LU Decomposition Methods, Interpolation and Curve Fitting: Polynomial Interpolation, Interpolation with Cubic Spline.	9
UNIT-II	
Roots of Equations: Incremental Search Method, Method of Bisection, Methods Based on Linear Interpolation, Newton–Raphson Method, Systems of Equations	9
UNIT-III	
Numerical Differentiation and Integration: Finite Difference Approximations, Richardson Extrapolation, Derivatives by Interpolation, Implicit and explicit integration schemes.	9
UNIT-IV	
Initial and Boundary Value Problems: Taylor Series Method, Runge–Kutta Methods,Shooting Method. **Symmetric Matrix Eigenvalue Problems**.	9

Textbooks

1.	Jaan Kiusalaas, Numerical Methods in Engineering with Matlab , Second Edition, Cambridge University Press.
2.	Arnold Neumaier, Introduction to Numerical Analysis, , Cambridge University Press.

Reference books

1.	Rao. V. Dukkipati, MATLAB an Introduction with Application, , New Age Publisher

MME-103	**MACHINING SCIENCE**	
Course Category	:	Program Core (PC)
Pre-requisites	:	NIL
Contact Hours/Week	:	Lecture: 3, Tutorial: 1, Practical: 0
Number of Credits	:	4
Course Assessment Methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, and one Minor test and One Major Theory
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Ability to understand the mechanics metal cutting, shear angle, chip flow and chip control methods.
2. Ability to apply the concept of Thermodynamics of chip formation, tool wear and tool life.
3. Ability to design and develop Economics of metal cutting-Single and multipass machining operations.
4. Ability to develop methods for defining Dynamic metal cutting, Problems associated with machining of plastics and Analysis of non-conventional machining processes ECM, EDM, LBM, WJM, USM etc.

Topics Covered

UNIT-I	
Mechanics of metal cutting-Tool geometry, Mechanics of orthogonal and oblique cutting, Shear angle relations in orthogonal cutting, Shear angle and chip flow direction in oblique cutting, Chip control methods, Analysis of cutting process, Machining with rotary tools	9
UNIT-II	
Thermodynamics of chip formation, Machining at super high speeds, Theories of tool wear, Basic action of cutting fluids, tool life, Factors governing tool life, Machinability-definition and evaluation.	9
UNIT-III	
Economics of metal cutting-Single and multipass machining operations, Criteria, variables, and restrictions for the economical conditions	9
UNIT-IV	
Dynamic metal cutting-Comparison of steady and dynamic process, Shear angle and force relationships, Grinding mechanics, Wheel characteristics and theory of wheel wear, Lapping, Honning, High speed grinding theory, Grinding of drills, form cutters etc., Problems associated with machining of plastics, Tools for plastic cutting, Analysis of non-conventional machining processes ECM, EDM, LBM, WJM, USM etc.	9

Textbooks

1.	Introduction to Machining Science- GK Lal (New Age International)
2.	Machining Fundamentals- Walker John R (Goodheart)

Reference books

1.	Non-Conventional Machining- P K Mishra (Narosa Publications)
2.	Metalwork and Machining Hints and tips (Workshop Practice)- Arnold Throp

MME-104	**ADVANCED COMPUTER AIDED MANUFACTURING**	
Course Category	:	Program Core (PC)
Pre-requisites	:	NIL
Contact Hours/Week	:	Lecture: 3, Tutorial: 1, Practical: 2
Number of Credits	:	5

Course Assessment Methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, practical work, record, viva voce and one Minor test and One Major Theory & Practical Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Understanding the implementation of automation in production system and ability to know the role of computer in the area of manufacturing.
2. Ability to design and develop various parts of CNC Machines for improving their effectiveness and implementation of adaptive control.
3. Ability to develop manual part program and computer assisted part program for the production of components
4. Ability to understand the various modules of FMS and apply the concept of group technology and computer assisted process planning.

Topics Covered

UNIT-I	
Introduction: Introduction to CAM, CAD/CAM interface, Introduction to Automation, Historical developments and future trends, automation in production system, automation strategies, advantages and disadvantages of automation, Need of NC system, fundamental of NC machine tool, Classification of NC machine tool, suitability and limitations, applications of NC system.	9
UNIT-II	
Features of CNC Machine Tool: Development in MCU technology, Principle of operation of CNC, standard controllers, Design considerations of CNC machines for improving machining accuracy – structural members, slideways, spindle drive, feed drive, lead screws; Methods for improving productivity , work holding device, automatic tool changer, features of CNC machining centres **Control of CNC Systems:** Open and Closed loop control systems, feedback devices, interpolators, Adaptive control systems.	9
UNIT-III	
CNC Part Programming: Part programming fundamentals**,** Manual Programming for turning, milling, drilling, etc., Tool length compensation, cutter radius compensation, canned cycle, Do loops, Subroutine and Macro; Concept of computer aided part programming, APT language structure, Geometry, motion and post processor commands, APT part program.	9
UNIT-IV	
FMS, CIMS & CAPP: Building blocks of flexible manufacturing systems (FMS), tool management systems, workpiece handling systems, FMS control, computer integrated manufacturing systems, computer aided process planning- variant and generative process planning.	9

EXPERIMENTS

Minimum Eight experiments are to be performed

1. Study on Retrofitting of Conventional Milling Machine to CNC Milling Machine.
2. To study the characteristics features of CNC lathe trainer (Model SS-PT-100).
3. To study the characteristics features of CNC Turning (XLTURN)
4. To study the characteristics features of CNC Milling (XLMILL)
5. Write a manual part program for turning operations and prepare the component on CNC Turning.
6. Write a manual part program for Grooving and threading operations and prepare the component on CNC Turning.
7. Write a manual part program for Peck drilling operations and prepare the component on CNC Turning.
8. Write a manual part program using linear and circular interpolation for CNC Milling and prepare the component.
9. Write a manual part program for rectangular pocket milling operation for CNC Milling and prepare the component.
10. Study and perform operations of Flexible Manufacturing System.

Textbooks

1.	Automation, Production Systems and Computer Integrated Manufacturing by Mikell P. Groover (PHI)

2.	Computer Control of Manufacturing System by Yoram Koren(McGraw Hill).
3.	Computer Aided manufacturing- P. N. Rao , N. K. Tewari & T. K. Kundra (Tata McGraw Hill).
4.	CAD/CAM/CIM – P. Radhakrishnan, S. Subrmanyam and V. Raju (New Age International)
Reference books	
1.	Principles of Computer Integrated Manufacturing – S. Kant Bajpai (PHI)
2.	Computer Aided Design & Manufacture – C. B. Besant & C. W. K. Lui (East West Press)

MME-105	**ADVANCED MACHINING PROCESSES**	
CourseCategory	:	Program Core (PC)
Pre-requisites	:	NIL
Contact Hours/Week	:	Lecture: 3, Tutorial: 1, Practical: 0
Number of Credits	:	4
Course Assessment Methods	:	Continuous assessment through tutorials, attendance, home assignments, and one Minor test and One Major Theory Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Able to understand the limitations of conventional and need of unconventional processes.
2. Able to understand working principle, mechanics of material removal, and applications of USM, AJM, and MAF.
3. Acquire the knowledge about working principle and applications of EDM, PAM, LBM and EBM.
4. Ability to know about chemical, electrochemical and hybrid unconventional machining processes.

Topics Covered

UNIT-I	
Introduction: Limitations of Conventional machining processes, Need of advanced machining processes and its classifications, Comparison between precision and micro machining, future trends of advanced machining	9
UNIT-II	
Mechanical Type Metal Removal Processes: Ultrasonic machining; Elements of the process; Tool design and economic considerations; Applications and limitations, Abrasive jet and Abrasive water jet machining principles; Mechanics of metal removal; Design of nozzles; applications, Abrasive finishing process, Magnetic abrasive finishing process	9
UNIT-III	
Thermal Type Advance Machining Processes: Classification, General principles and applications of Electro discharge, Plasma arc, Ion beam, Laser beam, Electron beam machining, Mechanics of metal removal in EDM, selection of EDM pulse generator dielectric, machining accuracy, surface finish and surface damage in EDM, Generation and control of electron beam for machining applications, advantages and limitations.	9
UNIT-IV	
Chemical and Electro-chemical Type Metal Removal Processes: Principle, working advantages, disadvantages and applications of Electrochemical, Chemical machining, Economy aspects of ECM, Electro-chemical deburring and honning **Hybrid Unconventional Machining Processes:** Introduction to ECDM, ECAM, Abrasive EDM etc.	9

Textbooks

1.	Advance Machining Processes- V.K. Jain (New Age)
2.	Modern Machining Processes- P.C. Pandey (New Age)
Reference books	
1.	Manufacturing Processes- Degarmo(McGraw-Hill International)
2.	Manufacturing Processes- Kalpakjian (Tata McGraw-Hill International)

MME-120	**MINOR PROJECT**	
CourseCategory	:	Program Core (PC)
Pre-requisites	:	NIL
Contact Hours/Week	:	Lecture: 0, Tutorial: 0, Practical: 8
Number of Credits	:	4
Course Assessment Methods	:	Continuous assessment through attendance, project reports, mid semester presentation and end semester presentation.
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Understanding of importance of literature survey.
2. Develop ability to comprehend the research paper.
3. Understanding of steps involved in writing the research paper.
4. Develop the ability to write a research paper.

MME-130	**DISSERTATION PART-I**	
Course Category	:	Program Core (PC)
Pre-requisite Subject	:	NIL
Contact Hours/Week	:	Lecture : 0, Tutorial : 0, Practical: 8
Number of Credits	:	4
Course Assessment Methods	:	Continuous assessment through attendance, project reports, mid semester presentation and end semester presentation.
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Analyze and apply prior knowledge to designing and implementing solutions to open-ended computational problems while considering multiple realistic constraints.
2. Analyze the selected topic, organize the content and communicate to audience in an effective manner
3. Analyze Database, Network and Application Design methods
4. Evaluate the various validation and verification methods

MME-140		**SEMINAR**
Course Category	:	Program Core (PC)
Pre-requisites	:	-
Contact Hours/Week	:	Lecture: 0, Tutorial: 0, Practical: 4
Number of Credits	:	2
Course Assessment Methods	:	Continuous assessment through presentations and viva voce
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course
1. Ability to understand the working in real environment and get acquainted with the organization structure, business operations and administrative functions. 2. They able to enhance the communications and presentation skills. 3. Ability to evaluate, credit, and synthesize sources. 4. Understanding to write technical documents and give oral presentations related to the work completed.		

MME-150	**DISSERTATION PART-II**	
Course category	:	Program Core (PC)
Pre-requisite Subject	:	Dissertation Part-I
Contact hours/week	:	Lecture : 0, Tutorial : 0, Practical: 28
Number of Credits	:	14
Course Assessment Methods	:	Continuous assessment through attendance, project reports, mid semester presentation and end semester presentation.
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course
1. Synthesizing and applying prior knowledge to designing and implementing solutions to open-ended computational problems while considering multiple realistic constraints. 2. Analyze the selected topic, organize the content and communicate to audience in an effective manner 3. Analyze Database, Network and Application Design methods 4. Evaluate the various validation and verification methods 5. Analyzing professional issues, including ethical, legal and security issues, related to computing projects		

MME-151	**MACHINE TOOL DESIGN**	
Course Category	:	Program Electives (PE)
Pre-requisite Subject	:	NIL
Contact Hours/Week	:	Lecture: 3, Tutorial: 1, Practical: 0
Number of Credits	:	4
Course Assessment Methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, practical work, record, viva voce and one Minor test and One Major Theory examination.

Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Design different machine tools considering static and dynamic loads.
2. Familiar with various attachments, equipment's and machine tools required for metal cutting processes
3. Able to select/optimize various machining parameters
4. Understand effect of vibrations on life of machine tools.
5. Understand design considerations for Special features in Machine tools.

Topics Covered

UNIT-I	
Machine Tool Drive: working and auxiliary motion in machine, Machine tool drives, Hydraulic transmission, Mechanical transmission, General requirements of machine tool design, Layout of machine tools. **Regulation of Speed and Feed Rates:** Aim of speed feed regulation, stepped regulation of speed, design of speed box, Design of feed box, Special cases of gear box design, Set stopped regulation of speed and feed rates.	9
UNIT-II	
Design of Machine Tool Structure: Fundamentals of machine tool structures and their requirements, Design criteria of machine tool structure, Static and dynamic stiffness, Design of beds and columns, Design of housing models, Techniques in design of machine tool structure.	9
UNIT-III	
Design of Guide-ways and power Screws: Function and type of guide-ways, design of slide-ways, Protecting devices for slide-ways, Design of power screws.	9
UNIT-IV	
Design of Spindles and Spindle Supports: Materials for spindles, Design of spindles, Antifriction bearings, sliding bearings. **Dynamics of Machines Tools:** General procedure of assessing dynamic stability of EES, Cutting processing, closed loop system, Dynamic characteristics of cutting process, Stability analysis.	9

Books & References

1. Machine Tool Design- N.K. Mehta (Tata McGraw Hill)
2. Machine Tool design Handbook (CMTI Bangalore)
3. Design of Machine Tools- S. K. Basu& D Pal (Oxford University Press)
4. Machine Tools & Tool Desig –P.C. Sharma (S. Chand Publishing)

MME-152	**DESIGN FOR MANUFACTURE AND ASSEMBLY**	
Course Category	:	Program Elective (PE)
Pre-requisites	:	NIL
Contact Hours/Week	:	Lecture: 3, Tutorial: 1, Practical: 0
Number of Credits	:	4
Course Assessment Methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, and one Minor test and One Major Theory examination.
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Understand the quality aspects of design for manufacture and assembly. 2. Apply the concept of DFM for casting, welding, forming and assembly. 3. Identify the design factors and processes as per customer specifications. 4. Apply the DFM method for a given product.		
Topics Covered		
UNIT-I		
Introduction to DFMA: History of DFMA, Steps for applying DFMA during product design, Advantages of applying DFMA during product design, Reasons for not implementing DFMA, Traditional design and manufacture Vs concurrent engineering, DFA index, poke-yoke, lean principles, DFMA as the tool for concurrent engineering, three DFMA criteria for retaining components for redesign of a product. **Introduction to Manufacturing Process:** Classification of manufacturing process, Basic manufacturing processes, Mechanical properties of material: Tensile properties, Engineering stress-strain, True stress strain, Compression properties, Shear properties, Introduction to materials and material selection: Classification of engineering materials, Material selection for product design.		9
UNIT-II		
Metal Casting: Appraisal of various casting processes, Selection of casting process, General design considerations for casting – Use of Solidification Simulation in casting design – Product design rules for sand casting. **Forging**: Design factors for Forging – Closed die forging design – Location of parting lines of dies – Drop forging die design – General design recommendations. **Extrusion, Sheet Metal Work & Plastics:**Design guidelines for Extruded sections - Keeler Goodman Forming Limit Diagram -Component Design for Blanking. Plastics: Viscoelastic and Creep behavior in plastics – Design guidelines for Plastic components. Injection moulding: Typical characteristics of injection moulded parts, Effect of shrinkage, Suitable materials, Design recommendations. **Design for powder metal processing:** Introduction to powder metal processing, Typical characteristics and applications, Limitations, Design recommendations.		9
UNIT-III		
Machining Process: Overview of various machining processes – general design rules for machining -Dimensional tolerance and surface roughness – Design for Machining ease – Redesigning of components for machining ease with suitable examples, General design recommendations for machined parts **Metal Joining:** Appraisal of various welding processes, Factors in design of weldments – General design guidelines – pre and post treatment of welds – Effects of thermal stresses in weld joints – Design of brazed joints. Design for adhesively bonded assemblies: Introduction, Typical characteristics, Suitable materials, Design recommendations for adhesive joint.		9
UNIT-IV		
Design for Assembly: The assembly process, Characteristics and applications, Example of common assembly, Economic significance of assembly, General taxonomies of assembly operation and systems, Developmentof Systematic DFA Methodology, Assembling a product, Design for Assembly: Introduction, Design consideration, Design for Fasteners: Introduction, Design recommendation for fasteners.		9
Textbooks		
1.	Geoffrey Boothroyd, Peter Dewhurst and Winston Knight (2002) Product Design forManufacture and Assembly, Second Edition, CRC press, Taylor & Francis, Florida,USA	
2.	George E. Deiter, Engineering design-Material & Processing Approach, Mc. Graw Hill, Intl. 2nd Ed.2000.	
3.	Handbook of Product Design for Manufacture: A Practical Guide to Low Cost Production- J.G. Bralla (McGraw Hill)	
Reference books		
1.	A.K Chitale and R.C Gupta, Product design and Manufacturing / A.K Chitale,Prentice – Hall of India,New Delhi, 2003.	
2.	Fundamental of Design and Manufacturing, G.K. Lal, Vijay Gupta, N.V.Reddy, Alpha Science Int Ltd.	
3.	Surender Kumar &GouthamSutradhar,Design and Manufacturing, Oxford & IBH,Publishing Co. Pvt.Ltd., New Delhi, 1998.	

MME-154A	**ROBOTIC ENGINEERING**	
Course Category	:	Program Elective (PE)
Pre-requisites	:	----
Contact Hours/Week	:	Lecture : 3, Tutorial : 1, Practical: 0
Number of Credits	:	4
Course Assessment Methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, One Minor test and One Major Theory
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Ability to understand the Classification of Robots, Robot specifications, applications and Robot Sensors.
2. Ability to solve problems related to Manipulator kinematics, modeling of mechanical systems and elements.
3. Ability to solve problems related to Manipulator dynamics.
4. Ability to design and develop various Robot Control and robot programming for welding, material handling.

Topics Covered

UNIT-I	**9**
Introduction Definition, Classification of Robots, Geometric classification and control classification, Robot Components-manipulator, controller and its elements, sensory devices, Functions of a robot system, Robot specifications and applications, **Robot Sensors** Introduction, Classification, Non-optical position sensors, Optical position sensors, Velocity sensors, Acceleration sensors, Contact and non-contact type proximity sensors.	
UNIT-II	9
Manipulator Kinematics Position and orientation of a rigid body, Homogeneous coordinates, Coordinate transformations-translational, rotational, Matrix operators, Coordinate reference frames, Homogeneous transformations and the manipulator, forward solution, inverse solution, Representation of joints, link representation using D-H parameters. **Mechanical Systems: Components, Dynamics and Modeling** Introduction, Linear motion, Rotational motion, Moment of Inertia-calculation and measurement, Mechanical work and power, Motion conversion, Rotary-to-rotary motion, Rotary-to-linear motion, Problems with real world components, Modeling of mechanical systems, elements, and examples.	
UNIT-III	9
Jacobians: Velocities, Static Forces Examples of D-H parameters and link transforms, Velocity analysis, linear and rotational velocity of rigid bodies, velocity propagation, Jacobians, Singularities, velocity transformation and inverse velocity and acceleration, force transformation and inverse force, examples. **Manipulator Dynamics** Introduction, Lagrange's equation kinetic and potential energy. Link inertia, Tensor, link Jacobian Manipulator inertia tensor. Newton - Euler formulation, Lagrange - Euler formulation, problems.	
UNIT-IV	9
Robot Control: Linear, Nonlinear and Force Control Control Techniques, Dynamics Systems, Transfer Function and State-Space Representation, Performance and stability of Feedback Control, Closed-loop control in position servo, Effect of friction and gravity, DC servomotor, position with no friction or gravity, position with nonzero friction and/or gravity, PID Control, State-Feedback Control, Joint Controllers. Control of a moving block, Multivariable Robot Control, Stability of Multi-DOF Robot, PD Position Control, Inverse Dynamic Control, Force control.	

Robot Programming Robot control sequencing, Language based programming, Program algorithm, examples, VAL language, robot programming for welding, machine tools, material handling etc.	

Textbooks	
1.	Introduction to Robotics, S.K.Saha, McGraw Hill Publication
2.	Robotics: Fundamental Concepts and Analysis, Ashitava Ghosal, Oxford University Press
3.	Robot Dynamics and Control, Mark W. Spong, M. Vidyasagar, John Wiley & Sons
3.	Robotic Engineering-R.D. Klafter, T.A. Chmielewski and M. Negin, Prentice-Hall International
2.	Robotics – K.S. Fu, R.C. Gonzalez & CSG Lee, McGraw Hill International
3.	Robotics-K.C. Jain and L.N. Aggrawal, Khanna Publishers
4.	Robotics for Engineers- Y. Koren, McGraw Hill
5.	Introduction to Robotics – J.J. Craig, Pearson Education
Reference books	
1.	Robotic Technology-Phillipe Collet, Prentice Hall of India
2.	An Introduction to Robot Technology- Coiffet and Chirooza, Kogan Page
3.	Robots & Manufacturing Automation – Asfahl , Wiley Eastern
4.	Industrial Robots- Groover, Mitchell Weiss, Nagel Octrey- McGraw Hill
5.	Robotics Technology and Flexible Automation, S.R. Deb and S. Deb, McGraw Hill Education

MME-159	**DESIGN OF EXPERIMENTS**	
Course Category	:	Program Electives (PE)
Pre-requisites	:	NIL
Contact Hours/Week	:	Lecture: 3, Tutorial: 1, Practical: 0
Number of Credits	:	4
Course Assessment Methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, and One Minor test and One Major Theory examination.
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course. Also, able to plan, design and conduct experiments efficiently and effectively, and analyse the resulting data to obtain objective conclusions. Both design and statistical analysis issues are discussed.

1. Understanding of western and Taguchi quality philosophy and steps involved in robust design.
2. Understanding of classical and factorial experiments and experimental design.
3. Opportunities to use the principles taught in the course arise in all phases of engineeringwork, including new product design and development, process development, & manufacturing process improvement.
4. Ability to analyse and interpret the experimental data using ANOVA and regression analysis.
5. Understanding of Taguchi's orthogonal arrays and Signal to Noise ratio, parameter design and tolerance design.

Topics Covered

UNIT-I	
Quality Control and Experimental Design: Quality assurance & Total Quality control, Basic statistical concepts, Control of accuracy and precision, Quality Engineering System. Western and Taguchi quality philosophy, Elements of cost, Noise factors causes of variation, Quadratic loss function and variation of quadratic loss functions.	9

Robust Design: Steps in robust design: parameter design and tolerance design, its application to control of processes with high variability reliability improvement through experiments,Illustration through numerical examples. Software applications and case studies	
UNIT-II	
ExperimentalDesign: Introduction and application of experimental design, single factor experiments, randomized blocks, Latin square designs and extensions. Fractional factorial designs, two-level, three-level and mixed-level factorials and fractional factorials, applications to quality control problems., factor effects, factor interactions, Fractional factorial design, Saturated design, Central composite designs, Illustration through numerical examples.	9
UNIT-III	
Analysis and Interpretation of Experimental Data: Measures of variability, Ranking method, column effect method and plotting method, Analysis of variance (ANOVA), parameter optimization. Mathematical models from experimental data, illustration through numerical examples.Repeated measures design, analysis of covariance and its applications in comparing alternatives.	9
UNIT-IV	
Taguchi's Orthogonal Arrays: Types orthogonal arrays, Selection of standard orthogonal arrays, Linear graphs and interaction assignment, dummy level technique, Compound factor method, modification of linear graphs,Strategies for constructing orthogonal arrays. **Signal to Noise ratio (S-N Ratios):**Evaluation of sensitivity to noise, Signal to noise ratios for static problems, STB,NTB,LTB – type criteria. **Parameter Design and Tolerance Design:** Parameter and tolerance design concepts, Taguchi's arrays, Parameter and tolerance design strategy, Illustrations through numerical examples**.**	9

Textbooks	
1.	M. S. Phadake - Quality Engineering using Robust Design, Prentice Hall, Englewood Clifts, New Jersey, 1989.
2.	Douglas Montgomery, Design and analysis of experiments, Willey India Pvt. Ltd., 5th Edition, 2007.
3.	P. J. Ross, Taguchi, Techniques for Quality Engineering, 2nd Edition. McGraw Hill Int. Edition, 1996.
4.	Sharma M K, Design and Analysis of Experiments, 2012, Prentice Hall India Learning Private Limited.
5.	Winer BJ, 1962, Statistical Principles in Experimental Design, 2nd Edition, McGraw-Hill
Reference books	
1.	T. B. Barker, M. Dekker, Quality by Experimental Design, Inc ASQC Quality Press, 1985
2.	Quality Control and Applications - B.L. Hansen & P.M. Ghare (Prentice Hall of India)
3.	C. F. Jeff Wu, Michael Hamada, Experiments planning, analysis and parameter design optimization, John Willey Ed., 2002.
4.	W. L. Condra, Marcel Dekker, Reliability improvement by Experiments, Inc ASQC Quality Press, 1985.
5.	Hinkelmann K and Kempthorne, O, 1994, Design and Analysis of Experiments (Vol I), Wiley.

MME-155	**MICRO-MACHINING AND PRECISION ENGINEERING**	
Course Category	:	Program Electives (PE)
Pre-requisites	:	NIL
Contact Hours/Week	:	Lecture: 3, Tutorial: 1, Practical: 0
Number of Credits	:	4
Course Assessment Methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, practical work, record, viva voce and one Minor test and One Major Theory examination.

Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. The importance of micromachining technologies by studied characterization of micro-machining, Tool making, Micro-machinability of materials, LIGA and Diamond micro-machining etc.
2. The Different machining principle of micro EDM, micro-WEDG, micro-ECM, hybrid micro-machining method, on-line measurement by machine vision and integrated probe.
3. Different Abrasive micromachining and micro grinding behavior of materials surface by Laser micromachining, laser micro-drilling, laser micro-adjustment, and laser surface structuring etc.
4. The different concepts regarding Micro-machining by finishing techniques by scanning tunneling microscopes, atomic force microscope, elastic transmission method, computer aided measurement testingetc.

Topics Covered	
UNIT-I	
Introduction to micromachining technologies, bulk micromachining, LIGA, Surface Micromachining,Characterization of micro-machining, Tool making, Micromachinability of materials, Diamond micro-machining: machining principles, diamond turning, diamond grinding, accuracy and dimensional control, , future trends in ultrahigh speed machining	9
UNIT-II	
Microelectro discharge Machining: Principles of micro-EDM, micro-EDM by Die-sinking and WEDG, micro-WEDM, micro-WEDG, micro-ECM, Principles of micro-turning, micro-drilling and micro-milling, hybrid micro-machining method, on-line measurement by machine vision and integrated probe.	9
UNIT-III	
Abrasive micromachining and micro grinding: Abrasive micromachining mechanisms, micro-grinding mechanism, micro-machining rate, micro-machining cooling media;Laser micromachining: Principles of laser material removal, laser micro-drilling, laser micro-adjustment,laser surface structuring, laser micro-cutting.	9
UNIT-IV	
Micro-machining by finishing techniques: micro-lapping, microhoning, magneto-abrasive micromachining and finishing (MAF), ELID Grinding, Measuring Techniques in micro-machining: stylus instruments, scanning tunneling microscopes, atomic force microscope, measurement of micromoles and slots using optical method, elastic transmission method, computer aided measurement testing, surface integrity and other related measurements	9

Textbooks	
1.	J. M. Geough, Micro-machining of Engineering Materials, Edited by Marcel Dekker, 2002
2.	R.W. Johnstone, M. Parameswaran, An introduction to surface-micromachining, Kluwer Academic Publishers, 2004
3.	N. P Mahalik. Micro-manufacturing and nano-technology, edited by, Springer Publication, 2006
4.	M. P. Groover, Automation, Production Systems and Computer-Integrated Manufacturing, 2003

Reference books	
1.	J. M. Geough, Micro-machining of Engineering Materials, Edited by Marcel Dekker, 2002
2.	N. P Mahalik. Micro-manufacturing and nano-technology, edited by, Springer Publication, 2006

MME-156	**PRODUCTION AND OPERATIONS MANAGEMENT**	
CourseCategory	:	Program Elective (PE)
Pre-requisites	:	NIL
Contact Hours/Week	:	Lecture: 3, Tutorial: 1, Practical: 0
Number of Credits	:	4

Course Assessment Methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, One Minor test and One Major Theory examination.
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Ability to understand the Operations strategy, forecasting method, MRP type systems, Embedding JIT into MRP.
2. Ability to solve problems of Scheduling & control functions, Simulation methodology and Two assembly simulation.
3. Ability to develop various Design of Facilities & Jobs, JIT implementation, Considerations in job design, Work measurements and standards.
4. Ability to apply the concept of Product Design & Process Selection.
5. able to understand the basics of material management and inventory.

Topics Covered

UNIT-I	
Introduction: Operations strategy, Framework for operations strategy in manufacturing. Selection of forecasting method, Focus forecasting, Aggregate planning techniques, Inventory systems for independent demand, **Operations Scheduling:** Scheduling & control functions, Priority rules and techniques, Single machine scheduling problems, Scheduling in jobs on 'm' machines, Personal scheduling.	9
UNIT-II	
Design of Facilities & Jobs: Strategic capacity planning concepts, determining capacity requirements, Planning service capacity, JIT production systems, JIT implementation requirements, Facility and Plant location methods, Facility, Process and Product layout, GT layout, Retail service layout, Computer aided layout techniques, Job design and work measurement, Work measurements and standards. **Product Design & Process Selection:** Product design process, Designing for the customer QFD, Value analysis, designing products for manufacturer & assembly, Choosing from alternative processes & equipment, Virtual factory, Waiting line management & models.	9
UNIT-III	
Static Inventory Models: Static inventory models under uncertainty, decision criteria for inventory problems MRP type systems. **Dynamic Inventory Models:** Dynamic inventory problems under risk and under uncertainty; Multi-stage inventory problems; Materials Requirement Planning (MRP), Inputs, Outputs, MRP computation, EOQ-MRP comparisons; MRP types	9
UNIT-IV	
Simulation: Simulation methodology and categories; Monte-Carlo simulation; perpetual inventory; Periodic simulation problems; Simulation of joint probability distribution. **Inventory Control systems:** Types of control systems; Selective inventory control; Inventory system development, Excess materials; Inventory system improvement; Aggregate inventory measurement.	9

Textbooks

1.	Production and Operations management- Adam & Ebert (Prentice Hall India)
2.	Operations management- Buffa (John Wiley)
3.	Operations management- Starr (Prentice Hall)
4.	Inventory Management - D. Chandra Bose (Prentice Hall of India)

Reference book

1.	Materials Management: An Integrated Approach - P. Gopalakrishnan & M. Sundersan (Prentice Hall of India)

MME-157	**ADDITIVE MANUFACTURING**	
Course Category	:	Program Elective (PE)
Pre-requisites	:	NIL
Contact Hours/Week	:	Lecture : 3, Tutorial : 1, Practical: 0
Number of Credits	:	4
Course Assessment Methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, one Minor test and One Major Theory examination.
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge and skills after completing this course

5. Ability to understand the fundamental of Additive manufacturing and its varieties like liquid based, solid based and powder-based AM technologies, their potential to support design and manufacturing.
6. Ability to understand the various types of Pre-processing, processing, post-processing errors in AM and to acknowledge the various types of data formats and software's used in AM.
7. Ability to demonstrate the applications of AM in design analysis, aerospace, automotive, biomedical and other fields and research challenges associated with AM.

Topics Covered	
UNIT-I	
Introduction: Need for Additive Manufacturing, Development of AM systems, AM Process Chain, commonly used Terms, Impact of AM on product development, Virtual prototyping, Rapid tooling, Rapid prototyping to AM, Classification of AM process, Advantages and Limitations, Applications of AM-Material Relationship, Application in Design, Application in Engineering, Analysis and Planning, Aerospace Industry, Automotive Industry, Medical and Bioengineering, Web Based Rapid Prototyping Systems etc.	9
UNIT-II	
Liquid-based AM Systems: Stereo lithography Apparatus (SLA): Working principle, Pre-build process, part building and post building processes, photo polymerization SL resin, part quality and process planning, recoating issues, advantages, limitations and applications. Case studies. Solid Ground Curing (SGC): Working principle, Process, Applications, Advantages and Disadvantages, Case studies. Polyjet: working principle, Process, Applications, Advantages and Disadvantages, Case studies. **Solid-based AM Systems:** Laminated Object Manufacturing (LOM): Working Principles, details of processes, products, materials, advantages, limitations and applications - Case studies. Fused Deposition Modeling (FDM): Principle, details of processes, process variables, types, products, materials and applications. Case studies. Multi-Jet Modelling (MJM): working principle, Process, Applications, Advantages and Disadvantages, Case studies.	9
UNIT-III	
Powder Based AM Systems: Selective laser sintering (SLS): Principle, process, Indirect and direct SLS- powder structures, materials, post processing, surface deviation and accuracy, Applications. Case studies. Laser Engineered Net Shaping (LENS): Process, working principle, Applications, Advantages and Disadvantages, Case studies. **Other Additive Manufacturing Systems:** Three-dimensional Printing (3DP): Principle, basic process, Physics of 3DP, types of printing, process capabilities, material system. Solid based, Liquid based, and powder based 3DP systems, strength and weakness, Applications and case studies. Shape Deposition Manufacturing (SDM), Ballistic Particle Manufacturing (BPM), Selective Laser Melting, Electron Beam Melting.	9
UNIT-IV	
AM Data Formats: Reengineering for Digital Representation, STL Format, STL File Problems, Consequence of Building Valid and Invalid Tessellated Models, STL file Repairs: Generic Solution, Other Translators, Newly Proposed Formats. Mesh Refining by Sub division Techniques.	9

AM Software's: Need for AM software, Features of various AM software's like MAGICS, Mimics, Solid View, View Expert, 3 D View, Velocity 2, Rhino, STL View 3 Data Expert and 3 D doctor, 3-matic, MeshLab.	
Textbooks	
1.	Gibson, I., Rosen, D.W. and Stucker, B., "Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing", Springer, 2010.
2.	Chua, C.K., Leong K.F. and Lim C.S., "Rapid prototyping: Principles and applications", second edition, World Scientific Publishers, 2010.
3.	Kamrani, A.K. and Nasr, E.A., "Rapid Prototyping: Theory and practice", Springer, 2006.
Reference books	
1.	Hilton, P.D. and Jacobs, P.F., Rapid Tooling: Technologies and Industrial Applications, CRC press, 2005.

MME-161	**FINITE ELEMENT METHOD**	
Course category	:	Program Electives (PE)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture : 3, Tutorial : 1, Practical: 0
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, practical work, record, viva voce , one major test and one major examination.
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. To develop the ability to generate the governing finite element equations for systems governed by partial differential equations.
2. To understand the use of the basic finite elements for structural applications using truss, beam, frame and plane elements;
3. To understand the application and use of the finite element method for heat transfer problems.
4. To demonstrate the ability to evaluate and interpret Finite Element Method analysis results for design and evaluation purposes.
5. To develop a basic understanding of the limitations of the Finite Element Method and understand the possible error sources in its use.

Topics Covered	
UNIT-I	
Introduction: Historical background,basic concepts of FEM**,** Comparison with Finite Difference Method, Advantages and limitations, Different approaches in Finite Element Method-Discrete, Variational approach, Weighted Residual methods.	9
UNIT-II	
Direct Problems- Spring, Hydraulic Network; Resistance Network and Truss Systems **Finite element analysis of 1-D problems:** formulation by different approaches (direct, potential energy and Galerkin); Derivation of elemental equations and their assembly, solution and its postprocessing. Applications in heat transfer, fluid mechanics and solid mechanics. Bending of beams, analysis of truss and frame.	9
UNIT-III	
Finite element analysis of 2-D problems: Finite Element modelling of single variable problems, triangular and rectangular elements; Applications in heat transfer, fluid mechanics and solid mechanics;	9
UNIT-IV	
Numerical considerations: numerical integration, error analysis, mesh refinement. Plane stress and plane strain problems; Bending of plates; Eigen value and time dependent problems; Discussion about preprocessors, postprocessors and finite element packages.	9

Books & References
1. An Introduction to Finite Element Method – J. N. Reddy (Tata McGraw Hill). 2. Finite Element Procedure in Engineering Analysis - K.J. Bathe (Tata McGraw Hill). (New Central book Agency) 3. Concepts and Application of Finite Element Analysis- R.D. Cook, D.S. Malcus and M.E. Plesha (John Wiley) 4. Introduction to Finite Elements in Engineering- T.R Chandrupatla and A.D. Belegundu (Prentice Hall India) 5. Numerical Methods– E. Balagurswamy (Tata Mc Graw Hill)

MME-169	**ADVANCE MATERIAL & CHARACTERIZATION**	
CourseCategory	:	Program Electives(PE)
Pre-requisites	:	NIL
Contact Hours/Week	:	Lecture: 3, Tutorial: 1, Practical: 0
Number of Credits	:	4
Course Assessment Methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, practical work, record, viva voce and One Minor test and One Major Theory & Practical Examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills, and attitudes after completing this course

1. Ability to understand the role of computer in the areas of automation, planning and manufacturing for improving their effectiveness.
2. Ability to develop manual part program and computer assisted part program to produce components.
3. Ability to design and develop various system such as feedback, interpolator, material handling and implementation of adaptive control.
4. Ability to apply the concept of group technology and computer assisted process planning.

Topics Covered	
UNIT-I	
Materials and Classification: Introduction, Demand of advanced materials,Classification of different materials and alloys. Macro and micro analysis of materials, Segregation and bonding, Strengthening mechanisms.	9
UNIT-II	
Properties of Materials: Flexural Test,Toughness tests, Creep characteristics, Hardness tests, Fracture test, Griffith's crack theory, Strain hardening, Single crystal growth. **Wear:** Modes of adhesive, abrasive, erosive, fretting, sliding.	9
UNIT-III	
Techniques of Materials Characterization: Definition; importance and application of X-ray diffraction technique for phase identification,Scanning Electron Microscope; Principles of image formation in SEM, Energy dispersive X-ray analysis, Thermo-mechanical behavior of composites materials, DSC, AFM.	9
UNIT-IV	
Modern Materials and Alloys: Super alloys-refractory materials, Shape memory alloys, Advanced Composites-Particulate and dispersion composites, Metal matrix and Ceramic matrix composites, Nano materials, Polymers and polymerization, Engineering applications of different materials.	9

Textbooks	
1.	Engineering Materials and Applications, P. Flinn and P.K. Trojan, MIR Publications
2.	Engineering Materials: Polymers, Ceramics and Composites, A.K Bhargava, Prentice Hall of India
3.	Manufacturing processes for Engineering Materials, SeropeKalpakjian, Wesley Publishing Co.

4.	An introduction to Physical Metallurgy, S.H. Avner, McGraw Hill
5.	Advances in Materials and Their Applications, P. Rama Rao, Wiley Eastern
6.	Mechanical Metallurgy, Dieter, McGraw Hill
7.	Material Science & Engineering, W.D. Callister, Jr, Wesley Publishing Co.
Reference books	
1.	Mechanical Metallurgy, Dieter, McGraw Hill
2.	Material Science & Engineering, W.D. Callister, Jr, Wesley Publishing Co.

MME-163	**INDUSTRIAL AUTOMATION**	
Course Category	:	Program Electives (PE)
Pre-requisites	:	NIL
Contact Hours/Week	:	Lecture : 3, Tutorial : 1, Practical: 0
Number of Credits	:	4
Course Assessment Methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, and Three Minor tests and One Major Theory.
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Ability to identify and explain potential areas of automation in manufacturing.
2. Ability to differentiate the various control aspects of automation.
3. Ability to design components and systems related to industrial automation considering the economic, social, manufacturability and sustainability aspects

Topics Covered

UNIT-I	
Introduction to Automation Automation in production system, Mechanization and automation, Types of automation, Principles and strategies of Automation, Basic elements of an automated system, Levels of automations, Advanced Automation Function, Mechanical, electrical, hydraulic and Pneumatic automation devices and controls, Economics of automation. **Control Technologies in Automation:**Industrial Control Systems, Process Industries Versus Discrete-Manufacturing Industries, Continuous Versus Discrete Control, Automatic Process Control, Building Blocks of Automation Systems, Distributed Control System: Functional Requirements & Configurations.	9
UNIT-II	
Automated Production Lines: Components of a manufacturing system, Single station manufacturing cells, Manual Automated Flow lines, Methods of Work-part Transport, Transfer Mechanism, Buffer Storage, Automation for Machining Operations, Design and Fabrication Considerations, Analysis of Transfer Lines Without Storage, Partial Automation, Automated Flow Lines with Storage Buffers, Computer Simulation of Automated Flow Lines.	9
UNIT-III	
Automated Assembly Systems & Line balancing: Fundamentals, The Assembly Process, Assembly Systems, Analysis of Assembly systems, Manual Assembly Lines, The Line Balancing Problem, Methods of Line Balancing, Flexible Manual Assembly Lines. Automated Assembly Systems: Design for Automated Assembly, Types of Automated Assembly Systems, Part Feeding Devices, Analysis of a Single Station Assembly Machine, Analysis of Multi-station Assembly Machines.	9
UNIT-IV	
Automated Inspection and Testing: Inspection and testing, Automated Inspection Principles and Methods, Sensor Technologies for Automated Inspection, Coordinate Measuring Machines, Other Contact Inspection Methods, Machine Vision, Other optical	9

Inspection Methods. The Future Automated Factory: Trends in Manufacturing, The Future Automated Factory, Human Workers in the Future Automated Factory, The social impact.	
Textbooks	
1.	Mikell P.Grover, Automation, Production Systems and Computer Integrated Manufacturing, Pearson Education Asia..
2.	Malov and Ivanov, Principles of Automation & Automated Production Process, Mir Publication.
3.	Oates and Georgy Newness, Automation in Production Engineering.
Reference books	
1.	Buzacott& shanty Kumar, Stochastic Models of Manufacturing Systems, Prentice Hall India
2.	K.S. Fu, R.C. Gonzalez, C.S.G. Lee, Robotics, McGraw Hill.
3.	YoremKoren, "Computer control Manufacturing Systems", McGraw Hill, 1999.

MME-164	**FLEXIBLE MANUFACTURING SYSTEM**	
CourseCategory	:	Program Electives (PE)
Pre-requisites	:	NIL
Contact Hours/Week	:	Lecture : 3, Tutorial : 1, Practical: 0
Number of Credits	:	4
Course Assessment Methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, practical work, record, viva voce and One Minor test and One Major Theory examination.
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. The understanding about factors responsible for the growth of FMS, FMS types and applications, Economic justification for FMS,Co-ordinate measuring machines, Cleaning and deburring machines, FMS system support equipment.
2. Ability to know about the concept of GT, Part family formation-coding and classification systems, mathematical programming and graph theoretic model approach for part grouping, Cellular vs. FMS production.
3. Ability to understand CAPP system: Importance, principle of Generative CAPP system.
4. Ability to understand the concept of Quantitative methods, Implementation techniques for CAPP, criteria for selecting a CAPP system and benefits of CAPP

Topics Covered	
UNIT-I	
Basics of FMS: Introduction and classification of FMS, Automated production cycle, Need, concept and measurement of flexibility, Types of flexibilities and its measurement,Economic justification and Functional requirements of FMS, FMS processing and quality assurance equipment, e.g., turning and machining centers, Co-ordinate measuring machines, Cleaning and deburring machines, AMHS equipment, cutting tool and tool management, Future trends of Flexible Manufacturing System.	9
UNIT-II	
Group Technology: Introduction of GT, Part family formation-coding and classification systems; Part-machine group analysis, Methods for cell formation, Use of different algorithms, mathematical programming and graph theoretic model approach for part grouping.	9

Determination of machining parameters:effect of parameters on production rate, cost andsurface quality, different approaches, advantages of mathematical approach over conventional approach,solving optimization models of machining processes.	
UNIT-III	
Brief of FMS software and FMS Simulations Structure and function of FMS software, simulations process, model of a Flexible manufacturing system, simulation software, limitations of simulations **Data bases in Flexible Manufacturing systems and its implementation** Manufacturing data systems, manufacturing data flow, computer-aided design and manufacturing considerations when planning for FMS, Implementation objectives, acceptance testing, Performance goals and expectation, maintenance	9
UNIT-IV	
Introduction to CAPP: Role of process planning,advantages of conventional process planning over CAPP, Generative CAPP system: Importance, principle of Generative CAPP system. **Determination of manufacturing tolerances**: Methods of toleranceallocation, sequential approach, integration of design and manufacturing tolerances. Determination of optimal index positions for executing fixed sequence, Quantitative methods.	9

Textbooks	
1.	Handbook of Flexible Manufacturing System – Editor:Nand K. Jha (Academic Press, San Diego,California)
2.	Automation, Production System & Computer Integrated Manufacturing-Groover (PHI)
3.	Flexible Manufacturing System – Wernecks (Spring- Verlag)
4.	FMS in Practice – Bonctto (Northox Ford)
5.	Flexible Manufacturing Cells and systems – W. W.Luggen (PHI)
6.	Performance Modelling of Automated Manufacturing Systems –Vishwanathan&Narahari (PHI)
7.	Computer Aided manufacturing- P. N. Rao , N. K. Tewari& T. K. Kundra (Tata McGraw Hill).
8.	CAD/CAM- P. N. Rao(Tata McGraw Hill)
9.	Mikell P. Groover, Automation, Production systems and Computer Integrated Manufacturing System, Prentice Hall, 2007.
Reference books	
1.	Handbook of Flexible Manufacturing System – Editor:Nand K. Jha (Academic Press, San Diego,California)
2.	Automation, Production System & Computer Integrated Manufacturing-Groover (PHI)
3.	Performance Modelling of Automated Manufacturing Systems –Vishwanathan&Narahari (PHI)
4.	Mikell P. Groover, Automation, Production systems and Computer Integrated Manufacturing System, Prentice Hall, 2007

MME-165	**CONCURRENT ENGINEERING & PRODUCT LIFECYCLE MANAGEMENT**	
Course Category	:	Program Elective (PE)
Pre-requisites	:	NIL
Contact Hours/Week	:	Lecture : 3, Tutorial : 1, Practical: 0
Number of Credits	:	4
Course Assessment Methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, Three Minor tests and One Major Theory examination.

Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Ability to understand the fundamentals of Concurrent Engineering, CE tool box and Collaborative product development.
2. Ability to apply the concept of IT support, Solid modeling, Product data management, Artificial Intelligence.
3. Ability to design and develop various Design Stage such as Lifecycle design of products, CE in optimal structural design, Importance of PLM, Implementing PLM, Responsibility for PLM etc.
4. Ability to understand Components of PLM, Product organizational structure, System components in lifecycle, slicing and dicing the systems, Interfaces, Information, Standards.

Topics Covered

UNIT-I	
Introduction: Extensive definition of Concurrent Engineering (CE), CE design methodologies, Review of CE techniques like DFM (Design for manufacture), DFA (Design for assembly), QFD (Quality function deployment), RP (Rapid prototyping), TD (Total design), for integrating these technologies, Organizing for CE, CE tool box, Collaborative product development.	9
UNIT-II	
Use of Information Technology: IT support, Solid modeling, Product data management, Collaborative product commerce, Artificial Intelligence, expert systems, Software hardware component design.	9
UNIT-III	
Design Stage: Lifecycle design of products, Opportunities for manufacturing enterprises, Modality of concurrent engineering design, Automated analysis Idealization control, CE in optimal structural design, Real time constraints. **Need for PLM:** Importance of PLM, Implementing PLM, Responsibility for PLM, Benefits to different managers, Components of PLM, Emergence of PLM, Lifecycle problems to resolve, Opportunities to seize.	9
UNIT-IV	
Components of PLM: Components of PLM, Product lifecycle activities, Product organizational structure, Human resources in product lifecycle, Methods, techniques, Practices, Methodologies, Processes, System components in lifecycle, slicing and dicing the systems, Interfaces, Information, Standards.	9

Textbooks

1.	Concurrent Engineering in Product Design and Development- I Moustapha(New Age International)
2.	Concurrent Engineering Fundamentals: Integrated Product Development - Prasad (Prentice hall India)
3.	Product Lifecycle Management - John Stark (Springer-Verlag, UK)
4.	Product Lifecycle Management- Michael Grieves (McGraw Hill)

Reference books

1.	Concurrent Engineering: Automation tools and Technology - Andrew Kusiak (Wiley Eastern)
2.	Design for Concurrent Engineering- J. Cleetus (CE Research Centre, Morgantown)
3.	Integrated Product Development- M.M. Anderson and L Hein (IFS Publications)

MME-166	**ADVANCED STRENGTH OF MATERIALS**	
Course Category	:	Program Electives(PE)
Pre-requisite Subject	:	NIL
Contact Hours/Week	:	Lecture : 3, Tutorial : 1, Practical: 0
Number of Credits	:	4
Course Assessment Methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, practical work, record, viva voce and one Minor test and One Major Theory examination.

Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. To provide a thorough understanding of advanced topics concerning the response of materials and structural elements to applied forces of deformation.
2. Students should obtain an understanding of advanced strength of materials principles and practices that should assist them in making informed design decisions and solving complex problems.
3. To acquaint with energy methods to solve structural problems.

Topics Covered

UNIT-I	
Stress Definition of Stress, Body Force, Surface Force and Stress Vector, Normal and Shear Stress Components, Rectangular Stress Components, The Stress Tensor - 3-D, The Stress Tensor is a Linear Transformation - the Cauchy Tetrahedron, Variation of the Stress Tensor from Point to Point in a Body in Equilibrium Equations of Equilibrium, Coordinate Changes and the Stress Tensor 6. Principal Stresses 7. Octahedral Stresses **Strain** Definition of Strain, Deformation in the Neighbourhood of a Point, Change in Length of a Linear Element—Linear Components,Rectangular Strain Components, Change in the Angle between Two Line Elements, Lagrangian and Eulerian Coordinate Systems and Equations of Compatibility, Strain Deviator and its Invariants	9
UNIT-II	
Stress - Strain Relations Introduction, Generalised Statement of Hooke's Law, Stress–Strain Relations for Isotropic Materials, Modulus of Rigidity,Bulk Modulus, Young's Modulus and Poisson's Ratio, Relations between the Elastic Constants, Displacement Equations of Equilibrium. **Linear Elasticity** Boundary Conditions and 15 equations of elasticity, Two-Dimensional Problems - plane stress and plane strain problems, Airy Stress Function, Techniques for Solving the Equations of Elasticity, Linear Thermoelasticity, Polar Coordinates -Thick-walled Cylinders,The Airy Stress Function in Polar Coordinates	9
UNIT-III	
Applications of Linear Elasticity and Its Approximations **Torsion**-Introduction, Torsion of General Prismatic Bars–Solid Sections, Alternative Approach, Torsion of Circular and Elliptical Bars, Torsion of Equilateral Triangular Bar, Torsion of Rectangular Bars, Membrane Analogy, Torsion of Thin-Walled Tubes, Torsion of Thin-Walled Multiple-Cell Closed Sections, Torsion of Bars with Thin Rectangular Sections, Torsion of Rolled Sections, Multiply Connected Sections **Bending of Beams** Introduction, Straight Beams and Asymmetrical Bending,Regarding Euler–Bernoulli Hypothesis, Shear Centre or Centre of Flexure, Shear Stresses in Thin-Walled Open Sections: Shear Centre, Shear Centres for a Few Other Sections, Bending of Curved Beams (Winkler-Bach Formula), Deflections of Thick Curved Bars	9
UNIT-IV	
Axisymmetric Problem Introduction,Thick-Walled Cylinder Subjected to Internal and ExternalPressures—Lame's Problem, Stresses in Composite Tubes—Shrink Fits, Sphere with Purely Radial Displacements, Stresses Due to Gravitation, Rotating Disks of Uniform Thickness, Disks of Variable Thickness, Rotating Shafts and Cylinders,Summary of Results for use in Problems **Energy Methods** Work, Strain Energy and Complementary Energy, Castigliano's Theorems-Method of Fictitious Loads and Statically Indeterminate Problems, Principle of Virtual Work, The Principle of Stationary Potential Energy	9

Books & References
1. Advanced Mechanics of Materials-by P. Boresi and Richard J. Schmidt (Wiley)
2. Advanced Strength and Applied Stress Analysis by R. G. Budynas, 2nd Edition, McGraw Hill Publishing Co, 1999.
3. Theory of Elasticity, 3rd Edition by S. P. Timoshenko, J. N. Goodier,McGraw Hill Publishing Co. 1970.
4. Solid Mechanics for Engineering by P. Raymond, 1st Edition, John Willey & Sons, 2001.
5. Advanced Mechanics of Solids by L. S. Srinath ((Tata McGraw Hill).)