PUDUCHERRY TECHNOLOGICAL UNIVERSITY
PUDUCHERRY–605014

(A Technological University of Government of Puducherry)

Curriculum and Syllabi
for
M.Tech. (Product Design and Manufacturing)

(With effect from Academic year 2020-21)

(Approved in Sixth Academic Council Meeting held on 20th March 2021)

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

Program Educational Objectives (PEOs) are broad statements that describe the career and professional accomplishments that the program is preparing graduates to achieve. They are consistent with the mission of the Institution and Department. Department faculty members continuously worked with stakeholders (local employers, industry and R&D advisors and the alumni) to review and update them periodically.The curriculum of M.Tech. (Product Design and Manufacturing) is designed to fulfill the Programme Educational Objectives (PEO) and Programme Outcomes (PO) listed below:

PEO1	Expertise in the field of Product Design and Manufacturing suit to technological enterprises, companies, organizations and industries both at national and international levels **(Eminence in Product Design and Manufacturing**)
PEO2	Inquisitive spirit to elicit creative and innovative outcomes through constructive efforts and analytical research in the field of Product Design and Manufacturing (**Research and Development**)
PEO3	Nurturing enthusiasm for the subject of interest and provide solid ground to respond to a lifetime of career challenges and changes through lifelong learning (**Passion for higher education**)
PEO4	Exhibit professionalism with greater responsibility in precise product design and exercise leadership-traits in realizing the products through advanced manufacturing techniques with concise qualities and values (**Professional ethics and leadership qualities**)
PEO5	Receptive to new technologies, skills, values, and actions for social, environmental and economic sustainability (**Sustainable development**)

PROGRAMME OUTCOMES (POs)

PO1	Carryout independent research/investigation and development work to solve practical problems (**Enhancing Research Capability**)
PO2	Write and present a substantial technical report/document (**Enhancing Presentation Skill)**
PO3	Demonstrate a degree of mastery over product design and manufacturing at a level higher than the bachelors program (**Mastery over the field of study**)
PO4	Able to use state of art tools and techniques to model and analyze the product components and systems (**Enhancing modeling and analyzing capabilities**)
PO5	Solve the challenges in the field of Product Design and Manufacturing through Design, development and evaluation of product components and systems (**Facing real world problems**)
PO6	Inculcate lifelong learning practice to acquire excellency in professional, ethical, legal, safety, sustainable, environmental and societal aspects of Product Design and Manufacturing. (**Professional development through lifelong learning**)

CURRICULUM

Distribution of Credits among the subjects grouped under various categories:

Courses are grouped under various categories and the credits to be earned in each category of courses are as follows:

Sl. No.	Category	Credits	Course Category Code (CCC)
1	Programme Core Course	24	PCC
2	Programme Specific Elective Courses	15	PSE
3	Open Elective Courses	03	OEC
4	Professional Activity Courses (Project Work, Seminar)	28	PAC
5	Mandatory Audit Courses	Non Credit	MAC
	Total	**70**	

Semester-wise Courses and Credits

Semester I

Course Code	Course	CCC	Periods			Credits
			L	T	P	
ME263	Computational Methods	PCC	2	1	0	3
ME264	Product Design	PCC	3	0	0	3
ME265	Newer Materials and Processing	PCC	3	0	0	3
MEZNN	Programme Specific Elective - 1	PSE	3	0	0	3
MEZNN	Programme Specific Elective - 2	PSE	3	0	0	3
ME266	CAD Laboratory	PCC	0	0	4	2
ME255	Research Methodology and IPR	PCC	2	0	0	2
AD2NN	Audit Course - I	MAC	2	0	0	0
Total			**23**			**19**

Semester II

Course Code	Course	CCC	Periods			Credits
			L	T	P	
ME267	Design Optimization Techniques	PCC	2	1	0	3
ME268	Modern Manufacturing Techniques	PCC	3	0	0	3
ME269	Design of Experiments	PCC	2	1	0	3
MEZNN	Programme Specific Elective - 3	PSE	3	0	0	3
MEZNN	Programme Specific Elective - 4	PSE	3	0	0	3
ME270	CIM Laboratory	PCC	0	0	4	2
ME271	Mini Project and Seminar	PAC	0	0	4	2
AD2NN	Audit Course - II	MAC	2	0	0	0
Total			**25**			**19**

Semester III

Course Code	Course	CCC	Periods			Credits
			L	T	P	
MEZNN	Programme Specific Elective - 5	PSE	3	0	0	3
OE2NN	Open Elective	OEC	3	0	0	3
ME272	Dissertation – Phase I	PAC	0	0	20	10
Total			**26**			**16**

Semester IV

Course Code	Course	CCC	Periods			Credits
			L	T	P	
ME273	Dissertation – Phase II	PAC	0	0	32	16
Total			**32**			**16**

Total Credits: 70

Audit Courses (MAC)

AD201	English for Research Paper Writing (HS)
AD202	Disaster Management (CE)
AD203	Value Education (HS)
AD204	Constitution of India (HS)
AD205	Pedagogy Studies (HS)
AD206	Stress Management by Yoga (HS)

Open Elective Courses (OEC)

OE201	Business Analytics (IT)
OE202	Industrial Safety and Maintenance (ME)
OE203	Operations Research (ME)
OE204	Cost Management of Engineering Projects (CE)
OE205	Composite Materials (PH)
OE206	Waste to Energy (CE)

Programme Specific Electives (PSE):

PSE-1/PSE -2	**MEZ21**	Advances in Casting and Welding
	MEZ22	Computer Aided Design
	MEZ23	Advanced Solid Mechanics
	MEZ24	Tool Design
	MEZ25	Composite Materials Technology
	MEZ26	Finite Element Method
	MEZ27	Hydraulics and Pneumatics
	MEZ28	Integrated Materials Management
PSE -3/PSE - 4	**MEZ29**	Design for Manufacture and Assembly
	MEZ30	Principles of Maintenance and Safety Engineering
	MEZ31	Principles of Tribology and Surface Engineering
	MEZ32	Logistics and Supply Chain Management
	MEZ33	Computer Aided Inspection and Quality Control
	MEZ34	Rapid Manufacturing Processes
	MEZ35	Industrial Design
	MEZ36	Nanotechnology
PSE - 5	**MEZ37**	Industry 4.0
	MEZ38	World Class Manufacturing
	MEZ39	Green Design and Manufacturing for Sustainability
	MEZ40	Advances in Electric and Autonomous Vehicle

Department: **Mechanical Engineering**			Programme: **M.Tech. (**Product Design and Manufacturing**)**						
Semester: **First**			Course Category Code: **PCC**			Semester Exam Type: **TY**			
Course Code	Course Name		Periods / Week			Credit	Maximum Marks		
			L	T	P		CA	SE	TM
ME263	**Computational Methods**		**2**	**1**	**-**	**3**	**40**	**60**	**100**
Prerequisite	**Nil.**								
Course Outcome	**CO1**	Can apply various methods in matrix theory and iterative methods to solve system of linear equations.							
	CO2	Can carry out linear and nonlinear regression analysis and can interpolate a dependent variable based on a given set of values by a suitable method							
	CO3	Can find integral value and differential coefficient based on a given set of values.							
	CO4	Can solve initial value problem of ODE.							
	CO5	Can solve boundary value problems of PDE.							

UNIT I	**Periods : 9**
Matrix theory: Solution of Linear simultaneous equations – direct methods of solution – Gauss elimination method, Gauss Jordan method, Crout's method – iterative methods of solution – Jacobi's method, Gauss Seidal method. Cholesky decomposition - Generalized Eigenvectors - Canonical basis - QR factorization - Least squares method - Singular value decomposition Determination of Eigen value by iteration – Power method.	**CO1**
UNIT II	**Periods : 9**
linear and nonlinear regression analysis– Method of least squares, fitting straight line, parabola and exponential, polynomial of degree N, applications. Interpolation (Finite differences): Newton's Divided Difference Formula, Lagrange's Interpolation-Forward and Backward Difference Formula-Stirling's and Bessel's Central Difference Formula..	**CO2**
UNIT III	**Periods : 9**
Numerical Differentiation and Integration: Numerical Differentiation with interpolation polynomials, Numerical Integration by Trapezoidal Simpson's(both 1/3 and 3/8)rule, Double integrals using Trapezoidal and Simpson's rule Two point and three point Gaussian quadrature formulae.	**CO3**
UNIT IV	**Periods : 9**
Initial value problems for Ordinary Differential Equations: Single Step methods, Taylors Series, Euler and Modified Euler, Runge-Kutta methods of first and second order Differential equations, Multi Step methods, Milne and Adam's-Bashforth predictor and corrector method.	**CO4**
UNIT V	**Periods : 9**
Boundary Value Problems for ODE and PDE : Finite difference for the second order Ordinary Differential Equations, Finite Difference solutions for one dimensional heat equations(both Implicit and Explicit), One Dimensional wave equation, Two Dimensional, Laplace and Poisson Equation.	**CO5**

Lecture Periods:45	**Tutorial Periods: -**	**Practical Periods: -**	**Total Periods: 45**

Reference Books

1. Dr. B.S. Grewal – Higher Engineering Mathematics, Khanna Publishers, 2000.
2. Douglas C. Montgomery and George C. Runger – Applied statistic and probability for engineers, Wiley Higher Education, 1998.
3. Dr. P.Kandasamy, Dr.K.Thilagavathy, Dr. K.Gunavathi- Numerical methods – S.Chand & Company, 2006.
4. Dr. E. Balagurusamy- Numerical Methods – Tata McGraw-Hill Education, 1999.

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	3	2	1	1
CO2	2	1	3	2	1	1
CO3	2	1	3	2	1	1
CO4	2	1	3	2	1	1
CO5	2	1	3	2	1	1

Score: **3** – High; **2** – Medium; **1** – Low

Department: **Mechanical Engineering**			Programme: **M.Tech.(**Product Design and Manufacturing**)**						
Semester: **First**			Course Category Code: **PCC**				Semester Exam Type: **TY**		
Course Code	Course Name		Periods / Week			Credit	Maximum Marks		
			L	T	P		CA	SE	TM
ME264	**Product Design**		**3**	**-**	**-**	**3**	**40**	**60**	**100**
Prerequisite	**Nil**								
Course Outcome	**CO1**	Can understand the basic concepts of product design and development and able to convert voice of customer into design specification.							
	CO2	Able to employ creative thinking methods and select suitable design concepts to solve design issues.							
	CO3	Able synthesis product architecture and can include industrial aspects in product design							
	CO4	Can evaluate design and can estimate cost of product.							
	CO5	Can effectively communicate the design and can prepare Patent Disclosure.							

UNIT I	**Periods : 9**
Definition - Design by Evolution and by Innovation - Need for developing products – the importance of engineering design – types of design -factors to be considered for product design -Production-Consumption cycle –Product life cycle. The morphology of design - Primary design Phases and flow charting. Product strategies, Market research - identifying customer needs -–voice of customer hierarchy of human needs-need gathering methods – affinity diagrams – needs importance- establishing engineering characteristics-competitive benchmarking- quality function deployment- house of quality-product design specification-case studies	**CO1**
UNIT II	**Periods : 9**
Creative thinking –creativity and problem solving- creative thinking methods- Concept generation and selection – Techniques -systematic methods for designing –functional decomposition – physical decomposition –functional representation –morphological methods-TRIZ- axiomatic design. Brain storming, Concept screening and scoring, Decision making –decision theory –utility theory –decision trees –concept evaluation methods –Pugh concept selection method- weighted decision matrix – analytic hierarchy process , concept testing.	**CO2**
UNIT III	**Periods : 9**
Introduction to embodiment design –product architecture – types of modular architecture –steps in developing product architecture. Industrial design – human factors design, Value of appearance - principles and laws of appearance –user friendly design – Designing for ease of maintenance – design for environment incorporating quality, safety and reliability into design.	**CO3**
UNIT IV	**Periods : 9**
Evaluation of Design – prototyping and testing – need for prototyping – types- principles-planning for prototypes. Cost evaluation –categories of cost –overhead costs – activity-based costing –methods of developing cost estimates – manufacturing cost –value analysis in costing.	**CO4**
UNIT V	**Periods : 9**
Communicating the design – methods - communication cycle, Report- types, and Visual aids. Patents and intellectual property- fundamental-types-infringement of patent rights, copyright-steps to prepare Patent Disclosure.	**CO5**

Lecture Periods:45	**Tutorial Periods: -**	**Practical Periods: -**	**Total Periods: 45**

Reference Books

1. Anita Goyal, Karl T Ulrich, Steven D Eppinger, “Product Design and Development “, 4th Edition, 2009, Tata McGraw-Hill Education, ISBN-10-007-14679-9
2. Clive L.Dym, Patrick Little, “Engineering Design: A Project-based Introduction”, 3rd Edition, John Wiley & Sons, 2009, ISBN 978-0-470-22596-7
3. George E.Dieter, Linda C.Schmidt, “Engineering Design”, McGraw-Hill International Edition, 4th Edition, 2009, ISBN 978-007-127189-9
4. Kevin Otto, Kristin Wood, “Product Design”, Indian Reprint 2004, Pearson Education,ISBN 9788177588217
5. Yousef Haik, T. M. M. Shahin, “Engineering Design Process”, 2nd Edition Reprint, Cengage Learning, 2010, ISBN 0495668141
6. Neeraj Pandey and Khushdeep Dharni,”Intellectual Property Rights”, PHI Learning Private Limited New Delhi, 2014.

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	3	2	2	2
CO2	1	1	3	2	2	2
CO3	1	1	3	2	2	2
CO4	1	1	3	2	2	2
CO5	1	1	3	2	2	2

Score: **3** – High; **2** – Medium; **1** – Low

Department: **Mechanical Engineering**		Programme: **M.Tech.(**Product Design and Manufacturing**)**						
Semester: **First**		Course Category Code: **PCC**				Semester Exam Type: **TY**		
Course Code	Course Name	Periods / Week			Credit	Maximum Marks		
		L	T	P		CA	SE	TM
ME265	**Newer Materials and Processing**	**3**	**-**	**-**	**3**	**40**	**60**	**100**
Prerequisite	**Nil.**							

Course Outcome		
	CO1	Explain the basic need of a newer materials and its applications
	CO2	Analyze the scope of Powder Metallurgy and Nanotechnology
	CO3	Determine the basic working of Metal forming and Metal joining techniques
	CO4	Discuss about various types of Special material removal processes
	CO5	Describe the structure and properties of a surface

UNIT I	**Periods : 9**
Introduction to Conventional materials, limitations. Newer materials – Plastic materials – Types and applications. Ceramic materials – Types and applications. Composite materials – Need for composites, classification and characteristics of composites, matrix and reinforcements, Processing of Polymer, ceramic and metal matrix composites – manufacturing and applications. Smart materials – shape memory alloys and applications.	**CO1**
UNIT II	**Periods : 9**
Introduction to powder metallurgy (P/M) Processes – Design considerations for P/M tooling – applications of P/M components. Concept of Nanotechnology – Nanomaterials and their preparation methods, Material Characterization – Optical microscopy, Scanning electron microscopy, atomic force microscopy and transmission electron microscopy	**CO2**
UNIT III	**Periods : 9**
Newer forming processes specifically with reference to applications – Super plastic forming, rubber forming, explosive, electro – hydraulic and magnetic pulse forming. Special metal joining processes – Ultrasonic welding, Friction welding, Explosive Welding, Electron Beam welding, Diffusion bonding.	**CO3**
UNIT IV	**Periods : 9**
Special material removal processes – Chemical machining, Electro chemical machining, Electrical Discharge machining, wire EDM, Water Jet machining – High speed machining –Micro machining.	**CO4**
UNIT V	**Periods : 9**
Surface Structure and properties – Surface coatings, Hard facing, Thermal spraying, Vapor deposition, Ion implantation, Hot dipping – Introduction to additive manufacturing.	**CO5**

Lecture Periods: 45	**Tutorial Periods: -**	**Practical Periods: -**	**Total Periods: 45**

Reference Books

1. Serope. Kalpakjain and Steven R.Schmid - Manufacturing Engineering and Technology, Addison Wesley Longman (Singapore) Pvt.Ltd., New Delhi, 2000.
2. E. Paul Degarmo, J.T. Black, and Ronald A Kohser. “Materials and Processing in Manufacturing,” John Wiley and Sons Inc., 12th Edition, 5th July 2017, ISBN: 978- 1118987674.
3.H.M.T-Production Technology, Tata McGraw Hill Publishing Co, 2002.
4. Carl Love, L-Welding Producers and Applications, Prentice Hall Inc., 1993.
5. Heine,R.W.Loper,C.Rand Rosenthal, P.C - Principles of Metal Casting, TMH Publishing co., 1991.

CO – PO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	1	3	1	2	2
CO2	2	1	3	1	2	2
CO3	2	1	3	1	2	2
CO4	2	1	3	1	2	2
CO5	2	1	3	1	2	2

Score: **3** – High; **2** – Medium; **1** – Low

Department: **Mechanical Engineering**			Programme: **M.Tech**.(Product Design and Manufacturing)						
Semester: **First**			Course Category Code: **PCC**				Semester Exam Type: **LB**		
Course Code	Course Name		Periods / Week			Credit	Maximum Marks		
			L	T	P		CA	SE	TM
ME 266	**CAD Laboratory**		-	-	4	2	40	60	100
Prerequisite	**Nil.**								
Course Outcome	**CO1**	Can write high level language programs for simple machine elements design							
	CO2	Can write script file to generate 2D and 3D drawings using AutoCAD.							
	CO3	Can model 3Dmodels and assemblies using a modelling software.							
	CO4	Able to carry out simple simulation							
	CO5	Able to carry out simple FE analysis							

List of Experiments :

I. Programming Computer aided design of machine elements – Development of programs using FORTRAN/ C language/ MATLAB for design, drawing & plotting of Machine Elements and Interfacing with packages like Auto CAD 1. Shaft 2. Couplings Output of the program should create AutoCAD Script file. Run the Script file to show Design Drawing in the computer screen.	**CO1**
II.DRAFTING Using AutoCAD Software draw 1. Orthographic views of the given 3D blocks. 2. 3D blocks for the given orthographic views	**CO2**
III.MODELLING Using any modelling Software like ProE/CATIA/IDEAS generate 1. Solid modelling of given 3D blocks 2. Assembly modellings.	**CO3**
IV.SIMULATION USING MATLAB 1. Effect of damping on a single degree damped vibrating system. 2. Transient heat transfer problem	**CO4**
V. FE ANALYSIS Using any FEA software packages like ANSYS/NISA etc solve for 1. Plane Stress Analysis on tooth profile. 2. 2D Asymmetric analysis to determine Hoop and longitudinal stress on thick cylinder	**CO5**

Lecture Periods: -	**Tutorial Periods: -**	**Practical Periods: 60**	**Total Periods: 60**

Reference Books

1.Rudra Pratap, "Getting Started with MATLAB", Oxford University Press, USA, Seventh edition,2019.
2.Cadfolks, "AutoCAD 2019 For Beginners", Createspace Independent Publishing Platform, ISBN: 9781719344623.
3.Nader Zamani,"CATIA V5 FEA Tutorials Release 20", SDC Publications; Release 20 edition, ISBN-10: 1585036544
4.Moaveni, "Finite Element Analysis Theory And Application With ANSYS", Pearson India, New Delhi

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	3	3	2	1
CO2	2	3	3	3	2	1
CO3	2	3	3	3	2	1
CO4	2	3	3	3	2	1
CO5	2	3	3	3	2	1

Score: **3** – High; **2** – Medium; **1** – Low

Department: **Mechanical Engineering**			Programme: **M.Tech.(**Product Design and Manufacturing**)**						
Semester: **First**			Course Category Code: **PCC**				Semester Exam Type: **TY**		
Course Code	Course Name		Periods / Week			Credit	Maximum Marks		
			L	T	P		CA	SE	TM
ME255	**Research Methodology and IPR**		**2**	**-**	**-**	**2**	**40**	**60**	**100**
Prerequisite	**Nil**								
Course Outcome	**CO1**	Able to understand different types of researches and their difference							
	CO2	Able to identify the research gap.							
	CO3	Can design the experiments and analyze the experimental data							
	CO4	Will effectively present Dissertation and Research Papers.							
	CO5	Can prepare Patent Disclosure and can justify Ethics in research							

UNIT I	**Periods** : **6**
Meaning of Research, Types of Research, Research Process, Problem definition, Objectives of Research, Research Questions, Research design, Approaches to Research, Quantitative vs. Qualitative Approach, Understanding Theory, Building and Validating Theoretical Models, Exploratory vs. Confirmatory Research, Experimental vs Theoretical Research, Importance of reasoning in research.	**CO1**
UNIT II	**Periods: 6**
Problem Formulation, Understanding Modeling & Simulation, Conducting Literature Review, Referencing, Information Sources, Information Retrieval, Role of libraries in Information Retrieval, Tools for identifying literatures, Indexing and abstracting services, Citation indexes	**CO2**
UNIT III	**Periods** :**6**
Experimental Research: Cause effect relationship, Development of Hypothesis, Measurement Systems Analysis, Error Propagation, Validity of experiments, Statistical Design of Experiments, Field Experiments, Data/Variable Types & Classification, Data collection, Numerical and Graphical Data Analysis: Sampling, Observation, Surveys, Inferential Statistics, and Interpretation of Results	**CO3**
UNIT IV	**Periods** : **6**
Preparation of Dissertation and Research Papers, Tables and illustrations, Guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript. References, Citation and listing system of documents.	**CO4**
UNIT V	**Periods** : **6**
Intellectual property rights (IPR) - patents-copyrights-Trademarks-Industrial design geographical indication. IPR rules and regulations of India. Preparation of Patent Disclosure. Ethics of Research-Scientific Misconduct- Forms of Scientific Misconduct. Plagiarism, Unscientific practices in thesis work, Ethics in science.	**CO5**

Lecture Periods: 30	**Tutorial Periods: -**	**Practical Periods: -**	**Total Periods:30**

Reference Books

1. Bordens, K. S. and Abbott, B. B., "Research Design and Methods – A Process Approach", 8th Edition, McGraw-Hill, 2011
2. C. R. Kothari, "Research Methodology – Methods and Techniques", 2nd Edition, New Age International Publishers
3. Davis, M., Davis K., and Dunagan M., "Scientific Papers and Presentations", 3rd Edition, Elsevier Inc.
4. Michael P. Marder," Research Methods for Science", Cambridge University Press, 2011
5. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008
6. Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New Technological Age". Aspen Law & Business; 6 edition July 2012

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	1			1
CO2	2	3	1			1
CO3	2	3	1			1
CO4	2	3	1			1
CO5	2	3	1			1

Score: **3** – High; **2** – Medium; **1** – Low

Department: **Mechanical Engineering**		Programme: **M.Tech**.(Product Design and Manufacturing)						
Semester: **Second**		Course Category Code: **PCC**				Semester Exam Type: **TY**		
Course Code	Course Name	Periods / Week			Credit	Maximum Marks		
		L	T	P		CA	SE	TM
ME267	**Design Optimization Techniques**	**2**	**1**	**-**	**3**	**40**	**60**	**100**
Prerequisite	Knowledge in matrix theory and differential calculus							

Course Outcome	**CO1**	Understand engineering optimization, optimum design and know different optimization techniques available for use. Also, can employ numerical methods for finding optimum solution of a function having single variable and unconstrained optimization.
	CO2	Can employ numerical methods for determining optimum solution for a function having multi-variable and unconstrained optimization problems with equality and inequality constraints.
	CO3	Can employ numerical methods for determining optimum solution for a function having multi-variable and constrained optimization.
	CO4	Can employ numerical methods for determining optimum solution for a multi-objective function having multi-variable and constrained optimization. Able to solve problems having mixed inequality constraints, discrete and continuous, linear and non-linear geometric, dynamic and integer programming.
	CO5	Able to use solution techniques for solving stochastic, linear and non-linear optimization problems using GA, SA and Ant Colony algorithms.

UNIT I	**Periods : 9**
Introduction – Principles of optimization, Formulation of objective function, design constraints- classification of optimization problems. Single variable unconstraint optimization – Boundary phase method- Fibonacci search, method- Golden section search method – Newton – Raphson method.	**CO1**
UNIT II	**Periods : 9**
Multi variable unconstraint optimization- classical method-Optimization with Equality and Inequality constraints- Simplex search method– Conjugate gradient method – Variable-metric method. (Applications of these techniques in Design and manufacturing problems)	**CO2**
UNIT III	**Periods : 9**
Multi variable constraint optimization: Lagrange's multipliers - Kuhn-Tucker conditions – Penalty function method – Frank-Wolfe method– Generalized projection method. (Applications of these techniques in Design and manufacturing problems)	**CO3**
UNIT IV	**Periods : 9**
Multi objective optimization: Conjugate gradient method - reduced Conjugate gradient method– Newton –Raphson method (Applications of these techniques in Design and manufacturing problems) Integer Programming – Branch and bound method, Introduction to Geometric programming and Dynamic programming.	**CO4**
UNIT V	**Periods : 9**
Stochastic method: Genetic algorithms (GAs): working principle – difference between GAs and traditional methods – GAs for constrained optimization – Simulated annealing- Ant colony algorithm.	**CO5**

Lecture Periods: 30	**Tutorial Periods: 15**	**Practical Periods: -**	**Total Periods: 45**

Reference Books

1. Deb, K., Optimization for engineering design, Prentice Hall of India, 2005.
2. Rao, S.S., Optimization theory and applications, Wiley Eastern, 1984.
3. Davis, L., Handbook of genetic algorithms, Van Nostrand Reinhold, 1991.
4. Linear and Nonlinear Optimization, I. Griva, S. Nash, and A. Sofer, 2nd Edition, Society for Industrial and Applied Mathematics, 2009

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	2	3	2
CO2	3	1	3	2	3	2
CO3	3	1	3	2	3	2
CO4	3	1	3	2	3	2
CO5	3	1	3	2	3	2

Score: **3** – High; **2** – Medium; **1** – Low

Department: **Mechanical Engineering**		Programme: **M.Tech**.(Product Design and Manufacturing)						
Semester: **Second**		Course Category Code: **PCC**				Semester Exam Type: **TY**		
Course Code	Course Name	Periods / Week			Credit	Maximum Marks		
		L	T	P		CA	SE	TM
ME268	**Modern Manufacturing Techniques**	**3**	**-**	**-**	**3**	**40**	**60**	**100**
Prerequisite	**Nil.**							
Course Outcome	**CO1**	Explain the scope and applications of CAM for functioning CNC operating system						
	CO2	Execute CNC part programming with CAD and CAM systems						
	CO3	Identify the basic idea of Quality Function Development						
	CO4	Explain the importance of Rapid Prototyping and its techniques						
	CO5	Define the characterization of Flexible Manufacturing System						

UNIT I	**Periods : 9**	
Introduction to Automation in manufacturing - Hard automation – study of Principles and working of automation, Handling, locations, orientation and part feeding devices. CAM – Scope and applications – NC in CAM – Principal types of CNC machine tools and their construction features – tooling for CNC – ISO designation for tooling – CNC operating system –FANUC, SINUMERIK – HINUMERIK		**CO1**
UNIT II	**Periods : 9**	
Programming for CNC machining – coordinate systems – manual part programming – computer assisted part programming – CNC part programming with CAD system. Single and mixed mode assembly lines – quantitative analysis of assembly systems. Material handling in CAM environment – types – Industrial Robots.		**CO2**
UNIT III	**Periods : 9**	
AGVS – AS/RS – Swarf handling and disposal of wastes – case studies in assembly. Concurrent Engineering and Design for Manufacturing, Quality Function Deployment – Process Planning – CAPP – Variant and Generative systems. Computer Aided Production Planning and Control – Aggregate production planning and master production schedule.		**CO3**
UNIT IV	**Periods : 9**	
MRP – MRP II – ERP - Capacity planning. Rapid prototyping: Need for rapid prototyping, Basic principles and advantages of RP, General features and classifications of different RP techniques with examples, Introduction to 3-D RP techniques: Fusion Deposition Modeling, Laminated Object Manufacturing and Stereo-lithography.		**CO4**
UNIT V	**Periods : 9**	
Flexible manufacturing cells, systems – characteristics – economics and technological justification – planning, installation, operation and evaluation issues – role of group technology and JIT in FMS – typical case studies future prospects.		**CO5**

Lecture Periods: 45	**Tutorial Periods: -**	**Practical Periods: -**	**Total Periods: 45**

Reference Books

1. Radhakrishnan.S and Subramanian.S - CAD/CAM/CIM", Prentice Hall of India, 2000.
2. AmitabhaGhosh- A Brief Introduction -Rapid Prototyping ,Affiliated East West Press Pvt. Ltd., 1997.
3. MikellP.Groover-Automation , Production Systems and Computer, Integrated Manufacturing, Second edition, Prentice Hall of India, 2002.
4. Kant Vajpayee, S.-Principles of Computer Integrated Manufacturing, Prentice Hall of India, 1999.

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	3	1	3	2
CO2	2	2	3	1	3	2
CO3	2	2	3	1	3	2
CO4	2	2	3	1	3	2
CO5	2	2	3	1	3	2

Score: **3** – High; **2** – Medium; **1** – Low

Department: **Mechanical Engineering**		Programme: **M.Tech.**(Product Design and Manufacturing)						
Semester: **Second**		Course Category Code: **PCC**				Semester Exam Type: **TY**		
Course Code	Course Name	Periods / Week			Credit	Maximum Marks		
		L	T	P		CA	SE	TM
ME269	**Design of Experiments**	**2**	**1**	**-**	**3**	**40**	**60**	**100**
Prerequisite	**Nil.**							

Course Outcome	**CO1**	Can perform simple hypothesis testing and will get idea of Experimental Design.
	CO2	Will perform single factor experiments.
	CO3	Will use different types factorial experiments and can determine optimum parameters setting through Response Surface Methodology.
	CO4	Can design and perform Orthogonal Array design experimentation.
	CO5	Can design and perform Simple static Robust Design experimentation based on Orthogonal Array design.

UNIT I	**Periods :9**
Introduction to test of hypothesis, inference concerning means, variances and proportions for small and large samples, t, F, chi square tests, goodness of fitness and test of independence. Basic Concepts –Need for experimental deign- Fundamentals- Application. Selection of an appropriate design, Criteria for evaluation, Factors and levels, Review of statistical inference – Importance of optimized design – Functional design – Parametric design.	**CO1**
UNIT II	**Periods : 9**
Single factor experiments: Completely randomized design, Analysis of variance (ANOVA), Effect of total sum of Squares, Randomized block design, Randomized incomplete block design, Latin square design.	**CO2**
UNIT III	**Periods : 9**
Factorial experiments: Two way analysis of variance, Complete factorial design, Nested design, Effect of confounding, Fractional factorial design -Regression approach– response surface methodology: The method of steepest ascent, response, Surface designs.	**CO3**
UNIT IV	**Periods : 9**
Steps in designing performance in to a product – Taguchi's definition of quality – Loss functions and manufacturing tolerances – orthogonal Arrays vs. classical statistical experiments – Graphic evaluations of main effects – ANOVA for Orthogonal Array, Selecting factors for Taguchi Experiments.	**CO4**
UNIT V	**Periods : 9**
Concept of S/N Ratios – Its significance in robust design – Case studies of S/N ratios in optimization – Identifying control and noise factors- Constrained Robust Design Approach – Applications.	**CO5**

Lecture Periods: 30	**Tutorial Periods: 15**	**Practical Periods: -**	**Total Periods: 45**

Reference Books

1. Douglus C. Montgomery - Design and Analysis of Experiments, John Wiley Sons, 1984.
2.Panneerselvam R, "Design and Analysis of Experiments", PHI Learning Pvt, New Delhi, 2012.
3. Charles R.Hicks, Holt, -Fundamental Concepts in design of experiments, 1984.
4. Tapan P.Bagchi - Methods Explained: Practical steps to Robust Design, Prentice Hall of India Private Limited, New Delhi, 1993.

CO – PO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	1	3	1	3	2
CO2	3	1	3	1	3	2
CO3	3	1	3	1	3	2
CO4	3	1	3	1	3	2
CO5	3	1	3	1	3	2

Score: **3** – High; **2** – Medium; **1** – Low

Department: **Mechanical Engineering**			Programme: **M.Tech**.(Product Design and Manufacturing)						
Semester: **Second**			Course Category Code:**PCC**				Semester Exam Type: **LB**		
Course Code	Course Name		Periods / Week			Credit	Maximum Marks		
			L	T	P		CA	SE	TM
ME 270	**CIM Laboratory**		-	-	**4**	**2**	**40**	**60**	**100**
Prerequisite	**Nil**								
Course Outcome	**CO1**	Able write Part Programs for simple machining operations in CNC lathe							
	CO2	Able write Part Programs for step, taper and thread cutting operations in CNC lathe							
	CO3	Able write Part Programs for simple machining operations in CNC Milling							
	CO4	Able write Part Programs for tool, die and pattern design.							
	CO5	To introduce Robot, FMS and other advanced Programs.							

List of Experiments:	
1. CNC part programming for simple turning operation 2. CNC part programming for box turning operation 3. CNC part programming for facing operation 4. CNC part programming for box facing operation	**CO1**
5. CNC part programming for step turning operation 6. CNC part programming for taper turning operation 7. CNC part programming for thread cutting operation	**CO2**
8. CNC part programming for end milling operation 9. CNC part programming for profile cutting in milling 10. CNC part programming for machining holes in milling	**CO3**
11. Generating G & M codes for the model created using solid edge package 12. Tool and die design for a plastic component 13. Pattern design for a casting component	**CO4**
14. Simple robot part programming for material handling 15. FMS programming for a simple layout	**CO5**

Lecture Periods: -	**Tutorial Periods: -**	**Practical Periods: 60**	**Total Periods: 60**

Reference Books

1. CNC Programming Fanuc Control by S.k. Sinha, Galgotia Publications, 2015
2. CNC Programming Tutorials: Examples G & M Codes - Guide to CNC Programming by G code & M code, by Thanh Tran, Su TP, Thanh X.Tran, Thanh Tran Publications, 2018
3. CNC Programming for Machining, by Kumar, Kaushik, Ranjan, Chikesh, Davim, J. Paulo, Springer, 2020

CO – PO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	3	3	2	3	1
CO2	2	3	3	2	3	1
CO3	2	3	3	2	3	1
CO4	2	3	3	2	3	1
CO5	2	3	3	2	3	1

Score: **3** – High; **2** – Medium; **1** – Low

Department: **Mechanical Engineering**			Programme: **M.Tech**.(Product Design and Manufacturing)						
Semester: **Second**			Course Category Code:**PAC**			Semester Exam Type: **LB**			
Course Code	Course Name		Periods / Week			Credit	Maximum Marks		
			L	T	P		CA	SE	TM
ME 271	**Mini Project and Seminar**		**-**	**-**	**4**	**2**	**100**		**100**
Prerequisite	**Nil**								
Course Outcome	**CO1**	Students can make use of the opportunity to work in industry and get exposure.							
	CO2	Try to solve the practical problem in industry by using analytical and computational tools.							
	CO3	To understand the concept and write a report/ research article							
	CO4	To improve the communication skill as well as presentation and explain their work technically							
Course content									
Students can take up small problems in the field of Product Design and Manufacturing as mini project. It can be related to solutions to engineering problem, verification and analysis of experimental data available, conducting experiments on various engineering subjects, material characterization, studying and applying a software tool for the solution of an engineering problems etc. This mini project work is evaluated by panel of examiners assigned by HoD.									
Lecture Periods: -	**Tutorial Periods: -**		**Practical Periods: 60**			**Total Periods: 60**			

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	-	2
CO2	3	3	3	3	-	2
CO3	3	3	3	-	-	-
CO4	3	3	3	-	-	-

Score: **3** – High; **2** – Medium; **1** – Low

Department: **Mechanical Engineering**		Programme: **M.Tech**.(Product Design and Manufacturing)						
Semester: **Third**		Course Category Code:**PAC**				Semester Exam Type: **LB**		
Course Code	Course Name	Periods / Week			Credit	Maximum Marks		
		L	T	P		CA	SE	TM
ME 272	**Dissertation – Phase I**	**-**	**-**	**20**	**10**	**250**	**250**	**500**
Prerequisite	**Nil**							

Course Outcome	**CO1**	Students can make use of the opportunity to work in industry and get exposure or identify problem and conduct experiment with in the department.
	CO2	Understand a problem and try to adopt methodology to solve the problem successfully.
	CO3	Solve the practical problem by conducting experiments and using analytical or computational software to get accuracy.
	CO4	Get the exposure with various standards, codes, testing methods, gains knowledge in design and experiment.
	CO5	Improve the communication as well as presentation skill and explain their work technically

Course content

The student individually works on a specific topic approved by the Head of the Department under the supervision of a faculty member who is conversant in that area of interest. The student can select a specific topic which is relevant to the area of product design and manufacturing which of current and the future needs of the country/society. They have to collect information related to the same through detailed review of literature and have to develop the methodology to solve the problem identified. The topic may be theoretical, modelling and simulation, experimental, fabrication type or case studies. At the end of the semester, after completing the work to the satisfaction of the supervisor and review committee, a detailed report should be submitted to the head of the department on clear definition of the identified problem, detailed literature review related to the area of work, methodology to be adopted and some initial work carried out. The students will be evaluated based on the report submitted and through a viva-voce examination by an internal and an external examiner.

Lecture Periods: -	**Tutorial Periods: -**	**Practical Periods: 300**	**Total Periods: 300**

CO – PO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	3	1	1
CO2	3	3	3	3	1	1
CO3	3	3	3	3	1	1
CO4	3	3	3	3	1	1
CO5	3	3	3	3	-	-

Score: **3** – High; **2** – Medium; **1** – Low

Department: **Mechanical Engineering**		Programme: **M.Tech**.(Product Design and Manufacturing)						
Semester: **Fourth**		Course Category Code: **PAC**				Semester Exam Type: **LB**		
Course Code	Course Name	Periods / Week			Credit	Maximum Marks		
		L	T	P		CA	SE	TM
ME 273	**Dissertation – Phase II**	**-**	**-**	**32**	**16**	**250**	**250**	**500**
Prerequisite	**Nil**							

Course Outcome	**CO1**	Students can make use of the opportunity to work in industry and get exposure or identify problem and conduct experiment with in the department
	CO2	Understand a problem and try to adopt methodology to solve the problem successfully.
	CO3	Solve the practical problem by conducting experiments and using analytical or computational software to get accuracy.
	CO4	Get the exposure with various standards, codes, testing methods, gains knowledge in design and experiment.
	CO5	Improve the communication as well as presentation skill and explain their work technically

Course content

The student should continue the phase I work on the selected topic as per the formulated methodology under the same supervisor. At the end of the semester, after completing the work to the satisfaction of the supervisor and project review committee, a detailed report should be prepared and submitted to the head of the department. The students will be evaluated based on the report submitted and the viva-voce examination by an internal and an external examiner.

Lecture Periods: -	**Tutorial Periods: -**	**Practical Periods: 480**	**Total Periods: 480**

CO – PO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	3	1	1
CO2	3	3	3	3	1	1
CO3	3	3	3	3	1	1
CO4	3	3	3	3	1	1
CO5	3	3	3	3	-	-

Score: **3** – High; **2** – Medium; **1** – Low

Department: **Mechanical Engineering**		Programme: **M.Tech.**(Product Design and Manufacturing)						
Semester: **First**		Course Category Code: **PSE-1/PSE-2**				Semester Exam Type: **TY**		
Course Code	Course Name	Periods / Week			Credit	Maximum Marks		
		L	T	P		CA	SE	TM
MEZ21	**Advances in Casting and Welding**	**3**	**-**	**-**	**3**	**40**	**60**	**100**
Prerequisite	**Nil.**							

Course Outcome	**CO1**	Can design the mould with minimal casting defects.
	CO2	Can select other Special casting processes.
	CO3	Can weld material such as steels, cast iron, Stainless steel, aluminium and Titanium alloys with minimal welding defects.
	CO4	Able select other unconventional and special welding processes for the practical requirement.
	CO5	Know recent industrial advancements in the fields of Casting and Welding.

UNIT I	**Periods : 9**	
Casting metallurgy and design - Heat transfer between metal and mould-Solidification of pure metal and alloys -Shrinkage in cast metals, progressive and directional solidification – Principles of grating and rising – Degasification of the melt - Design considerations in casting – Designing for directional solidification and minimum stresses -casting defects		**CO1**
UNIT II	**Periods : 9**	
Special casting processes - Shell moulding, Precision investment casting, CO moulding, Centrifugal casting, Die casting and Continuous casting.		**CO2**
UNIT III	**Periods : 9**	
Welding metallurgy and design - Heat affected Zone and its characteristics - Weldability of steels, cast iron, Stainless steel, aluminium and Titanium alloys - Hydrogen embrittlement – Lamellar tearing - Residual stress – Heat transfer and Solidification - Analysis of stresses in welded structures - pre and post welding heat treatments – Weld joint design - Welding defects - testing of weldment.		**CO3**
UNIT IV	**Periods : 9**	
Unconventional and special welding processes - Friction welding - Explosive welding – Diffusion bonding – High frequency Induction welding - Ultrasonic welding -Electron beam welding – Laser beam welding.		**CO4**
UNIT V	**Periods : 9**	
Recent advances in casting and welding - Layout of mechanised foundry - sand reclamation Material handling in foundry - pollution control in Foundry - Recent trends in casting – Computer Aided design of Castings, Low pressure die casting, Squeeze casting, and full mould casting process. Automation in welding - Welding robots - Overview of automation of welding in aerospace, nuclear, surface transport vehicles and under water welding.		**CO5**

Lecture Periods:45	**Tutorial Periods: -**	**Practical Periods: -**	**Total Periods: 45**

Reference Books

1. Mukherjee P.C.-Fundamentals of Metal casting Oxford - IBH,1979.
2. Lancaster J.F.-Metallurgy of Welding - George Allen & Unwin Publishers,1980.
3. Titoun.D & Stepanov .YU.A- Foundry Practice, MIR Publishers, Moscow, 1981.
4. Cornu. J. - Advanced Welding systems -Volumes me, II and III, JAICO Publishers, 1994

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	3	1	1	1
CO2	2	2	3	1	1	1
CO3	2	2	3	1	1	1
CO4	2	2	3	1	1	1
CO5	2	2	3	1	1	1

Score: **3** – High; **2** – Medium; **1** – Low

Department: **Mechanical Engineering**		Programme: **M.Tech.**(Product Design and Manufacturing)						
Semester:**First**		Course Category Code: **PSE-1/PSE-2**				Semester Exam Type: **TY**		
Course Code	Course Name	Periods / Week			Credit	Maximum Marks		
		L	T	P		CA	SE	TM
MEZ22	**Computer Aided Design**	**3**	**-**	**-**	**3**	**40**	**60**	**100**
Prerequisite	**Nil.**							

Course Outcome	**CO1**	can get familiarized with the computer graphics application in design
	CO2	Can reinforce the knowledge of Geometric Modeling -its basics and fundamentals.
	CO3	Can get basic idea about assembly modeling and data and program storage techniques and CAD data exchange standards.
	CO4	can get familiarized with advanced modelling features.
	CO5	Can learn about FE modelling techniques.

UNIT I	**Periods** :**9**
Principles of Computer Graphics: Point plotting, drawing of lines, Bresenham's circle algorithm. Transformation in Graphics: co-ordinate system used in Graphics and windowing , view port, views, 2D transformations – rotation, scaling, translation, mirror, reflection and shear - homogeneous transformations – concatenation, 3D Transformation – Perspective Projection – Technique (Description of techniques only)	**CO1**
UNIT II	**Periods** :**9**
Geometric Modeling: Classification of Geometric Modeling – Wire frame, Surface and Solid Modeling, applications – representation of curves and surfaces – Parametric form – Design of curved shapes- Cubic spline – Bezier curve – B-spline – Design of Surfaces - features of Surface Modeling Package - Solid Primitives, CSG, B-rep and description of other modeling techniques like Pure primitive instancing, cell decomposition, spatial occupancy enumeration, Boolean Operations (join, cut, intersection), Creating 3D objects from 2D profiles (extrusion, revolving etc)	**CO2**
UNIT III	**Periods : 9**
Assembly modeling - interferences of positions and orientation - tolerances analysis – mass property calculations - mechanism simulation. Graphics standard & Data storage: Standards for computer graphics GKS. Data exchange standards – IGES, STEP. Data structures for entity storage – Data structure for interactive modeling. Relational databases – introduction to SQL language, Role of OOPS in CAD.	**CO3**
UNIT IV	**Periods : 9**
Visual realism: Hidden – Line – Surface – solid removal algorithms shading – coloring. Introduction to parametric and variational geometry-based software's and their principles creation of prismatic and lofted parts using these packages- Feature based modeling. An overview of modeling software like PRO-E, CATIA, IDEAS, SOLID EDGE etc.	**CO4**
UNIT V	**Periods : 9**
Introduction to Finite Element Analysis – Steps of FEM for solving physical problem, conversions of physical model into FE model, CAD techniques to finite element data preparation- discretization techniques, Selection of elements, modelling with high and lower order elements- transition of element mesh, Mesh conditions to be satisfied for coarse- mesh regions- stress concentration regions, manual, semi-automatic and Automatic mesh generation- modeling of boundary and loading conditions, Application of symmetric and antisymmetric boundary conditions, Presentation of results - CAD applications of FEM , substructure modeling.	**CO5**

Lecture Periods: 45	**Tutorial Periods: -**	**Practical Periods: -**	**Total Periods: 45**

Reference Books

1. Chris Mcmahon and Jimmie - CAD/CAM – Principle Practice and Manufacturing Management, Addision Wesley England, 2000.
2. Sadhu Singh - Computer Aided Design and Manufacturing, II Edition, KhannaPublishers, New Delhi, 2000.
3. P.Radhakrishnan et al - CAD/CAM/CIM, New Age International P Ltd., New Delhi, 2000.
4. M.P.Groover and E.W.Zimmers - CAD/CAM; Computer Aided Design and Manufacturing, Tata McGraw Hill Publishing Co. Ltd., New Delhi, 2003.
5. Ibrahim Zeid - CAD/CAM Theory and Practice, Tata McGraw Hill Publishing Co. Ltd.,New Delhi, 1992.

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	2	3	2	2	1
CO2	1	2	3	2	2	1
CO3	1	2	3	2	2	1
CO4	1	2	3	2	2	1
CO5	1	2	3	2	2	1

Score: **3** – High; **2** – Medium; **1** – Low

Department: **Mechanical Engineering**		Programme: **M.Tech.**(Product Design and Manufacturing)						
Semester: **First**		Course Category Code: **PSE-1/PSE-2**				Semester Exam Type: **TY**		
Course Code	Course Name	Periods / Week			Credit	Maximum Marks		
		L	T	P		CA	SE	TM
MEZ23	**Advanced Solid Mechanics**	**3**	**-**	**-**	**3**	**40**	**60**	**100**
Prerequisite	**Nil.**							

Course Outcome	**CO1**	Able to understand basics of 3D and 2D elasticity.
	CO2	Can design unsymmetrically bending members.
	CO3	Able to design curved members and members subjected to Hertzian stress.
	CO4	Can determine shear stress distribution on non circular members subject to torsional load.
	CO5	Able to design plate structural members subjected to Point and Distributed Loads.

UNIT I	**Periods : 9**
Elasticity- Stress - Strain relations and general equations of elasticity in Cartesian and Polar coordinates, differential equations of equilibrium – compatibility-boundary conditions- representation of three-dimensional stress of a tension generalized hook's law– Mohr's circle method-St. Venant's principle – plane stress-Energy methods.	**CO1**
UNIT II	**Periods :9**
Shear center: Bending axis and shear center-shear center unsymmetrical sections. Unsymmetrical bending: Bending stresses and deflections in Beams subjected to Nonsymmetrical bending	**CO2**
UNIT III	**Periods : 9**
Analysis of stresses in beams with large curvature – Stress distribution in curved beams – Stresses in crane hooks and C clamps – Contact Stresses – Hertz equation for contact stresses – applications to rolling contact elements.	**CO3**
UNIT IV	**Periods : 9**
Torsion : Linear elastic solution; Prandtl elastic membrane (Soap-Film) Analogy; Narrow rectangular cross Section Hollow thin wall torsion members ,Multiply connected Cross Section.	**CO4**
UNIT V	**Periods : 9**
Mathematical modeling of plates with normal loads – Point and Distributed Loads – Support conditions – Rectangular plates - Stresses along coordinate axes– Plate deformations.	**CO5**

Lecture Periods: 45	**Tutorial Periods: -**	**Practical Periods: -**	**Total Periods: 45**

Reference Books

1. Boresi A.P., Schmidt R.J., Advanced Mechanics of Materials, John Wiley and Sons, 2009.
2. Srinath. L.S., Advanced Mechanics of solids, Tata McGraw Hill, 2008.
3. Allan F. Bower, "Applied Mechanics of Solids", CRC press, Special Indian Edition,2012, 2010
4. K. Baskar and T.K. Varadan, "Theory of Isotropic/Orthotropic Elasticity", Ane Books Pvt. Ltd., New Delhi, 2009

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	3	1	2	1
CO2	2	1	3	1	2	1
CO3	2	1	3	1	2	1
CO4	2	1	3	1	2	1
CO5	2	1	3	1	2	1

Score: **3** – High; **2** – Medium; **1** – Low

Department: **Mechanical Engineering**			Programme: **M.Tech.**(Product Design and Manufacturing)						
Semester: **First**			Course Category Code: **PSE-1/PSE-2**				Semester Exam Type: **TY**		
Course Code	Course Name		Periods / Week			Credit	Maximum Marks		
			L	T	P		CA	SE	TM
MEZ24	**Tool Design**		**3**	**-**	**-**	**3**	**40**	**60**	**100**
Prerequisite	**Nil.**								
Course Outcome	**CO1**	will be in a position to know about jigs and fixtures in detail.							
	CO2	can design jigs for industrial applications.							
	CO3	can design fixtures for industrial applications.							
	CO4	Will have knowledge on press tools							
	CO5	can design various dies.							

UNIT I	**Periods : 9**
Locating and Clamping Devices: Principles of Jigs and Fixtures design-Locating principles-Locating elements-Standard parts-Clamping devices-Mechanical actuation-Pneumatic & hydraulic actuation-Analysis of clamping forces.	**CO1**
UNIT II	**Periods : 9**
Jigs: Drill bushes - Different types of jigs- plate, latch, channel, box, post, angle plate, angular post, turnover, pot jigs - Automatic drill jigs – Rack & pinion operated and Air operated jig components - Design and development of jigs for the given components.	**CO2**
UNIT III	**Periods : 9**
Fixtures: Types of fixtures - Boring, Lathe, Milling, Broaching fixtures – Grinding, Planning and Shaping fixtures – Assembly, Inspection and Welding fixtures – Modular fixtures – Design and development of fixtures for the given components.	**CO3**
UNIT IV	**Periods : 9**
Press Tools: Press working terminology-Presses and Press accessories-Computation of capacities and tonnage requirements-Strip layout.	**CO4**
UNIT V	**Periods : 9**
Dies: and development of various types of Cutting, Forming and Drawing dies – Blank development for cylindrical and non cylindrical shells – Compound, Progressive and Combination dies.	**CO5**

Lecture Periods: 45	**Tutorial Periods: -**	**Practical Periods: -**	**Lecture Periods: 45**

Reference Books

1. Mehta NK - Machine Tool Design & Numerical Control, Tata McGraw Hill Publisher New Delhi 2009
2. CMTI - Machine Tool Design Handbook, Tata McGraw Hill publisher New Delhi 2009.
2. Basu SK & Pal DK - Design of Machine Tools, India Book House Pvt Ltd, New Delhi 2009.

CO – PO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	2	3	2	2	2
CO2	2	2	3	2	2	2
CO3	2	2	3	2	2	2
CO4	2	2	3	2	2	2
CO5	2	2	3	2	2	2

Score: **3** – High; **2** – Medium; **1** – Low

Department: **Mechanical Engineering**		Programme: **M.Tech.**(Product Design and Manufacturing)						
Semester: **First**		Course Category Code: **PSE-1/ PSE-2**				Semester Exam Type: **TY**		
Course Code	Course Name	Periods / Week			Credit	Maximum Marks		
		L	T	P		CA	SE	TM
MEZ25	**Composite Materials Technology**	**3**	**-**	**-**	**3**	**40**	**60**	**100**
Prerequisite	**Nil.**							

Course Outcome	**CO1**	Can understand the formulation of new materials and its composition, advantages and limitations
	CO2	Able to blend different types of fibers with matrix and designing the load transfer between fibers of matrix, its advantages and limitations
	CO3	Gain knowledge on dispersing of different metal or material with the monolithic material and understanding the interfacing phenomena
	CO4	Can acquire Knowledge on different types of MMC Production & fabrication methods
	CO5	Will understand the macro & micro mechanics for better designing of composite materials to enhance its mechanical properties

UNIT I	**Periods : 9**
Definition – Need – General Characteristics, Matrices – Polymer, Metal, Carbon and Ceramic Matrices, Reinforcement – Types – fibers, whiskers and particles, Reinforcement materials, Selection, advantages and limitations.	**CO1**
UNIT II	**Periods : 9**
Polymer Matrix Composites – Matrix Resins – Thermosetting resins, Thermoplastic resins, Polyacryl ethers (PAE), Thermoplastic Polyimides (TPI), Polyacrylene Sulfide, molecularly ordered liquid Crystals (MOLC), Polyblends Alloys, Fibers and Laminar Composites.	**CO2**
UNIT III	**Periods : 9**
Metal Matrix Composites – Matrix selection, Reinforcement and reinforcement selection, Matrix reinforcement interface, Interaction zone, Interface bond strength.	**CO3**
UNIT IV	**Periods : 9**
Polymer Matrix Production Methods – Bag Moulding, Compression Moulding, Pultrusion, Filament Winding, Metal Matrix Composites - Fabrication methods – Solid State Techniques and Liquid State Techniques.	**CO4**
UNIT V	**Periods** :**9**
Micro mechanics and macro mechanics of composites, monotonic strength and fracture, Fatigue and Creep, Applications of composites. Composites Processing.	**CO5**

Lecture Periods: 45	**Tutorial Periods: -**	**Practical Periods: -**	**Total Periods: 45**

Reference Books

1. Krishan Chawala, K.-Composite Materials: Science and Engineering, Springer, 2001.
2. Sanjay K.Mazumdar-Composites Manufacturing: Materials, Product and Process Engineering, CRC Press, 2002.
3. F.L.Mathews and Rawlings,R.D -Composite Materials Engineering and Science, CRC press, 2002.
2. Mallic P.k - Fiber Reinforced Composites: Materials, Manufacturing and Design, Marcel DekkarInc, 1993.

CO – PO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	1	3	1	3	2
CO2	3	1	3	1	3	2
CO3	3	1	3	1	3	2
CO4	3	1	3	1	3	2
CO5	3	1	3	1	3	2

Score: **3** – High; **2** – Medium; **1** – Low

Department: **Mechanical Engineering**		Programme: **M.Tech.**(Product Design and Manufacturing)						
Semester: **First**		Course Category Code: **PSE-1/PSE-2**				Semester Exam Type: **TY**		
Course Code	Course Name	Periods / Week			Credit	Maximum Marks		
		L	T	P		CA	SE	TM
MEZ26	**Finite Element Method**	**2**	**1**	**-**	**3**	**40**	**60**	**100**
Prerequisite	**Nil.**							

Course Outcome	**CO1**	Can use global approximate solutions for BVPs and can adopt Galerkin FE for simple 1D problems
	CO2	Will solve Plane truss FE problems and 1D FE problems with 1 dof or 2 dofs .
	CO3	Can develop 1D or 2D Superparametric, Subparametric and Isoparametric elements and carry out numerical integration mostly used in FEA.
	CO4	Will solve Plane Stress, Plain Strain and Axisymmetric FE linear elastic static structural Problems.
	CO5	Will solve thin and thick plate and Axisymmetric FE linear steady static heat transfer Problems.

UNIT I	**Periods** :**9**	
Basic Concept of FEM, discretisation, comparison with finite difference method, advantages and disadvantages, history of development, application. Variational and Weighted Residual Formation: Boundary value problems, approximated methods of solution, review of variational calculus, geometric and natural boundary condition, method of Weighted residuals, Rayleigh Ritz and Galerkin methods of finite element formulations and convergence criteria, weak formulation -simple problems.		**CO1**
UNIT II	**Periods** :**9**	
One dimensional second order equations, discretisation of domain into elements, derivation of element equations, assembly of element equation, imposition of boundary conditions, solution of equations - post processing, Direct stiffness method (DSM)- Fundamental steps in DSM, Plane Truss, Calculation of Reaction, Internal forces and stresses. Extension of fourth order equations and their solutions – examples from solid mechanics, heat transfer.		**CO2**
UNIT III	**Periods : 9**	
Classification of C0, C1 continuous problems-Parameter functions, its properties- completeness and compatibility condition, One-dimensional elements, Global coordinates Two-dimensional elements, three noded triangular elements and four noded quadrilateral elements. Natural coordinate systems – Lagrangian Interpolation Polynomials- Serendipity Formulation – Difference between Superparametric, Subparametric and Isoparametric Elements, Isoparamatric Elements Formulation, length coordinates– 1D bar elements, C0 continuous shape function, beam elements, C1 continuous shape function - 2D Triangular elements, Rectangular elements. – Area coordinates- Numerical integration – simple Problems using Gauss quadrature technique.		**CO3**
UNIT IV	**Periods : 9**	
Basic Boundary Value Problems in 2 Dimensions – Introduction to Theory of Elasticity – Plane Stress – Plain Strain and Axisymmetric Formulation – Principle of virtual work – Weak Formulation – Triangular, Quadrilateral elements - Element matrices using energy approach. -Simple problems using three noded triangular elements only.		**CO4**
UNIT V	**Periods : 9**	
Finite Element Analysis of 2D Steady State Thermal Problems - Green-Gauss Theorem-Element equation formulation – Variational calculus approach- Galerkin approach – General Two Dimensional Heat Conduction –Axisymmetric Heat conduction - Triangular, Quadrilateral elements - Simple problems using three noded triangular element only.		**CO5**

Lecture Periods: 30	**Tutorial Periods: 15**	**Practical Periods: -**	**Total Periods: 45**

Reference Books

1. Krishanamoorthy C.S - Finite Element Analysis for Engineers- Theory and Programming, Tata McGraw Hill Publishing Company Ltd.,1998.
2. Frank L. Stasa - Applied Finite Element Analysis for Engineers, CBS International Edition, 1985.
3. Reddy J.N - A Introduction to Finite Element Method, McGraw Hill, International Edition,1993.
4. Rao.S.S, - Finite Element Method in Engineering , Pergamon. 2010

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	2	1
CO2	3	1	3	3	2	1
CO3	3	1	3	3	2	1
CO4	3	1	3	3	2	1
CO5	3	1	3	3	2	1

Score: **3** – High; **2** – Medium; **1** – Low2

Department: **Mechanical Engineering**		Programme: **M.Tech.**(Product Design and Manufacturing)						
Semester: **First**		Course Category Code: **PSE-1/PSE-2**				Semester Exam Type: **TY**		
Course Code	Course Name	Periods / Week			Credit	Maximum Marks		
		L	T	P		CA	SE	TM
MEZ27	**Hydraulics and Pneumatics**	**3**	**-**	**-**	**3**	**40**	**60**	**100**
Prerequisite	**Nil.**							

Course Outcome	**CO1**	Familiarize with Automatic controls, its need, importance, classifications and types.
	CO2	Familiarize with Hydraulic power basic components, suitability, requirements and usage
	CO3	Will design Hydraulic power automation circuits for a given industrial application in a cost-effective manner.
	CO4	Will design Pneumatic power automation circuits for a given industrial application in a cost effective manner.
	CO5	Will design Hybrid power automation circuits/ electro-mechanical systems for a given industrial application in a cost effective manner.

UNIT I	**Periods : 9**
Principles of automatic controls: Basic concepts of open and closed loop feedback control systems, block diagram representation of physical system, spring mass system, torsion system, hydraulic system, transfer function from block diagram for mechanical, electro-mechanical and hydraulic system. Controls and sensors used in machine tools.	**CO1**
UNIT II	**Periods : 9**
Automation in hydraulic systems: Hydraulic systems components – constructional details and characteristics of pumps – actuator – control and regulation elements.	**CO2**
UNIT III	**Periods : 9**
Hydraulic circuits: reciprocation operation of multi cylinder unit – quick return – sequencing, synchronizing circuits – accumulator circuits – safety circuits – circuits for press, drilling, milling and grinding – servo system – selection of components.	**CO3**
UNIT IV	**Periods : 9**
Automation in pneumatic system: Pneumatic principles – elements of pneumatic system – control valves – basic pneumatic and hydro pneumatic circuits – logic circuits – pneumatic sensors – maintenance of pneumatic systems.	**CO4**
UNIT V	**Periods : 9**
Architecture of Microprocessor – interfacing – data transfer schemes – application of Microprocessor in hydraulic and pneumatic systems – use of microprocessor for sequencing –PLC – low cost automation.	**CO5**

Lecture Periods: 45	**Tutorial Periods: -**	**Practical Periods: -**	**Total Periods: 45**

Reference Books

1. A. Esposito - Fluid Power with applications, Prentice Hall, 2001.
2. Andrew Par - Hydraulics and Pneumatics for Technicians, Jaico Publishing, 1980.
3. Majumdar SR- Pneumatic System Principles and Maintenance, Tata McGraw Hill, 1995.

CO – PO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	1	3	2	2	2
CO2	1	1	3	2	2	2
CO3	1	1	3	2	2	2
CO4	1	1	3	2	2	2
CO5	1	1	3	2	2	2

Score: **3** – High; **2** – Medium; **1** – Low2

Department: **Mechanical Engineering**		Programme: **M.Tech.**(Product Design and Manufacturing)						
Semester: **First**		Course Category Code: **PSE-1/PSE-2**				Semester Exam Type: **TY**		
Course Code	Course Name	Periods / Week			Credit	Maximum Marks		
		L	T	P		CA	SE	TM
MEZ28	**Integrated Materials Management**	**3**	**-**	**-**	**3**	**40**	**60**	**100**
Prerequisite	**Nil.**							

Course Outcome	**CO1**	shall be able to identify, study, compare, and evaluate alternatives, select and maintain relations with good supplier(s) for purchase of quality materials at minimum cost
	CO2	shall be able to manage the stores effectively in terms of material storage, handling, codification/standardization and stock verification
	CO3	Shall be able to analyze the inventory situation of a company and suggest suitable improvements.
	CO4	shall be able to appreciate the importance of physical distribution and related documentation
	CO5	shall be able to understand how logistics and supply chain management can be used for the progress of the organization

UNIT I	**Periods : 9**	
Integrated Materials Management Concept - materials planning and budgeting – Quality specification – source selection - purchase systems – negotiation –delivery conditions - Make or Buy – Purchasing of capital equipment – international purchasing – import substitution – public buying –legal aspects - contracts – vendor rating – buyer-seller relationship and ethics.		**CO1**
UNIT II	**Periods : 9**	
Stores Management – stores systems and procedures – incoming materials control – stores accounting and stock verification – obsolete, surplus and scrap management – codification and standardization - value analysis – material handling – storing and material handling equipments.		**CO2**
UNIT III	**Periods : 9**	
Inventory Control: inventory models - purchase model with instantaneous replenishment and without shortages, manufacturing model without shortages, purchase model with shortage and manufacturing model with shortages – operation of inventory systems – quantity discounts - P & Q systems of inventory replenishment – multiple item model with shortage limitation –determination of stock level of perishable items under probabilistic condition – MRP I and II.		**CO3**
UNIT IV	**Periods : 9**	
Concepts of Physical distribution – need, importance and management – Warehouses – location and layout types - receiving and shipping procedures - Application of OR techniques (Transportation problems only). Common carriers – Insurance coverage – Transportation documents – railway / lorry receipts – Bill of lading – clearing, forwarding and demurrage - evaluation of materials management performance – computers in materials management.		**CO4**
UNIT V	**Periods : 9**	
Creating the logistics vision – problems with conventional organizations – developing logistics organizations – need for integration – managing supply chain as a network – process integration and ECR – comakership and logistics partnerships – supplier development. New organizational paradigm – managing supply chain of the future – role of information in the virtual supply chain – route map to integrated supply chain.		**CO5**

Lecture Periods: 45	**Tutorial Periods: -**	**Practical Periods: -**	**Total Periods: 45**

Reference Books

1. Gopalakrishnan, P. and Sundaresan, M. - Materials Management – An integrated approach, PHI, 2011.
2. Martin Christopher Logistics & Supply Chain Management, Pitman Publishing, 2011.
3. Dutta, A.K. - Materials Management – Procedures, Text and Cases, PHI., 2004.
4. Panneerselvam, R. - Operations Research, Prentice Hall of India, New Delhi, 2006.

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	3	1	2	1
CO2	2	1	3	1	2	1
CO3	2	1	3	1	2	1
CO4	2	1	3	1	2	1
CO5	2	1	3	1	2	1

Score: **3** – High; **2** – Medium; **1** – Low

Department: **Mechanical Engineering**		Programme: **M.Tech.**(Product Design and Manufacturing)						
Semester: **Second**		Course Category Code: **PSE-3/PSE-4**				Semester Exam Type: **TY**		
Course Code	Course Name	Periods / Week			Credit	Maximum Marks		
		L	T	P		CA	SE	TM
MEZ29	**Design for Manufacture and Assembly**	**3**	**-**	**-**	**3**	**40**	**60**	**100**

Prerequisite	**Nil.**	
Course Outcome	**CO1**	Understand the various factors influencing the manufacturability of components.
	CO2	Can apply the practically possible manufacturable concepts of forging, casting, welding and machining in design.
	CO3	Will design a system/component/process to meet desired design goals with realistic constraints such as economic, environmental, social, ethical, health and safety, manufacturability, and sustainability.
	CO4	Can apply the casting guile lines in manufacturing.
	CO5	Can employ geometric tolerances for critical mechanical components.

UNIT I	**Periods : 9**
General design principles, Effect of material properties on design, Effect of manufacturing process on design, mechanisms selection, evaluation method, Process capability.	**CO1**
UNIT II	**Periods : 9**
Working principle, Material, Manufacture, Design - Possible solutions - Materials choice -Influence of materials on form design - form design of welded members, forgings and castings.	**CO2**
UNIT III	**Periods : 9**
Design features to facilitate machining - drills - milling cutters - keyways - Doweling procedures, counter sunk screws - Reduction of machined area - simplification by separation – simplification by amalgamation - Design for machinability - Design for economy - Design for capability -Design for accessibility - Design for assembly.	**CO3**
UNIT IV	**Periods** :**9**
Redesign of castings based on parting line considerations - Minimizing core requirements, machined holes, redesign of cast members to obviate cores.	**CO4**
UNIT V	**Periods** :**9**
Feature tolerances - Geometric tolerances - Assembly limits – Datum features – Tolerance stacks - Design for assembly and disassembly, General approach - case studies.	**CO5**

Lecture Periods: 45	**Tutorial Periods: -**	**Practical Periods: -**	**Total Periods: 45**

Reference Books

1. Geoffrey Boothroyd, Peter Dewhurst and, Winston A. Knight -Product Design for Manufacture and Assembly Third Edition (Manufacturing Engineering and Materials Processing) CRC Press 2010.
2. Robert Matousek-Engineering Design-A systematic approach, Blackie&SonsLtd.1963.
3. James G. Bralla- Hand Book of Product Design for Manufacturing McGraw Hill Co., 1986.
4. Swift K.G. -Knowledge based design for manufacture, Koga Page Ltd., 1987

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	3	1	3	2
CO2	1	1	3	1	3	2
CO3	1	1	3	1	3	2
CO4	1	1	3	1	3	2
CO5	1	1	3	1	3	2

Score: **3** – High; **2** – Medium; **1** – Low

Department: **Mechanical Engineering**			Programme: **M.Tech.**(Product Design and Manufacturing)						
Semester: **Second**			Course Category Code: **PSE-3/PSE-4**				Semester Exam Type: **TY**		
Course Code	Course Name		Periods / Week			Credit	Maximum Marks		
			L	T	P		CA	SE	TM
MEZ30	**Principles of Maintenance and Safety Engineering**		**3**	**-**	**-**	**3**	**40**	**60**	**100**
Prerequisite	**Nil.**								
Course Outcome	**CO1**	Outline the importance of various types of Maintenance and Energy conservation							
	CO2	Explain the importance of Predictive Maintenance and its types							
	CO3	Explain the importance of different types of Maintenance management							
	CO4	Discuss the role of Safety and Maintenance in productivity							
	CO5	Describe about different safety standards and codes							

UNIT I	**Periods : 9**
Objectives of maintenance - types of maintenance – Breakdown, preventive and predictive maintenance – Repair cycle - Repair Complexity, Lubrication and Lubricants. Maintenance of Mechanical transmission systems and process plants-Energy conservation and auditing-Case studies.	**CO1**
UNIT II	**Periods :9**
Predictive Maintenance - vibration and noise as maintenance tool - wear debris analysis - Condition monitoring concepts applied to industries - Total Productive Maintenance (TPM) –Evaluation of O.E.E-Economics of Maintenance-Case studies.	**CO2**
UNIT III	**Periods : 9**
Importance of maintenance management-types of maintenance organization- maintenance of stores and spare parts management – ABC analysis – Value analysis – Computer aided maintenance.	**CO3**
UNIT IV	**Periods : 9**
Safety and productivity - causes of accidents in industries – accident reporting and investigation - measuring safety performance - Safety organizations and functions - Factories act and rules- The Code on Occupational Safety, Health and Working Conditions, 2020-ISO 18000 and standards.	**CO4**
UNIT V	**Periods : 9**
Safety Codes and Standards - General Safety considerations in Material Handling equipments - Machine Shop machineries-pressure vessels and pressurized pipelines – welding equipments – operation and inspection of extinguishers – prevention and spread of fire – emergency exit facilities.	**CO5**

Lecture Periods: 45	**Tutorial Periods: -**	**Practical Periods: -**	**Total Periods:45**

Reference Books

1. Gopalakrishnan. P - Maintenance and Spare parts Management, Prentice Hall of India Pvt. Ltd., New Delhi, 1990.
2. Panneerselvam. R- Production and Operations Management, Prentice Hall of India, New Delhi, 2006
3. Garg, H.P. - Industrial Maintenance, S. Chand & Co Ltd., New Delhi, 1990.
4. Alexandrov - Material Handling Equipment, Mir Publications,1981.

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	3	1	2	2
CO2	1	1	3	1	2	2
CO3	1	1	3	1	2	2
CO4	1	1	3	1	2	2
CO5	1	1	3	1	2	2

Score: **3** – High; **2** – Medium; **1** – Low

Department: **Mechanical Engineering**		Programme: **M.Tech.**(Product Design and Manufacturing)						
Semester: **Second**		Course Category Code: **PSE-3/PSE-4**				Semester Exam Type: **TY**		
Course Code	Course Name	Periods / Week			Credit	Maximum Marks		
		L	T	P		CA	SE	TM
MEZ31	**Principles of Tribology**	**3**	**-**	**-**	**3**	**40**	**60**	**100**
Prerequisite	**Nil.**							

Course Outcome	**CO1**	Describe surface topography, physico-chemical aspects of solid surfaces and surface interactions. Analysis of surface roughness- Measurement of surface roughness-Measurement of real area of contact.
	CO2	Recognize the laws of friction, mechanisms of friction, stick slip and surface temperature.
	CO3	Appreciate the various modes of wear: adhesive, delamination, fretting, abrasive, erosive, corrosive, oxidational (mild and severe), melt, and the wear-mechanism maps.
	CO4	Identify types of lubrication: boundary, solid-film, hydrodynamic, and hydrostatic lubrication. Analysis of hydrodynamic and hydrostatic lubrication with problems. Examine applications/case studies: sliding contacts, rolling contacts, bearing design, bearing selection, lubrication and mountings.
	CO5	Understand and identify the different types of coatings for industrial engineering components. To know about the latest coating techniques.

UNIT I	**Periods : 9**	
Introduction to tribology-Factors influencing Tribological phenomena-Engineering surfaces Surface characterization, Computation of surface parameters. Surface measurement techniques Apparent and real area of contact. Introduction to nano tribology.		**CO1**
UNIT II	**Periods : 9**	
Genesis of friction-Various laws and theory of friction-friction in contacting rough surfaces sliding and Rolling friction-frictional heating and temperature rise.		**CO2**
UNIT III	**Periods : 9**	
Wear and wear types-Mechanisms of wear - Adhesive, abrasive, corrosive, erosion, fatigue, fretting, etc., -Wear of metals and non-metals- Wear models – wear maps-wear damage.		**CO3**
UNIT IV	**Periods : 9**	
Introduction to lubrication-Lubrication regimes-Thick Film, Mixed, Boundary – Hydrodynamic Journal and Thrust Bearings- General Reynolds equation- Various mechanisms of pressure development in oil film-Performance parameters. Design of hydrodynamically lubricated bearings using Raimondi-Boyd charts. Composition and properties of lubricant, Evaluation and testing of lubricants.		**CO4**
UNIT V	**Periods : 9**	
Surface modification techniques-Improving wear resistance-Surface coating techniques such as electrochemical depositions, anodizing, thermal spraying, Chemical Vapour Deposition (CVD),Physical Vapour Deposition (PVD), etc. and their applications.		**CO5**

Lecture Periods: 45	**Tutorial Periods: -**	**Practical Periods: -**	**Total Periods: 45**

Reference Books

1. Majumdar, B.C. - Introduction to Tribology of Bearings," Allied Publishers, 1992.
2. Athre, K Biswas,S - Bearings selection and Maintenance", Galcotia Publishers, 2004.
3. Halling, J., -Principles of Lubrication, Macmillan Press Ltd., 1975.
4. Hamrock B.J, Schmid S.R., Jacobson B.O- Fundamentals of fluid film lubrication, 2 Ed., Marcel Dekkar, 2004.

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	3	1	2	1
CO2	2	1	3	1	2	1
CO3	2	1	3	1	2	1
CO4	2	1	3	1	2	1
CO5	2	1	3	1	2	1

Score: **3** – High; **2** – Medium; **1** – Low

Department: **Mechanical Engineering**		Programme: **M.Tech.**(Product Design and Manufacturing)						
Semester: **Second**		Course Category Code: **PSE-3/PSE-4**				Semester Exam Type: **TY**		
Course Code	Course Name	Periods / Week			Credit	Maximum Marks		
		L	T	P		CA	SE	TM
MEZ32	**Logistics and Supply Chain Management**	**3**	**-**	**-**	**3**	**40**	**60**	**100**
Prerequisite	**Nil.**							

Course Outcome	**CO1**	shall be able to understand the strategic role of logistics to have sustainable competitive advantage in the market place
	CO2	shall be able to estimate logistics cost and customer profitability and to set benchmarking priorities
	CO3	shall be able to understand the concept of lead time and implement quick response logistics
	CO4	shall be appreciate the role of information technology & systems in integrating the partners in the supply chain
	CO5	shall be able to establish a trusting relationship with the partners and resolve conflicts, if any

UNIT I	**Periods : 9**	
Logistics and Competitive Strategy: Competitive advantage – gaining competitive advantage through logistics – mission of logistics management – supply chain and competitive performance – changing logistics environment. Customer Service Dimension: marketing and logistics interface – customer service and customer retention – service driven logistics systems – setting customer service priorities – setting service standards.		**CO1**
UNIT II	**Periods : 9**	
Measuring Logistics Cost and Performance: concept of total cost analysis – principles of logistics costing – logistics and the bottom line – logistics and shareholder value – customer profitability analysis – direct product profitability – cost drivers and activity-based costing. Benchmarking the Supply Chain: benchmarking the logistics process – mapping supply chain processes – supplier and distribution benchmarking – setting benchmarking priorities – identifying logistics performance indicators. Managing the global pipeline: trend towards globalization in the supply chain – challenge of global logistics - organizing for global logistics.		**CO2**
UNIT III	**Periods : 9**	
Strategic Lead-Time Management: time based competition – concept of lead-time – logistics pipeline management – logistics value engineering – lead-time gap. Just-in-time and Quick Response Logistics – Japanese philosophy – implications for logistics –quick response logistics – vendor managed inventory – logistics information systems – logistics systems dynamics – production strategies for quick response.		**CO3**
UNIT IV	**Periods : 9**	
Managing the Supply Chain: creating logistics vision – problems with conventional organizations – developing logistics organizations - logistics as a vehicle for change – need for integration – managing supply chain as a network – process integration and ECR – co-makership and logistics partnerships – supplier development. Role of Information Systems and Technology in SCM : importance of information in an integrated SCM environment – inter organisational information systems (IOIS) – information requirements determination for a supply chain IOIS – information and technology applications of SCM.		**CO4**
UNIT V	**Periods : 9**	
Developing and Maintaining Supply Chain Relationships: conceptual model of alliance development – developing a trusting relationship with partners in supply chain – resolving conflicts in supply chain relationship. Cases in SCM. - Future Challenges in SCM: greening of supply chain – design for SCM – intelligent information systems.		**CO5**

Lecture Periods: 45	**Tutorial Periods: -**	**Practical Periods: -**	**Total Periods: 45**

Reference Books

1. Martin Christopher - Logistics and Supply Chain Management, Pitman Publishing, IV Edition, 2011.
2. Robert B Handfield and Ernest L Nicholas Jr - Introduction to Supply Chain Management, Pearson Education, 2017
3. Ayers, J B - Handbook of Supply Chain Management, Taylor & Francis, 2006
4. Scharj, P B and Lansen, TS - Managing the Global Supply Chain, Viva Books, New Delhi, 2000.

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	3	2	2	1
CO2	2	1	3	2	2	1
CO3	2	1	3	2	2	1
CO4	2	1	3	2	2	1
CO5	2	1	3	2	2	1

Score: **3** – High; **2** – Medium; **1** – Low

Department: **Mechanical Engineering**		Programme: **M.Tech.**(Product Design and Manufacturing)						
Semester: **Second**		Course Category Code: **PSE-3/PSE-4**				Semester Exam Type: **TY**		
Course Code	Course Name	Periods / Week			Credit	Maximum Marks		
		L	T	P		CA	SE	TM
MEZ33	**Computer Aided Inspection And Quality Control**	**3**	**-**	**-**	**3**	**40**	**60**	**100**
Prerequisite	**Nil.**							

Course Outcome	**CO1**	Knowledge on Quality Management system and its mandatory requirements, standards and procedures. Quality control by inspection methods
	CO2	In depth view of sophisticated inspection methods and its relevant benefits by reducing rejection rate of the produce.
	CO3	Advanced Measuring methods to calibrate dimensions and deviation as per specifications
	CO4	Usage of lasers. Interfacing computers in machine tools testing, inspection and assessment of Quality Assurance for the product or service
	CO5	Knowledge on contemporary quality measurement techniques for product improvement and development. Also the advent of computers in quality control estimation.

UNIT I	**Periods : 9**
Quality – definition- Traditional and modern QC – ISO 9000 and ISO 14000 standards- CAQC Software required- Automatic Inspection: Inspection Fundamentals – Sampling versus 100% inspection - Contact Inspection techniques: CMM –Types- construction, operation and programming – software- applications and benefits- Flexible Inspection systems- Inspection probes on machine tools- Automatic shaft inspection.	**CO1**
UNIT II	**Periods : 9**
Machine Vision, Image Processing and its Application in Inspection-optical inspection – Linear Array Devices, Optical Triangulation Techniques - Non-Contact Sensors For Surface Finish Measurements- non contact non optical inspection technologies- Electrical field- radiation techniques- ultrasonic methods.	**CO2**
UNIT III	**Periods : 9**
Optical projection comparator- Bosch and lamp projector – laser viewer for production profile checks- optoelectronic dimensional gauging, operations and applications- co-ordinate measuring robots- process control robot digital height gauge with SPC- air gauging with electronic sensors.	**CO3**
UNIT IV	**Periods : 9**
Laser Interferometer, Speckle Measurements, Laser Scanning Systems- - Testing of Machine Tools Using Laser Interferometer- Robotic gauging and inspection systems- expert knowledge based real time inspection system. Computer Aided Quality Assurance Records- Calibration Control -Automatic Quality Data Acquisition.	**CO4**
UNIT V	**Periods : 9**
Computer Aided Quality Control–Objectives of CAQC- Computers in QC- CAQC Charts for Attributes and Variables – Study of CAQC Software like STAT- Introduction to six sigma - 6σ Methods and Tools - 6σ for manufacturing – 6 σ for product development.	**CO5**

Lecture Periods: 45	**Tutorial Periods: -**	**Practical Periods: -**	**Total Periods: 45**

Reference Books

1. Mikell P.Groover,- Automation, Production Systems and Computer Integrated Manufacturing, Second Edition, Prentice Hall of India,2002.
2. Sadhu Singh - CAD/CAM, Khanna Publishers, 2000.
3. Khanna, O.P. - Engineering Metrology, Khanna Publishers, 1998.

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	3	2	2	1
CO2	2	1	3	2	2	1
CO3	2	1	3	2	2	1
CO4	2	1	3	2	2	1
CO5	2	1	3	2	2	1

Score: **3** – High; **2** – Medium; **1** – Low

Department: **Mechanical Engineering**		Programme: **M.Tech.**(Product Design and Manufacturing)						
Semester: **Second**		Course Category Code: **PSE-3/PSE-4**				Semester Exam Type: **TY**		
Course Code	Course Name	Periods / Week			Credit	Maximum Marks		
		L	T	P		CA	SE	TM
MEZ34	**Rapid Manufacturing Processes**	**3**	**-**	**-**	**3**	**40**	**60**	**100**
Prerequisite	**Nil.**							
Course Outcome	**CO1**	Can explain the concept of Design and its development						
	CO2	Able to describe the basic structure of Product Development Cycle						
	CO3	Will determine the Generative Manufacturing Process for Rapid Prototyping						
	CO4	Can discuss various types of Rapid Prototyping techniques and their importance						
	CO5	Can analyze the scope of Direct 3-Dimensional Techniques in Rapid Prototyping						
UNIT I						**Periods : 9**		
Basic concept of design, Practical Issues in Design, Information in Design, Tools for Design, Recent developments in theories of design.								**CO1**
UNIT II						**Periods : 9**		
Product Development Cycle – Data requirements, Modeling, Data representation, part orientation and support, from CAD / CAM, STL format, Slicing, Post Processing.								**CO2**
UNIT III						**Periods** :**9**		
Engineering Manufacturing, Overview of existing technologies of prototyping and tooling, General features and classification of Generative Manufacturing process (GMP) for Rapid Prototyping.								**CO3**
UNIT IV						**Periods : 9**		
Two-Dimensional Layer – by Layer Techniques- Sterio-lithography (SL), Solid Foil Polymerization (SFP), Selective Laser Sintering (SLS), Selective Powder Building (SPB), Ballistic Particle Manufacturing (PM), Fused Deposition Modelling (FDM), Laminated Object Manufacturing (LOM), Solid Ground curing (SGC).								**CO4**
UNIT V						**Periods : 9**		
Direct three-Dimensional Techniques – Beam Interference Solidification (BIS), Ballistic Particle Manufacturing, Programmable Moulding, Comparison of GMP characteristics, considerations for adopting RP technology.								**CO5**
Lecture Periods: 45	**Tutorial Periods: -**	**Practical Periods: -**				**Total Periods:45**		

Reference Books

1. Radhakrishnan, P. Subramanaya,S and Raju.v - CAD/CAM/CIM, New age international (P) Ltd.,
2. Amitabha Ghosh, - Rapid Prototyping-A Brief Introduction, Affiliated East West Press Pvt.Ltd., 1997.
3. Richard Bizmingham, Graham Cleland, Robert Driver and Dwid Maffin - Understanding Engineering Design, Prentice Hall of India, 1998.

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	3	2	2	2
CO2	2	1	3	2	2	2
CO3	2	1	3	2	2	2
CO4	2	1	3	2	2	2
CO5	2	1	3	2	2	2

Score: **3** – High; **2** – Medium; **1** – Low

Department: **Mechanical Engineering**		Programme: **M.Tech.(**Product Design and Manufacturing**)**						
Semester: **Second**		Course Category Code: **PSE-3/PSE-4**				Semester Exam Type: **TY**		
Course Code	Course Name	Periods / Week			Credit	Maximum Marks		
		L	T	P		CA	SE	TM
MEZ35	**Industrial Design**	**3**	**-**	**-**	**3**	**40**	**60**	**100**
Prerequisite	**Nil.**							

Course Outcome	**CO1**	Can get knowledge about manual, mechanical and automated systems.
	CO2	Understand the importance of ergonomics and can apply in the design of new products.
	CO3	Can carry out environmental friendly design.
	CO4	Can gain knowledge on the effect of biomechanics, bio thermodynamics, bioenergetics on the design and development of new products
	CO5	Can do information processing and can understand the effects of other human factors.

UNIT I	**Periods : 9**
Introduction- Definition – Human & Machine system – Manual; Mechanical; Automated system, Input of Information - Auditory, Visual, Oral, Olfactory display & Communication. Human Output and Control – Physical work, Manual material handling, Physiological performance: Motor Skill, human control of systems, controls & data entry devices, hand tools & devices.	**CO1**
UNIT II	**Periods : 9**
Work place and equipment design- Applied anthropometry, Workspace design and seating, arrangement of components within a physical space, interpersonal aspects of work place design, and design of repetitive task, design of manual handling activity task, work capacity, stress, and fatigue. Design of Equipment: Ergonomic factors to be considered in the design of displays and control, design for maintainability, design of human computer interaction.	**CO2**
UNIT III	**Periods : 9**
Environmental design: Vision and illumination design – Climate, Noise, Motion, Sound, and Vibration.	**CO3**
UNIT IV	**Periods : 9**
Biomechanics, bio thermodynamics, bioenergetics: Biostatic mechanics, statics of rigid bodies, upper extremity of hand, lower extremity and foot, bending, lifting and carrying, biodynamic mechanics, human body kinematics, kinetics, impact and collision, human activity analysis, ergonomic tools, RULA, REBA, NOISH lifting equation – Bio thermal fundamentals, human operator heat transfer, human system bioenergetics, thermoregulatory physiology, human operator thermo regularity, passive operator, active operator, heat stress.	**CO4**
UNIT V	**Periods : 9**
Cognitive ergonomics & human factor application: Information Theory Information processing, Signal detection theory, Human response, human errors, cognitive task analysis. Human factors applications: Human error, accidents, human factors and the automobile, organizational and social aspects, steps according to ISO.DIS6385, OSHA's approach, virtual environments	**CO5**

Lecture Periods: 45	**Tutorial Periods: -**	**Practical Periods: -**	**Total Periods: 45**

Reference Books

1. Bridger R S, “Introduction to Ergonomics”, Taylor and Francis, London, 2003.
2. Chandler Allen Phillips, “Human Factors Engineering”, John Wiley and sons, New York, 2000
3. Mark S Sanders, “Human Factors in Engineering and Design”, McGraw Hill, New York, 1993.
4. Martin Helander, A guide to Human Factors and Ergonomics, 2nd Edition, CRC, Taylor & Francis Group 2006.
5. MeCormik, J., Human Factors Engineering and Design, McGraw Hill, 1992

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	3	2	3	3
CO2	2	2	3	2	3	3
CO3	2	2	3	2	3	3
CO4	2	2	3	2	3	3
CO5	2	2	3	2	3	3

Score: **3** – High; **2** – Medium; **1** – Low

Department:**Mechanical Engineering**		Programme: **M.Tech.(** Product Design and Manufacturing**)**						
Semester: **Second**		Course Category Code: **PSE-3/PSE-4**				Semester Exam Type: **TY**		
Course Code	Course Name	Periods / Week			Credit	Maximum Marks		
		L	T	P		CA	SE	TM
MEZ36	**Nanotechnology**	**3**	**-**	**-**	**3**	**40**	**60**	**100**
Prerequisite	**Nil.**							

Course Outcome	**CO1**	Understand the fundamentals and overview of nanoscience and nanorevolution
	CO2	Know the properties of nanomaterials, carbon naotubes, kinetics
	CO3	Able to outline the various techniques used in the synthesis of nanomaterials
	CO4	Appreciate the various characterization techniques and their applications in nanotechnology.
	CO5	Understand the opportunities, challenges and applications of nanotechnology in various industrial and health care areas.

UNIT I	**Periods** :**9**	
Elements of Nanoscience and Nanotechnology – Fundamentals and overview of nanoscience – Nanorevolution of the 20th century – Properties at nanoscale: Optical, Electronic and Magnetic		**CO1**
UNIT II	**Periods** :**9**	
Properties of Nanomaterials – Quantum Dots, Wells, Wires, Bucky balls and Carbon nanotubes, Nanostructures – Kinetics in nanostructured materials – Zero dimensional, One dimensional and Two dimensional nanostructures		**CO2**
UNIT III	**Periods** :**9**	
Synthesis of Nanomaterials – Sol-gel processing – Mechanical alloying and Mechanical milling -Inert gas condensation technique – Nanolithography - CVD – Wet deposition technique- Self-assembly approach		**CO3**
UNIT IV	**Periods** :**9**	
Characterization – Scanning Electron Microscopy (SEM) – EDAX analysis - Scanning Probe Microscopy (SPM) – X-Ray Diffraction (XRD) - Transmission Electron Microscopy (TEM) – Nanoindentation - Atomic Force Microscopy (AFM) - STM and their applications in nanotechnology.		**CO4**
UNIT V	**Periods** :**9**	
Applications of Nanotechnology – Nanodevices and Nanosensors – Nanofabrication and Nanomachining – Nanocoatings – Nanotechnology in Energy systems-Health care-Solar PV cells-Fuel cells- Automotive.		**CO5**

Lecture Periods: 45	**Tutorial Periods: -**	**Practical Periods: -**	**Total Periods: 45**

Reference Books

1. A Textbook of Nanoscience and Nanotechnology, by T. Pradeep, Tata McGraw-Hill Education India, August 2012

2.Nanoscience and Nanotechnology: Fundamentals of Frontiers, by Shubra Singh and M.S. Ramachandra Rao, Wiley, 2013

3**.** Comprehensive Nanoscience and Nanotechnology, by David L. Andrews, Robert H. Lipson and Thomas, Elsevier, January 2019

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	1	2	2
CO2	3	1	3	1	2	2
CO3	3	1	3	1	2	2
CO4	3	1	3	1	2	2
CO5	3	1	3	1	2	2

Score: **3** – High; **2** – Medium; **1** – Low

Department: **Mechanical Engineering**			Programme: **M.Tech.(** Product Design and Manufacturing**)**						
Semester: **Third**			Course Category Code: **PSE - 5**				Semester Exam Type: **TY**		
Course Code	Course Name		Periods / Week			Credit	Maximum Marks		
			L	T	P		CA	SE	TM
MEZ37	**Industry 4.0 (I4.0)**		**3**	**-**	**-**	**3**	**40**	**60**	**100**
Prerequisite	**Nil.**								
Course Outcome	**CO1**	Understand the drivers, enablers and compelling forces of Industry 4.0							
	CO2	Appreciate the smartness in smart factories, smart cities, smart products and smart services							
	CO3	Able to outline the various systems used in a manufacturing plant and their role in an Industry 4.0 world							
	CO4	Appreciate the power of Cloud Computing in a networked economy							
	CO5	Understand the opportunities, challenges brought about by Industry 4.0 and how organisations and individuals should prepare to reap the benefits							

UNIT I	**Periods** :**9**	
Introduction to Industry 4.0: The Various Industrial Revolutions, Digitalisation and the Networked Economy, Drivers, Enablers, Compelling Forces and Challenges for Industry 4.0, The Journey so far: Developments in USA, Europe, India and other countries, Comparison of Industry 4.0 Factory and Today's Factory, Trends of Industrial Big Data and Predictive Analytics for Smart Business Transformation		**CO1**
UNIT II	**Periods** :**9**	
Road to Industry 4.0: Internet of Things (IoT), Industrial Internet of Things (IIoT) and Internet of Services, Smart Manufacturing, Smart Devices and Products, Smart Logistics and Smart Cities		**CO2**
UNIT III	**Periods** :**9**	
Related Disciplines: System, Technologies for enabling Industry 4.0, Cyberphysical Systems, Robotic Automation and Collaborative Robots, Support System for Industry 4.0, Mobile Computing, Cyber Security		**CO3**
UNIT IV	**Periods** :**9**	
Role of data, information, knowledge and collaboration in future organizations: Resource-based view of a firm, Data as a new resource for organizations, Harnessing and sharing knowledge in organizations, Cloud Computing Basics, Cloud Computing and Industry 4.0		**CO4**
UNIT V	**Periods** :**9**	
Applications and Case Studies: Applications of I4.0 in automotive, oil, chemical and pharmaceutical industry - Case studies in India Business issues in Industry 4.0: Opportunities and Challenges, Future of Works and Skills for Workers in the Industry 4.0 Era, Strategies for competing in an Industry 4.0 world		**CO5**

Lecture Periods: 45	**Tutorial Periods: -**	**Practical Periods: -**	**Total Periods: 45**

Reference Books

1. Industry 4.0: The Industrial Internet of Things, by Alasdair Gilchrist, Apress, June 2016
2. Industrial Internet of Things: Cyber manufacturing Systems by Sabina Jeschke, Christian Brecher, Houbing Song, Danda B. Rawat , Springer, October 2016
3. Industry 4.0: Managing The Digital Transformation, Ustundag, Alp, Cevikcan, Emre, Springer, 2018.

CO – PO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	2	3	2	2	2
CO2	2	2	3	2	2	2
CO3	2	2	3	2	2	2
CO4	2	2	3	2	2	2
CO5	2	2	3	2	2	2

Score: **3** – High; **2** – Medium; **1** – Low

Department: **Mechanical Engineering**			Programme: **M.Tech**.(Product Design and Manufacturing)						
Semester: **Third**			Course Category Code: **PSE - 5**				Semester Exam Type: **TY**		
Course Code	Course Name		Periods / Week			Credit	Maximum Marks		
			L	T	P		CA	SE	TM
MEZ38	**World Class Manufacturing**		**3**	**-**	**-**	**3**	**40**	**60**	**100**
Prerequisite	**Nil.**								
Course Outcome	**CO1**	Can understand the intricacies of contemporary World Class Manufacturing strategies, practices adopted in domestic and international arena							
	CO2	Gain ability to develop strategies to identify the value stream of product leading to less waste and higher customer value							
	CO3	Can emphasize the need for a comprehensive maintenance schedules for machines and systems , TPM, safety management, policies and implementation							
	CO4	Can understand the concept of TQM for continuous improvement leading to seamless product flow starting from procurement, production and delivery							
	CO5	Can acquire knowledge on World Class Manufacturing in terms of maintaining non depleting inventory to achieve business excellence							

UNIT I	**Periods : 9**
Introduction to World-Class Manufacturing (WCM): Manufacturing Excellence and Competitiveness, Meaning of World-class, Competing in World markets, WCM Techniques, Review of frameworks for WCM, Justification of WCM; An overview of manufacturing strategy: concepts, manufacturing strategy formulation and implementation, Manufacturing strategy – examples from the industry (Indian and international context).	**CO1**
UNIT II	**Periods : 9**
Introduction to Lean Manufacturing - Elements of Lean manufacturing : Stability, Standardized work, Just in time, Jidoka, Hoshin Planning, The culture of lean, Implementation of Lean manufacturing : Implementation framework for the Lean manufacturing, Case Studies.	**CO2**
UNIT III	**Periods : 9**
Total Productive Maintenance (TPM)- An overview of various maintenance systems, Evolution of TPM, Productivity and TPM, OEE, TPM and TQC, Small Group Activities, Pillars of TQM, Kobetsu-Kaizen (Continuous Improvement), Jishu-Hozen (Autonomous maintenance), Planned Maintenance System, Skill upgrade training, Initial control (Equipment Life cycle management), Hinshitsu-Hozen (Quality Maintenance), Office TPM, Total safety management, Implementation, 5s, Case Studies.	**CO3**
UNIT IV	**Periods : 9**
Total Quality Management (TQM) - Definition, Understanding quality, Evolution of TQM, Framework for TQM, Commitment and leadership, Customer satisfaction, Employee involvement, Continuous process improvement, Supplier partnership, Performance measures, Formulation and implementation of TQM, Case Studies.	**CO4**
UNIT V	**Periods : 9**
Salient features of WCM - Supply Chain Management & key issues in SCM, Role of Information system in WCM, Knowledge management - Introduction, Benefits, Tools and techniques, Study of various performance measures in world class organization, Human Resource Dimensions in WCM.	**CO5**

Lecture Periods: 45	**Tutorial Periods: -**	**Practical Periods: -**	**Total Periods: 45**

Reference Books

1. Jim Todd, “World-class Manufacturing”, McGraw Hill, London, 1995.
2. Schonberger R.J., “World Class Manufacturing - The Lesson of Simplicity”, Free Press, 1986.
3. Marcus, A A., Management strategy: achieving sustained competitive advantage, New York : McGraw-Hill/Irwin, 2011
4. Voss C.A., "Manufacturing Strategy: Process and Content", Chapman & Hall, London, 1992.
5. Pascal, D., “Lean production simplified”, 2nd Edition, Productivity Press, 2007.
6. Nakajima, S., “Introduction to Total Productive Maintenance”, Productivity Press, 1988.
7. Besterfield D. H., et al., "Total Quality Management", Pearson Education, 1999.
8. Mohanty R.P. and Deshmukh S.G., “Advanced Operations Management”, Pearson Education, 2003

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	3	2	2	2
CO2	2	2	3	2	2	2
CO3	2	2	3	2	2	2
CO4	2	2	3	2	2	2
CO5	2	2	3	2	2	2

Score: **3** – High; **2** – Medium; **1** – Low

Department: **Mechanical Engineering**		Programme: **M.Tech**.(Product Design and Manufacturing)						
Semester: **Third**		Course Category Code: **PSE-5**				Semester Exam Type: **TY**		
Course Code	Course Name	Periods / Week			Credit	Maximum Marks		
		L	T	P		CA	SE	TM
MEZ39	**Green Design and Manufacturing for Sustainability**	**3**	**-**	**-**	**3**	**40**	**60**	**100**
Prerequisite	**Nil**							
Course Outcome	**CO1**	Understand the importance, causes and issues of sustainable development.						
	CO2	Can establish the relationship Industrial Ecology between Sustainability						
	CO3	Can apply different design guidelines in Engineering Design.						
	CO4	Can give Green Design solution for important mechanical Components						
	CO5	Can give suggestion for Environmentally Benign Manufacturing						

UNIT I	**Periods : 9**	
Introduction to Sustainability, Principles, and Its Effect on Design and Manufacturing, definition, Fundamentals- Changing our Definitions of Growth and Progress-Resource Consumption and Environmental Pollution, Principles of Sustainable Design - Economy of Resources, Life Cycle Design, Humane Design		**CO1**
UNIT II	**Periods : 9**	
Industrial Ecology and Sustainability, Economics of Sustainable Engineering, Analytical Techniques for Sustainability Analysis. Green Design and EOL Treatment- Principles of Green Design, End-of-Life Treatment and Environmental Impact Scenario.		**CO2**
UNIT III	**Periods : 9**	
Sustainability and its applications in Engineering Design, Sustainability: Past and Present, The Taguchi Analogy Applied to Sustainable Engineering Design, Ecosourcing, Design for Sustainable Manufacture, Design for Sustainable Use, Design for Sustainable Maintenance, Design for Sustainable Disposal, Measurement of Sustainability, Sustainability Compromise		**CO3**
UNIT IV	**Periods : 9**	
Green Design of mechanical components- Spring Design for Sustainability-Environmentally Conscious Design of Gears, Shaft Design, Bearings and Green Engineering, Fastener Design Design for Environment , Snap-Fit Design, Finite Element Analysis (FEA) and Computer-Aided Design (CAD), Computer-Aided Design Examples		**CO4**
UNIT V	**Periods : 9**	
Environmentally Benign Manufacturing, Introduction-Turning Operation- Drilling Operations- Milling-Grinding, Cutting Tools and Sustainability Considerations, Foundry Processes, Metal-Forming Processes.International Regulations for Green Design and Manufacturing		**CO5**

Lecture Periods: 45	**Tutorial Periods: -**	**Practical Periods: -**	**Total Periods: 45**

Reference Books

1. Nand K. Jha, "**Green Design and Manufacturing for Sustainability**", ISBN 9781466505261, CRC Press, 2015
2. Anthony Johnson and Andy Gibson, "Sustainability in Engineering Design" , ISBN: 9780080993690, Academic Press,2014.
3. Fabio Giudice, Guido La Rosa, Antonino Risitano, "Product Design for the Environment", ISBN 9780367111977, CRC Press, 2006.

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	2	2	2
CO2	3	1	3	2	2	2
CO3	3	1	3	2	2	2
CO4	3	1	3	2	2	2
CO5	3	1	3	2	2	2

Score: **3** – High; **2** – Medium; **1** – Low

Department: **Mechanical Engineering**		Programme: **M.Tech**.(Product Design and Manufacturing)						
Semester: **Third**		Course Category Code: **PSE-5**				Semester Exam Type: **TY**		
Course Code	Course Name	Periods / Week			Credit	Maximum Marks		
		L	T	P		CA	SE	TM
MEZ40	**Advances in Electric and Autonomous Vehicle**	**3**	**-**	**-**	**3**	**40**	**60**	**100**
Prerequisite	**Nil.**							

Course Outcome	**CO1**	Knowing Battery Vehicle benefits, such as Reduce traffic congestion, collisional incidents and the cost and time of Transport
	CO2	Understanding of Electric Vehicle and HEV Technology
	CO3	Fuel supply storage Fuel cell Electric Vehicle vis a vis chemical battery operated Electric Vehicle
	CO4	Improve transportation safety, Integration and Synergy of Simulation using Scientific Computing with Artificial Intelligence for Mathematical modeling, simulations, and control of Autonomous Transport
	CO5	Data driven prediction using machine learning for Autonomous Transport of EVs, HEV and FCVs and Role of computational modeling as indispensable tool for skill set development

UNIT I	**Periods : 9**
Review of EV, Hybrid and Fuel Cell Vehicle Technologies, Vehicle Propulsion, Technology of Fuel Supply and Battery Energy Storage	**CO1**
UNIT II	**Periods : 9**
Electric Vehicle – Configuration, Performance, Tractive Effort, Energy Consumption, Electric Propulsion, HEVs – Plugin, Mild hybrid, Regenerative braking	**CO2**
UNIT III	**Periods : 9**
Fuel Cells – Principle of operation, Types characteristics, Fuel Cell Vehicle – design methodology, parametric design, power design	**CO3**
UNIT IV	**Periods : 9**
Autonomous ground vehicles - Components, Control Systems and Operation of AVs, Sensors, Automated Driving Levels - Autonomy types, Path planning, Communications, connected Autonomous Electric Vehicles	**CO4**
UNIT V	**Periods : 9**
Introduction to Machine Learning – Types, Preprocessing, Features, Evaluation, Machine Learning Framework for Autonomous Transport, machine learning algorithms, Machine Learning Interface to Self Driven Transport, Edge and High Performance Computing for Autonomous Transport	**CO5**

Lecture Periods: 45	**Tutorial Periods:-**	**Practical Periods: -**	**Total Periods: 45**

Reference Books

1.Mehradad Ehsani, Yimin Gao, Stefano Longo and Ali Emadi (2018), Modern Electric, Hybrid Electric, and Fuel Cell Vehicles – Fundamentals, Theory and Design, CRC Press, New York.

2.Umit Ozguner, Tankut Acarman and Keith Redmill, (2011), Autonomous Ground Vehicles, Artech House, Boston.

3. Andreas C. Muller and Sarah Guido (2016), Introduction to Machine Learning with Python A Guide for Data Scientists, O'Reilly Media, Inc., Boston.

4. Wei Liu (2017), Hybrid Electric Vehicle System Modeling and Control, Wiley, New Jersey.

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	2	3	2
CO2	3	2	2	3	3	2
CO3	3	2	2	2	3	2
CO4	3	3	3	2	3	2
CO5	3	2	2	2	3	2

Score: **3** – High; **2** – Medium; **1** – Low