Mahatma Education Society's

Pillai College of Engineering

(Autonomous)

Affiliated to University of Mumbai

Dr. K. M. Vasudevan Pillai's Campus , Sector 16, New Panvel – 410 206.

Department of Mechanical Engineering

Syllabus
of

M.Tech. in Mechanical Engineering

for
The Admission Batch of AY 2022-23

First Year - Effective from Academic Year **2022-23**

Second Year - Effective from Academic Year **2023-24**

as per

Choice Based Credit and Grading System

Mahatma Education Society's

Pillai College of Engineering

Vision

Pillai College of Engineering (PCE) will admit, educate and train a diverse population of students who are academically prepared to benefit from the Institute's infrastructure and faculty experience, to become responsible professionals or entrepreneurs in a technical arena. It will further attract, develop and retain, dedicated, excellent teachers, scholars and professionals from diverse backgrounds whose work gives them knowledge beyond the classroom and who are committed to making a significant difference in the lives of their students and the community.

Mission

To develop professional engineers with respect for the environment and make them responsible citizens in technological development both from an Indian and global perspective. This objective is fulfilled through quality education, practical training and interaction with industries and social organizations.

Dr. K. M. Vasudevan Pillai's Campus , Sector - 16, New Panvel – 410 206

Department of Mechanical Engineering

Vision

To develop a world class programme with excellence in teaching, learning and research that would lead to growth, innovation and recognition.

Mission

The mission of the Mechanical Engineering Program is to benefit the society at large by providing technical education to interested and capable students. These technocrats should be able to apply basic and contemporary science, engineering and research skills to identify problems in the industry and academia and be able to develop practical solutions to them.

Program Structure for
Master of Technology in (Mechanical) CAD/CAM & Robotics Engineering

Semester I

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract	Theory	Practical	Total
ME500T	Computer Programming Paradigms	03	--	03	--	03
ME501T	Business Communication and Intellectual Property	03	--	03	--	03
ME50xT	Department Level Optional Course-I	03	--	03	--	03
ME50xT	Department Level Optional Course-II	03	--	03	--	03
ME50xT	Department Level Optional Course-III	03	--	03	--	03
ME515L	Robotics and Mechatronics Lab	--	02	--	01	01
ME516L	Dissertation-I	--	02	--	01	01
TOTAL		**15**	**04**	**15**	**02**	**17**

Course Code	Course Name	Examination Scheme							
		Theory							
		Internal Assessment			End Sem Exam	Exam Duration (Hrs)	Term Work	Oral/ Practs	Total
		IA 1	IA 2	Avg					
ME500T	Computer Programming Paradigms	40	40	40	60	3	-	-	100
ME501T	Business Communication and Intellectual Property	40	40	40	60	3	-	-	100
ME50xT	Department Level Optional Course-I	40	40	40	60	3	-	-	100
ME50xT	Department Level Optional Course-II	40	40	40	60	3	-	-	100
ME50xT	Department Level Optional Course-III	40	40	40	60	3	-	-	100
ME515L	Robotics and Mechatronics Lab	--	--	--	--	--	25	25	50
ME516L	Dissertation-I	--	--	--	--	--	25	25	50
TOTAL		**200**	**200**	**200**	**300**	**15**	**50**	**50**	**600**

Department Level Optional Course:

Course Code	Course Name
DLOC-I	
ME502T	Computer Aided Synthesis of Mechanisms
ME503T	Advanced Finite Element Analysis
ME504T	Artificial Intelligence and Neural Network
DLOC-II	
ME505T	Smart Materials
ME506T	Fatigue and Fracture Analysis
ME507T	Advanced Composites and Polymeric Materials
DLOC-III	
ME508T	Microprocessor and Controllers
ME509T	Mechatronics
ME510T	Control Engineering

Program Structure for
Master of Technology in (Mechanical) CAD/CAM & Robotics Engineering

Semester II

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract	Theory	Pract	Total
ME517T	Computer Aided Manufacturing	03	--	03	--	03
ME518T	Robotics	03	--	03	--	03
ME5xxT	Department Level Optional Course-IV	03	--	03	--	03
ME5xxT	Department Level Optional Course-V	03	--	03	--	03
ME5xxT	Department Level Optional Course-VI	03	--	03	--	03
ME532L	Modelling and Simulation Lab	--	02	--	01	01
ME533L	Dissertation-II	--	02	--	01	01
TOTAL		**15**	**04**	**15**	**02**	**17**

Course Code	Course Name	Examination Scheme							
		Theory							
		Internal Assessment			End Sem Exam	Exam Duration (Hrs)	Term Work	Pract/ Oral	Total
		IA 1	IA 2	Avg					
ME517T	Computer Aided Manufacturing	40	40	40	60	3	--	--	100
ME518T	Robotics	40	40	40	60	3	--	--	100
ME5xxT	Department Level Optional Course-IV	40	40	40	60	3	--	--	100
ME5xxT	Department Level Optional Course-V	40	40	40	60	3	--	--	100
ME5xxT	Department Level Optional Course-VI	40	40	40	60	3	--	--	100
ME532L	Modelling and Simulation Lab	--	--	--	--	--	25	25	50
ME533L	Dissertation-II	--	--	--	--	--	25	25	50
TOTAL		**200**	**200**	**200**	**300**	**15**	**50**	**50**	**600**

Department Level Optional Course:

Course Code	Course Name
DLOC-IV	
ME519T	Additive Manufacturing
ME520T	Mirco Electro Mechanical Systems
ME521T	Manufacturing Analytics
DLOC-V	
ME522T	Product Design & Development
ME523T	Quality Engineering
ME524T	Optimization Techniques
DLOC-VI	
ME525T	Data Science & Expert System
ME526T	Computer Aided Design
ME527T	Reliability Engineering

Program Structure for
Master of Technology in (Mechanical) CAD/CAM & Robotics Engineering

Semester III

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract	Theory	Pract	Total
ME600LC	Internship / Relevant Certification	-	-	-	03	03
ME601LC	Dissertation-III	-	-	-	12	12
TOTAL		-	-	-	15	**15**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract/ Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (Hrs)			
		IA 1	IA 2	Avg					
ME600LC	Internship / Relevant Certification	-	-	-	-	-	50	50	100
ME601LC	Dissertation-III	-	-	-	-	-	100	-	100
TOTAL		-	-	-	-	-	150	50	200

Program Structure for
Master of Technology in (Mechanical) CAD/CAM & Robotics Engineering

Semester IV

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract	Theory	Pract	Total
ME603LC	Dissertation-IV	-	30	-	15	15
		-	30	-	15	**15**

Course Code	Course Name	Examination Scheme							
		Theory							
		Internal Assessment			End Sem Exam	Exam Duration (Hrs)	Term Work	Pract/ Oral	Total
		Test 1	Test 2	Avg					
ME603LC	Dissertation-IV	-	-	-	-	-	100	100	200
TOTAL		-	-	-	-	-	100	100	200

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ME500T	Computer Programming Paradigms	Contact Hours	3	-	-	3
		Credits	3	-	-	3

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal Assessment			End Sem Exam				
		IA 1	IA 2	Average					
ME500T	Computer Programming Paradigms	40	40	40	60	-	-	-	100

Course Objectives:

1. To Introduce students to functional, logic and concurrent programming paradigms.
2. To Enable students to formulate newer abstractions in the above paradigms.
3. To Familiarize students with writing functional and Object oriented programs.
4. To Prepare students to solve real-world problems using appropriate programming paradigms

Course Outcomes:

On successful completion of course learner/student will be able to:

1. Understand and apply the concepts that form the basis of functional, logic and object oriented programming paradigms.
2. Formulate abstractions with procedures and data in different programming paradigms.
3. Write programs in different programming paradigms especially functional, logic and object oriented paradigms.
4. Formulate, implement and solve a given problem scenario using appropriate programming paradigm

Detailed Theory Syllabus:

Sr. No.	Module	Detailed Content	Hours
1	**Introduction**	**Overview of different programming paradigms –** Imperative,logical, functional and object-oriented Programming.	2
2	**Java Programming**	**Introduction:** Principles of OOP, Classes, Objects, Abstraction, Encapsulation, Inheritance, Polymorphism, Message passing Features of Java Language , Data Types, Operators. **Control Statements:** If-Statement, If-else, Nested-if, Switch Statement, break, continue. **Iteration Statements:** for-loop, while-loop, and do-while-loop.	8
3	**Python Programming**	**Introduction:** Features, Identifiers, Keywords, Indention, Variables and Comments, Basic data types: Numeric, Boolean, Compound. **Operators:** Arithmetic, comparison, relational, assignment, logical, bitwise, membership, identity operators, operator	8

		precedence. **Control flow statements:** Conditional statements (if, if…else, nested if. Looping in Python: while-loop, for-loop, nested-loops, Loop manipulation using continue, pass, break. **Functions:** Introduction to Functions, Decorators, Iterators and Generators.	
4	**R Programing**	**Introduction:** Basic functionalities of R , data types and operations: numbers, characters and composites, Numeric variables, strings and factors,R packages. **Data structures:** vectors, matrices, lists and data frames.Grouping, loops and conditional execution, Functions. **Exploratory data analysis:** Range, summary, mean, variance, median, standard deviation, histogram, box plot, scatterplot, Graphics and tables , Visualizations and interpretation of results.	8
5	**Matlab programming**	**Introduction:** Features, Interface, File Types, Array, Matrix Operation. Arithmetic Operator Logical, Relational. **Branch and Loop:** If-statement, If-else statement, Else-if statement Pause, Break, Continue, Switch-case, try-catch, Return Statement, For Loop,While Loop. Types of Function, Return Types. **Interface and Graphics:** Plotting, Multiple Plot, 2-D Plot, Introduction to Graphical User Interface, GUI Function, Property, GUI Component Design.	8
6	**Metaverse Technology**	History, Features, Metaverse value chain, Technologies Involved in the Metaverse. Blockchain Adoption in Metaverse, AR, VR, MR in Metaverse, NFT (non-fungible token) for Metaverse. Financial and Economics of Metaverse, Benefits of Metaverse, Use-cases.	5

Theory Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation: Class Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum

Books and References:

A. Books:

1. Scott M L, Programming Language Pragmatics, 4th Edn., Morgan Kaufmann Publishers, 2015
2. E. Balaguruswamy, “Programming with Java A primer”, Fifth edition, Tata McGraw Hill Publication
3. Dr. R. Nageswara Rao, ”Core Python Programming” , Dreamtech Press, Wiley Publication
4. Metaverse: Introduction to The Virtual Reality, Augmented Reality,ISBN-13 : 978-1806030484
5. Beginning R: The Statistical Programming Language by Dr. Mark Gardener, Wiley Publications
6. Peter I. Kattan, MATLAB for Beginners: A Gentle Approach, 2008. ISBN: 9781438203096

B. References:

1. Programming Languages: Concepts and Constructs; 2nd Edition, Ravi Sethi, Pearson Education Asia, 1996.
2. Herbert Schildt, “Java-The Complete Reference”, Tenth Edition, Oracle Press, Tata McGraw Hill Education.
3. Navigating the Metaverse by Cathy Hackl, Dirk Lueth, Tommaso Di Bartolo, John Arkontaky, Yat Siu Released May 2022 Publisher(s): Wiley ISBN: 9781119898993
4. Hands-On Programming with R by Grolemund, O Reilly Publications
5. Stormy Attaway, "MATLAB: A Practical Introduction to Programming and Problem Solving," 2018, Butterworth-Heinemann, ISBN: 978-0128154793

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ME501T	Business Communication and Intellectual property	Contact Hours	3	-	-	3
		Credits	3	-	-	3

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal Assessment			End Sem Exam				
		IA 1	IA 2	Average					
ME501T	Business Communication and Intellectual Property Rights	40	40	40	60	-	-	-	100

Course Objectives:

1. To provide an outline to effective organisational communication
2. To enable learners to formulate professional documents in a structured manner that meets the corporate requirements.
3. To foster a comprehensive understanding of marketing strategies for establishing the brand of the business using digital technologies and aim at better customer experience
4. To develop creative and impactful presentation skills
5. To acquaint learners with the procedure of obtaining Patents, Copyrights, Trademarks and Industrial designs
6. To inculcate the ethical code of conduct and corporate etiquettes.

Course Outcomes:

1. Apply business communication strategies and principles to prepare effective communication for developing and presenting business messages
2. Acquire the writing skills necessary for professional documents to meet the corporate requirement.
3. Understand existing and emerging social media tools to execute a comprehensive communication plan
4. Able to illustrate effective presentation, research, organisational and creative skills necessary for lifelong learning.
5. Recognize the crucial role of IP in organisations of different industrial sectors for the purposes of product and technology development
6. Able to determine the importance of ethics and etiquettes in social and professional situations

Prerequisite: Basic language skills

DETAILED SYLLABUS:

Sr. No.	Module	Detailed Content	Hours	CO Mapping
I	Business Communication	1.1 Role of communication in business organisation 1.2 Relevance of communication 1.3 Types- Verbal Non-verbal 1.4 Channels- Vertical, Horizontal and Lateral	2	CO1
II	Business Writing	2.1 Business Proposals (SWOT analysis) 2.2 Grant / Research Proposals 2.3 1.2 Memos 2.4 1.3 Press Releases 2.5 1.4 Business Plans	8	CO2
III	Digital Social Media	3.1 Communicating via Social Media 3.2 Social Media and Public Relations, Social Media strategy and Planning 3.3. Content Strategy. Web Content, Organisation and Distribution 3.4 Social Networking Sites (LinkedIn, Twitter), Photo sharing Sites (Instagram, Snapchat, Pinterest 3.5 News Writing and Community Management 3.6. Facebook and business 3.7. You Tube and Livestreaming	6	CO3
IV	Speaking Skills	4.1 Speaking on Panels, Moderating Panels, Speaking as keynote or Individual Talk 4.2 Introducing speakers, Summarising speeches and Meeting conference content 4.3 Presentation Skills- a) Visually present relationship between two or more data sets b) Data Presentation Methods- Line graph, Column chart, Vertical bar, scatter plot c) Presentation style- Audience analysis, Care and concern for the audience, effective use of transitions and animations, slide design and content	7	CO4
V	Intellectual Property for Business	5.1. Meaning, Relevance, Business Impact, Protection of Intellectual Property 5.2. Types of Intellectual Property **Copyrights –** Introduction, Nature of copyright, Indian copyright law, copyright works, Author and ownership of copyright,	8	CO5

		Licensing of copyrights, Infringement of copyrights, Remedies and actions, Copyright for digital media, Software/ Internet **Patents**- Concept of patent, Product/Process Patents, Patent Law, Patentable subject matter, Patentability criteria, Duration of patent, Procedure for filing Patent Application, Types of Applications, Procedure of Opposition, Revocation of Patents, Ownership and Maintenance of Patents, Compulsory licensing, Qualification and registration Procedure **Trademarks**- Introduction, Rationale of protection of trademark as (a) an aspect of commercial and (b) of consumer rights, Kinds of marks (brand names, logos, signatures, symbols, well known marks, certification marks and service marks), Indian Trademarks Law, Procedure for Registration of Trademarks, Non Registrable Trademarks, Infringement of Trademarks and Right of Goodwill, Offences and Penalties **Trade secrets** **Designs**- Need for Protection of Industrial designs, Procedure and Infringement **Geographical Indications** – Concept, Procedure of Registration, duration of protection, Infringement, Penalties and Remedies		
VI	Ethics And Ethical Code of Conduct	6.1 Writing Resume and statement of purpose 6.2 Business and corporate activities(special emphasis on business meetings, emails, blogs and webpages) 6.3 Personal ethics, conflicting values, choosing a moral response, the process of making ethical decisions.	4	CO6

Sr. No.	Details of Assignments	Details of Activities	Hours	CO Mapping
I	Written assignment on summarising a research proposal 4 page grant proposal (to be included as part of term work)	Example of summarising techniques to be demonstrated.	4	CO1, CO2
II	Written assignment on blog posts, web content	NA	4	CO1, CO3, CO4
III	Presentation skills	Mock Presentation	6	CO1, CO4
IV	Written Assignment on Resume writing/Statement of Purpose.	NA	2	CO2, CO6
V	Written Assignment on Intellectual Property	NA	4	CO5

Text Books/References:

1. Raman Meenakshi & Singh Prakash, Business Communication Second edition, Oxford University Press, Paperback, 2012
2. Jeremy Harris Lipschultz, Social Media Communication: Concepts, Practices, Data, Law and Ethics Third edition, Paperback, 2020
3. V. K. Ahuja, Intellectual Property Rights In India, Hardcover, 2015

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ME502T	Computer Aided Synthesis of Mechanisms	Contact Hours	3	-	-	3
		Credits	3	-	-	3

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal Assessment			End Sem Exam				
		IA 1	IA 2	Average					
ME502T	Computer Aided Synthesis of Mechanisms	40	40	40	60	-	-	-	100

Prerequisites:

1. Mechanics
2. Vector theory
3. Linear Algebra
4. Kinematics of Machinery

Course Objectives:

1. Understand the various types of synthesis of mechanisms.
2. Understand graphical and analytical techniques commonly used in the synthesis of mechanisms.
3. Simulate synthesis of mechanisms (analytical techniques) using computer programs.
4. Synthesize 3 accuracy and 4 accuracy points by geometric and algebraic methods.

Course Outcomes: Upon successful completion of this course, learner will be able to:

1. Understand the basics of kinematics and mechanisms.
2. Understand the three general phases of kinematic synthesis.
3. Apply the graphical and analytical techniques commonly used in the synthesis of mechanisms.
4. Formulate and solve problems of analysis and synthesis of mechanisms using modern IT tools.
5. Synthesize mechanisms with 3 and 4 accuracy points using geometric and algebraic methods.

Module	Detail Content	Hrs.
1.	**Type Synthesis, Number Synthesis, Dimensional Synthesis**: Type synthesis, Number synthesis, Dimensional synthesis, Accuracy points, Spacing of accuracy points, Chebyshev polynomials.	6
2.	**Synthesis of Mechanisms**: Introduction, Synthesis, Function, Path and Motion Generation, Limiting Conditions, Graphical and Analytical Synthesis of Four bar and Slider Crank Mechanisms.	7
3.	**Linkage Synthesis with Three Accuracy Points (Geometric Methods):** Concept of poles, relative poles, pole triangle of four bar and slider crank mechanism. Application in position generation, function generation problems.	7
4.	**Linkage Synthesis with Four Accuracy Points (Geometric Methods):** Concept of opposite pole quadrilateral, Center point curve, Circle point curve, Application in position generation problems.	7

5.	**Linkage Synthesis with Three Accuracy Points:** (Algebraic Method). Freudenstein displacement equation of four bar linkage for three accuracy points, Crank-follower linkage synthesis, angular velocities and acceleration. **Linkage Synthesis with Three Accuracy Points:** Complex Number Method.	8
6.	**The Euler Savary Equation and Cubic of Stationary Curvature:** The Euler Savary equation and the Inflection circle, The cubic of stationary curvature.	4

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation: Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum

Text/Reference Books:

1. Theory of Mechanisms & Machines by Amitabha Ghosh, Asok Kumar Mallik, Affiliated East-West Press Pvt Ltd.
2. Mechanism and Machine Theory by J.S.Rao and R.V.Dukkipati, New Age International.
3. Theory of Machines and Mechanisms (India Edition) by John J. Uicker Jr., Gordon R. Pennock and Joseph E. Shigley, Oxford University Press.
4. R.L. Norton, Kinematics and Dynamics of Machinery, First Edition in SI, Tata McGraw Hill Publishing Company Ltd, New Delhi.
5. Kinematics and Dynamics of plane mechanisms, Jeremy Hirschhorn, McGraw-Hill, 1962.
6. Design of machinery, Robert L Norton third edition, McGraw-Hill, 2004.
7. Kinematic Linkage Design, Allen S.Hall Jr., Prentice-Hall of India, 1964.
8. Kinematics and Dynamics of Machinery, Charles E Wilson, Pearson, 3rd Edition.

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ME503T	Advanced Finite Element Analysis	Contact Hours	3	-	-	3
		Credits	3	-	-	3

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal Assessment			End Sem Exam				
		IA 1	IA 2	Average					
ME503T	Advanced Finite Element Analysis	40	40	40	60	-	-	-	100

Course Objectives:

1. To equip with the Finite Element Analysis fundamentals.
2. To apply finite element formulation for the solution of mechanical engineering problems.
3. To solve various real-life problems using FEA.

Course Outcomes: Learner will be able to

1. Discretize the problem domain using appropriate elements.
2. Apply weighted residual methods to solve governing differential equations of the problem domain.
3. Develop finite element equations for various one-dimensional and two-dimensional elements.
4. Apply the finite element formulation to solve one-dimensional and two-dimensional problems in solid mechanics and heat transfer.

Module	Detail Content	Hrs.
1	**Introduction** Basic concept, historical background, general steps, engineering applications, derivation of finite element equations using direct approach, assembly of element equations, solution of problems in one dimensional structural analysis, heat transfer and fluid flow.	05
2	**Basic Procedure** **Discretization of domain** Introduction, basic element types, discretization process, node numbering scheme, element quality checks. **Interpolation models** Introduction, Polynomial form of interpolation functions, simplex, complex and multiplex elements, Pascal's triangle and pyramid, selection of interpolation polynomial, compatibility and completeness requirements, one dimensional simplex element, one dimensional complex element, two-dimensional simplex element, natural coordinates.	05
3	**Higher Order and Isoparametric Elements** Introduction, higher order one-dimensional elements, higher order one-dimensional and two-dimensional elements in terms of natural coordinates, higher order one-dimensional and two-dimensional elements in terms of classical interpolation polynomials, Isoparametric elements, numerical integration.	04

4	**Formulation of Element Characteristics Matrices and Vectors** Introduction, variational approach, solution of problems using variational (Rayleigh-Ritz) method, derivation of finite element equations using variational approach, weighted residual approach, solution of problems using weighted residual methods, derivation of finite element equations using weighted residual approach.	05
5	**Application to Solid Mechanics Problems** Basic equations of solid Mechanics, principle of minimum potential energy, formulation of element equations using variation approach, one - and two-dimensional problem with body forces, initial or thermal strains. **Analysis of Trusses, Beams** Introduction, space truss element, beam element **Dynamic Analysis** Dynamic equations of motion, consistent and lumped mass matrices of bar and truss elements, free vibration analysis, axial vibration of rod and stepped bar.	15
6	**Application to Heat Transfer Problems** Basic equations of heat transfer, governing equation for three dimensional bodies, formulation of element equations for heat transfer problems, one-dimensional heat transfer equations, straight and tapered fin analysis, convection from end surface of fin, two-dimensional heat transfer equations, two-dimensional problem with conduction, edge convection, face convection, heat generation source etc.	05

Assessment Scheme:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation: Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum

Reference Books:

1. J. N. Reddy; An Introduction to Finite Element Method; 3rd Edition, McGraw Hill, 2013.
2. R. D. Cook, Davis S. Malkus, Michael E. Plesha and Robert J. Witt; Concepts and Applications of Finite Element Analysis; 4th Edition, Wiley, 2015.
3. S. S. Rao; The Finite Element Method in Engineering; 5th Edition, Elsevier, Butter Worth Heinemann, 2011.
4. O. C. Zienkewitz and R. L. Taylor; The Finite Element Method, Vol. I and II, 6th Edition, Elsevier, Butter Worth Heinemann, 2005.
5. K.L. Bathe and E.L. Wilson; Finite Element Methods; Prentice Hall, 1976.
6. David V Hutton; Fundamentals of Finite element analysis; 7th Edition Tata McGraw Hill, 2005.
7. T. R. Chandrapatla and A. D. Belegundu; Introduction to Finite Elements in Engineering; 4th Edition, Pearson, 2012.
8. D. L. Logan; A first course in Finite Element Method; 5th Edition, Cengage Learning, 2012.
9. P.Seshu; Text book of Finite Element Analysis; 10th Edition, Prentice Hall of India, 2012.

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ME504T	Artificial Intelligence and Neural Network	Contact Hours	3	-	-	3
		Credits	3	-	-	3

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal Assessment			End Sem Exam				
		IA 1	IA 2	Average					
ME504T	Artificial Intelligence and Neural Network	40	40	40	60	-	-	-	100

Course Objectives:

1. To impart knowledge about Artificial Intelligence.
2. Develop the skills to gain basic understanding of the areas of Artificial Neural Networks
3. To get a basic insight of Artificial Neural Networks.

Course Outcomes: Learner will be able to

1. Understand and solve basic AI based problems.
2. Apply AI techniques to real-world problems to develop intelligent systems.
3. Understand the fundamental theory and concepts of neural networks, Identify different neural network architectures, algorithms, applications and their limitations.
4. Understand appropriate learning rules for each of the architectures and learns several neural network paradigms and its applications

Module	Detail Contents	Hrs.
1	**Introduction to AI:** Define Artificial Intelligence, Define AI techniques, Problem solving using State Space Search, applying Heuristics, Hill climbing ,Search using BFS, DFS	6
2	**Knowledge representation and Logic Programming:** Representing Knowledge as Rules, Representing simple facts in logic, Computable functions and predicates, Procedural vs Declarative knowledge, Forward vs Backward reasoning, Logic Programming-Predicate Logic, First order logic. Inference in first order logic.	8
3	**Introduction to neural network**: Biological neuro-system, neurons and its mathematical models, Neural networks viewed as Directed Graphs, Network Architectures, Knowledge Representation, Artificial Intelligence and Neural Networks Learning Process — Error Correction learning, Memory based learning, Hebbian learning, Competitive, Boltzmann learning, Credit Assignment Problem, Memory, Adaption, Statistical nature of the learning process.	6
4	**Back Propagation:** Back propagation and differentiation, Hessian matrix, Generalization, Cross validation, Network pruning Techniques, Virtues and limitations of back propagation learning, Accelerated convergence, supervised learning	6
5	**Single Layer Perceptions**: Adaptive filtering problem, Unconstrained Organization Techniques, Linear least square filters, least mean square algorithm, learning	8

	curves, Learning rate annealing techniques, perceptron — convergence theorem, Relation between perceptron and Bayes classifier for a Gaussian Environment Multilayer Perceptron — Back propagation algorithm XQR problem, Heuristics, Output representation and decision rule, Computer experiment, feature detection.	
6	**Key Application Areas:** Expert system, decision support systems, Speech and vision, Natural language processing, Information retrieval, Semantic Web	5

Assessment Scheme:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation: Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum

References:

1. Neural networks: A comprehensive foundation/ Simon Hhaykin/ PHI.
2. Artificial Intelligence by Elaine Rich, Kevin Knight and Shivashankar B Nair, Tata McGraw Hill
3. Artificial neural networks! B.Vegnanarayana /PHI.
4. Neural networks in Computer intelligence! Li Mm Fu/ TMH/2003.
5. Neural networks! James A Freeman David M S kapura/ Pearson education/2004.
6. Introduction to Artificial Neural Systems/Jacek M. Zurada/JAICO Publishing House Ed. 2006.

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ME505T	Smart Materials	Contact Hours	3	-	-	3
		Credits	3	-	-	3

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal Assessment			End Sem Exam				
		IA 1	IA 2	Average					
ME505T	Smart Materials	40	40	40	60	-	-	-	100

Course Objectives:

1. To study the working principles of various smart materials.
2. To identify applicability of various smart materials as actuator and sensor.
3. To study advances in smart materials

Course Outcomes: Learner will be able to

1. Classify the different Smart Materials
2. Understand the mechanism of input-output responses for smart materials

Module	Content	Hrs.
1	**Introduction** Introduction to the smart materials and smart structures, Classification of Smart Materials and introduction to Shape Memory alloys, Piezoelectric and Electro strictive Materials - Electro and Magnetorheological fluids-Functionally graded materials, Electro active polymers	07
2	**Shape Memory Alloys** Working of Shape Memory Alloys, The Mechanisms of the Shape Memory Effect and Superelasticity, Training of a shape memory alloys ,Ni-Ti alloys phase transformation. Shape Memory Alloy Actuators.	06
3	**Piezoelectric Materials** Constitutive relationship, Electromechanical coupling coefficients, Piezoelectric constants, Piezoceramic materials, Variation of coupling coefficients in hard and soft piezoceramics, Polycrystalline vs single crystal piezoelectric materials, Polyvinylidene fluoride, Piezoelectric composites; Piezoelectric Actuators: Induced strain actuation model, Piezoelectric sensors	08
4	**Magnetostrictive Materials** Constitutive relationship, magnetomechanical coupling coefficients, Joule Effect, Villari Effect, Matteuci Effect, Wiedemann effect, Giant magnetostriction in Terfenol-D, Terfenol-D particulate composites, Galfenol and Metglas materials	06
5	**Artificial Muscles with Polymeric Nanocomposites** Ionic polymeric conductor/metal nanocomposites, fabrication and manufacturing methods of electrically and chemically active ionic polymeric sensors, actuators, and artificial muscles, and electrically active polymeric nanocomposites and	06

	artificial muscles. modeling and testing various artificial muscles to show the viability of chemoactive and electroactive muscles. self healing polymers.	
6	**New Trends in Smart Materials** Solid state SMA engine, Electro or magnetorheological engine mounts, Electrorheological and magnetorheological fluids in dampers, Shape Memory tumble flaps, Semi-active vibration damping systems, Electrochromic rear-view mirrors and Chromogenic material, Energy Harvesting Materials, Biomimetics	06

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation: Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum

Text Books:

1. Fundamentals of Smart Materials, Mohsen Shahinpoor, Royal Society of Chemistry, , London, UK.
2. Smart materials and structures, Mukesh V Gandhi; Brian S Thompson, Chapman & Hall, London ; New York : 1992.
3. Smart Materials Taxonomy, Victor Goldade, Serge Shil'ko, Aleksander, Neverov CRC Press, 2015

References:

1. Smart Structures and Materials, Brian Culshaw, Artech House, 2000
2. Electrochromic smart materials : fabrication and applications, Jian Wei Xu; Ming Hui Chua; Kwok Wei Shah, Royal Society of Chemistry, London, UK ,2019
3. Smart Materials, Mel Schwartz, CRC Press
4. https://nptel.ac.in/courses/112/104/112104251/
5. https://onlinecourses.nptel.ac.in/noc19_me68/
6. https://nptel.ac.in/courses/112/104/112104173/

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ME506T	Fatigue and Fracture Analysis	Contact Hours	3	-	-	3
		Credits	3	-	-	3

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal Assessment			End Sem Exam				
		IA 1	IA 2	Average					
ME506T	Fatigue and Fracture Analysis	40	40	40	60	-	-	-	100

Course Objectives:

1. Students will be able to identify, document, and research materials related failures while understanding differences between manufacturing, design defects and/or product degradation or misuse.
2. Students will become familiar with and have access to materials characterization equipment as part of a hands-on project.
3. Students will be familiar with a general review of stress analysis, modes of failure, engineering materials and will shift into identifying failures, fractography, failure research publications and litigation/liability issues.

Course Outcomes: Learner will be able to

1. Understand factors responsible failure of materials
2. Differentiate fracture modes and failure mechanisms for ductile, brittle, fatigue, creep, corrosion and wear failure
3. Determine fracture toughness of brittle and ductile materials
4. Predict life of materials under fatigue loading
5. Analyze failure through case studies and select tools for failure analysis

Module	Detail Content	Hrs
1	**Introduction:** Importance of failure analysis at design stage, modes of mechanical failure, introduction to linear elastic fracture mechanics	6
2	**High Cycle Fatigue**: Introduction, fatigue loading, Stress Cycles, the S-N curves, effect of mean stress on fatigue, multi axial fatigue stresses, using multi axial fatigue failure theories.	6
3	**Low-Cycle Fatigue**: Introduction, the strain cycling concept, the strain life curve and low cycle fatigue relationships, the influence of nonzero mean strain and nonzero mean stress, cumulative damage rule in low-cycle fatigue.	6
4	**Fracture Mechanics**: Introduction, the Linear damage theory, cumulative damage theories, life prediction based on local stress-strain and fracture mechanics concepts, service loading simulation and full scale fatigue testing, damage tolerance and fracture control.	8
5	**Creep, Stress Rupture and Fatigue**: Introduction, prediction of long-term creep behaviour, theories for predicting creep behaviour, creep under uniaxial state of	6

	stress and multi axial state of stress, cumulative creep concept, combined creep and fatigue.	
6	**Case studies**	4

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation: Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum

Reference Books:

1. F. Madoyag, Metal Fatigue Design and Theory
2. L. Sors, Fatigue Design of Machine Components, Pergamon Press
3. S. T. Rolfe and J. M. Barson, Fracture and Fatigue Control Structures, Prentice Hall.
4. David Broek, Elementary Engineering Fracture Mechanics, Noordnoff
5. G. E. Dieter, Mechanical Metallurgy, Tata McGraw Hill Book Co., New Delhi.

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ME507T	Advanced Composites and Polymeric Materials	Contact Hours	3	-	-	3
		Credits	3	-	-	3

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal Assessment			End Sem Exam				
		IA 1	IA 2	Average					
ME507T	Advanced Composites and Polymeric Materials	40	40	40	60	-	-	-	100

Prerequisites:

1. Chemistry of Engineering materials
2. Materials science and metallurgy

Course Objectives:

1. To equip students with fundamental knowledge of polymeric and composite materials.
2. To achieve an understanding of principles of design in plastics and composites, and to explore the multiple new opportunities .

Course Outcomes:

Upon successful completion of this course, learner will be able to

1. Differentiate the behaviour and specialties of orthotropic materials.
2. Apply theory of elasticity and mechanics of orthotropic materials and behavior under bi-axial stress conditions.
3. Understand the concept of design optimization with proper material selection and its application.
4. Choose or design a material system to reduce the weight of a car and improve its fuel efficiency.
5. Make a good selection of materials for engineering applications

Module	Detail Content	Hrs.
1.	Introduction to composite materials, evolution and applications in engineering. Characteristics and classification of composite materials; Fibrous, laminated and particulate composites. Basic terminologies; volume fraction and weight fraction. Laminae and laminates. Different fibres, matrices and their properties. Advantages and disadvantages of polymer matrix composites, metal matrix composites and ceramic matrix composites. Mechanical properties of unidirectional composite lamina. Longitudinal and transverse Young modulus, shear modulus, Poisson ratio.	7
2.	Empirical relationship of Halpin-Tsai. Longitudinal and transverse Strength. Composites under compressive loading. Properties of angle ply lamina. Transformation of Young moduli, shear modulus. Concept of coupling coefficients. General and special orthotropic materials. Psai Pagano invariants Strength of orthotropic lamina. Biaxial strength theories. Maximum strength,	6

	maximum strain theory. Tsai-Hill maximum work theory. Tsai Wu tensor theory.	
3.	Applications of the above theories to pressure vessels, composite shafts etc. Codes and engineering representation of Laminates. Macro mechanical behavior of a laminate. Laminate stiffness for different types; symmetric, anti-symmetric, cross ply laminates. Stresses in different laminae in a laminate.	6
4.	High Performance plastics and Composites in Automobile Industry, Processing of polymer composites, Hand-layup, Spray-layup, Compression molding Injection molding. Reaction injection molding, Autoclaving, Resin transfer molding, Filament winding, Pultrusion. Sheet molding, Pre-pegging	6
5.	Challenges in primary processing of composites, Secondary processing of polymer composites, Joining of polymer composites, Adhesive joining Mechanical joining, Microwave joining, Induction and resistance welding, Drilling of polymer composites. Conventional vs ultrasonic drilling, Remedies for reducing drilling induced damages,	6
6.	Applications of advanced composites and polymers -Aerospace and biomedical field.Case studies on development of new systems for improved performance.Emerging 3D printable composites and polymer matrix composites	6

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation : Class Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Books/References:

1. Mallick, P. K. , “Fibre-Reinforced Composites, CRC press,” New York, 2007
2. Jones, R.M., “Mechanics of Composite Materials,” Mc Graw Hill, New Delhi
3. Broutman and Agarwal, “Analysis and Performance of Composite materials”, John Willey and Sons, New York
4. Ehsan Bafekrpour, “Advanced Composite Materials:Properties and Applications2017
5. Sohel Rana; Raul Fangueiro,”Advanced composite materials for aerospace engineering : processing, properties and applications,Woodhead Publishing,2016

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ME508T	Microprocessor and Controllers	Contact Hours	3	-	-	3
		Credits	3	-	-	3

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal Assessment			End Sem Exam				
		IA 1	IA 2	Average					
ME508T	Microprocessor and Controllers	40	40	40	60	-	-	-	100

Course Objectives:

1. To understand the basic concepts of microcomputer systems.
2. To understand the architecture of 16-bit Microprocessor 8086.
3. To understand the architecture of 8-bit Microcontroller 8051.
4. To write programs for 8051 Microcontroller.
5. To understand peripheral devices and their interfacing to microcontrollers.

Course Outcomes: Upon successful completion of this course, the learner will be able to

1. Understand the basic concepts of microcomputer systems.
2. Understand the detailed architecture of 8086 microprocessor and 8051 microcontroller.
3. Study the in-depth working of the 8051 microcontroller and their Instruction set.
4. Interface various peripheral devices to 8051 microcontroller.
5. Write programs for 8051 microcontroller.

Module	Detail Content		Hrs.
1.	**Introduction to Microcomputer System**		06
	1.1	Block diagram of microprocessor based system: CPU, I/O Devices, Clock, Memory, Concept of Address, Data and Control Bus and Tristate logic.	
	1.2	Concepts of Program counter register, Reset, Stack and stack pointer , Subroutine and Interrupts.	
	1.3	Concept of RISC & CISC Architecture	
	1.4	Concept of Harvard & Von Neumann Architecture	
2.	**Architecture of 8086 Microprocessor**		08
	2.1	Major features of 8086 processor,	
	2.2	8086 CPU Architecture and the pipelined operation,	
	2.3	Programmer's Model & Memory Segmentation.	
	2.4	8086 pin description in detail.	
3.	**8051 Microcontroller Architecture**		06
	3.1	Comparison between Microprocessor and Microcontroller	
	3.2	Features, architecture and pin configurations	

	3.3	Memory organization	
4.	**8051 Microcontroller assembly language programming**		08
	4.1	Addressing modes of 8051.	
	4.1	Assembler directives of 8051.	
	4.2	Instruction Set: Data transfer, Arithmetic, Logical, Branching.	
	4.4	Programs related to: arithmetic, logical, delay, input, output, timer, counters, port, serial communication, and interrupts.	
5.	**8051 Internal Hardware & Programming**		10
	5.1	I/O port structure and programming.	
	5.2	Interrupts and programming.	
	5.3	Timer/Counter and programming.	
	5.4	Serial port and programming.	
6.	**8051 Interfacing & Applications**		08
	6.1	Display interfacing: 7-segment LED display, 16x2 generic alphanumeric LCD display.	
	6.2	Analog devices interfacing: 8-bit ADC/DAC	
	6.3	Motor interfacing: Relay, dc motor, stepper motor and servo motor.	

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation: Class Test/ Assignments / Quiz/ Case studies/ Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Text Books:

1. Microprocessor and Interfacing: By Douglas Hall (TMH Publication)
2. M. A. Mazidi, J. G. Mazidi and R. D. Mckinlay, “The 8051 Microcontroller & Embedded systems”, Pearson Publications, Second Edition 2006.
3. C. Kenneth J. Ayala and D. V. Gadre, “The 8051 Microcontroller & Embedded system using assembly & ‘C’ ”, Cengage Learning, Edition 2010.

Reference Books:

1. 8086 Microprocessor Programming and Interfacing the PC: By Kenneth Ayala (West Publication)
2. Microcomputer Systems: 8086/8088 family Architecture, Programming and Design: By Liu & Gibson (PHI Publication).
3. Satish Shah, “The 8051 Microcontrollers”, Oxford publication first edition 2010.
4. “MCS@51 Microcontroller, Family users Manual” Intel

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ME509T	Mechatronics	Contact Hours	3	-	-	3
		Credits	3	-	-	3

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal Assessment			End Sem Exam				
		IA 1	IA 2	Average					
ME509T	Mechatronics	40	40	40	60	-	-	-	100

Course Objectives:

1. Synergize the mechanisms of physical devices with Electronics, Electrical and Information systems to problems and challenges in the areas of mechatronics
2. Acquire knowledge of mechatronics in the field of product design, development and manufacturing
3. To Understand Basics of Microcontroller interface.

Course Outcomes: Upon successful completion of this course, the learner will be able to

1. Understand structure of mechatronics systems
2. Demonstrate knowledge of pneumatic, hydraulic, electrical circuits and combinations with logic design
3. Understand mechatronics components and systems for a given application
4. Simulate mechatronics problems by simulation softwares
5. Demonstrate team-oriented skills within the field of mechatronics

Module	Detail Content	Hrs.
1.	Introduction to Mechatronics - Traditional and Mechatronics design, Mechatronics Key elements, Basic Components of Mechatronics Systems, Integrated design issues in Mechatronics, Mechatronics Design process, Mechatronics System in Factory, Home and Business Applications, Objectives, Advantages and Disadvantages of Mechatronics.	6
2.	Overview of Micro-processors and Micro-controllers - 8051 Micro-controllers, Functional Block diagram and Architecture, Instruction set and Assembly Language Programming.	6
3.	Interfacing hardware with real world - Analog Interface and Data acquisition, Digital I/O interfacing, special function interfacing, signal conditioning, special utility support hardware Interfacing of: HEX-keyboards, LCD display, ADC, DAC and stepper motor with 8051 Micro controller	8
4.	Overview of Sensors and Transducers - Sensors for motion and position, Force Torque and Tactile Sensors, Range Sensors, Proximity Sensors, Ultrasonic Sensors. Interfacing of sensors with micro-computer system. Micro and Nano Sensors in Mechatronics.	8
5.	Development of circuits for Industrial automation by Pneumatic systems,	6

	Electro-Pneumatic systems, Hydraulic systems, Electro - Hydraulic systems. Logic Gates - AND, OR, NOT, NAND and NOR, applications of basic control circuits based on these gates, Karnaugh map for signal simplification. PLC - Over view and applications of Programmable Logic Controllers in Manufacturing, Relay logic, programming a PLC using ladder diagram programming, Ladder logic programme for control of single cylinder and two cylinder pneumatic systems and hydraulic systems.	
6.	Case Studies of Mechatronics Systems - Timed Switch, Pick and Place Robot, Car Park Barrier, Automatic Camera, Car Engine Management, Bar Code System, CNC Machine, ABS, Artificial Intelligence in Mechatronics, Fuzzy Logic applications in Mechatronics.	6

Theory Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation: Class Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum

Text/Reference Books:

1. The 8051 microcontroller and embedded systems using assembly and C by M.A. Mazidi, J. Mazidi and R. D. McKinlay. PHI, second edition
2. The 8051 microcontroiler Architecture, Programming and Applications Kenneth J T Ayala, Pemam International Publishing, (India).
3. Process control & Instrumentation technology : Cirtis D Johnson
4. C.W.De Silva, Mechatronics: An Integrated Approach, Publisher: CRC
5. Mechatronics - Electronic Control Systems in Mechanical Engineering, Bolton Pearson education,
6. Mechatronics system design, by Devdas Shetty, Richard A Kolk, Second Editon, Cengage Learning, Inc

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ME510T	Control Engineering	Contact Hours	3	-	-	3
		Credits	3	-	-	3

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal Assessment			End Sem Exam				
		IA 1	IA 2	Average					
ME510T	Control Engineering	40	40	40	60	-	-	-	100

Course Objectives:

1. To study concept of mathematical modelling of the control system
2. To acquaint with control system under different time domain
3. To study concepts of stability & various methods.
4. To study Multi-Input Multi-Output systems using state space
5. To study application of control systems for mechanical systems.

Course Outcomes: Learner will be able to

1. Design mathematical models of system/process.
2. Analyse error and differentiate various types of control systems using time domain specifications
3. Analyse various methods and problems associated with stability
4. Analyse systems using graphical methods in frequency response
5. Understand the concept of state space methods for system analysis
6. Comprehend and apply concepts of control systems in mechanical Engineering.

Module	Detail Content	Hrs.
1	**Introduction to the Control Systems** 1.1 Introduction to control systems, Classification of control system. Open loop and closed loop systems. 1.2 Mathematical modelling of control systems(Spring mass damper, electrical systems,thermal, fluid systems), concept of transfer function, Block diagram algebra	6
2	**Time Response Analysis** 2.1 Transient and steady state analysis of first and second order systems. Time Domain specifications. Step response of second order system. Steady-state error, error coefficients, steady state analysis of different type of systems using step, ramp and parabolic inputs	6
3	**Stability analysis** 3.1 Introduction to concepts of stability, Concept of S-plane Routh-Hurwitz Criteria for stability; Relative stability analysis; Root-Locus technique and construction of root-loci.	8
4	**Frequency Response Analysis** 4.1 Introduction to frequency response; Frequency response plots: Polar plot and Bode plot; Performance specifications in frequency domain.	8

	4.2 Stability margins in frequency domain; Mapping contours in s-plane; The Nyquist criterion; Relative stability using Nyquist criterion. Polar plots	
5	**State space modeling** 5.1 Concept of state, state variable, state model. State space representation using physical and phase variables, decomposition of transfer function, diagonalisation. State transition matrix. Transfer function from state model. Controllability and observability of linear systems.	6
6	**Introduction to Controller Design** 6.1 Characteristics of feedback: Sensitivity to parametric variation; Disturbance rejection; Steady-state accuracy. 6.2 Feedback controller design using Root-locus; Reshaping the root-locus; Cascade lead, lag and lag-lead compensator. 6.3 Feedback control design using Bode plot; Reshaping the bode plot; Cascade lead, lag and lag-lead compensator.	5

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation: Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum

Text Books:

1. Norman Nise, “Control Systems Engineering”, Wiley, 8th edition, 2019.
2. M. Gopal, “Control Systems: Principles and Design”, 3rd edition, Tata McGraw Hill, 2008.
3. Richard Dorf, Robert Bishop, “Modern Control Systems”, 11th edition, Pearson Education, 2008

Reference Books:

1. Golnaraghi Farid, B. C. Kuo, “Automatic Control Systems”, 10th edition, McGraw Hill, 2017.
2. K. Ogata, “Modern Control Engineering”, 6th edition, Prentice Hall, 2010.
3. I.J. Nagrath, M. Gopal, “Control System Engineering”, New Age International, 2009.

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ME515L	Robotics and Mechatronics Lab	Contact Hours	2	-	-	2
		Credits	1	-	-	1

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal Assessment			End Sem Exam				
		IA 1	IA 2	Average					
ME515L	Robotics and Mechatronics Lab	-	-	-	-	25	25	-	50

Course Objectives

1. To study interfacing of sensors and actuators with microcontroller
2. To study Programming and Manipulating an industrial Manipulator.
3. To study the role of control systems in robotics.
4. To study automation using Pneumatics and Hydraulics
5. To study programmable logic controllers.

Course Outcomes: Learner will be able to…

1. Demonstrate implementation of interfacing actuators using microcontrollers
2. To understand and operate industrial manipulators
3. Design and develop a control system for specific applications.
4. Understand Robot anatomy and components
5. To develop any pneumatic, hydraulic and plc system.

Exercise	Detail Contents	Hrs
1	Real time interfacing of sensors (temperature, humidity, position, level etc.) and actuator (stepper motor, dc motor, servo motor etc.) with microcontroller and Ethernet shield and controlling the actuator and monitoring of sensor output remotely using internet.	3
2	Interfacing of Stepper Motor with microcontroller and its programming for Rotational or XY table (It is suggested to program to vary the position of rotary or XY table and compare the positioning accuracy using standard calibrated angular or linear sensor)	3

3	Interfacing of DC Motor with microcontroller and its programming for characterization of DC motor setup (It is suggested to program to vary the speed of DC motor and determine its load-speed characteristics)	3
4	Robotics: Real Time demonstration of line following robot using standard robotic kit	3
5	Demonstration and study of functions of components of the robotics arm.	3
6	Simulation of sequential operation upto three cylinders using simulation software electro-hydraulic circuits.	3
7	Development of Pneumatic circuits to understand pneumatic components and their working on training kit.	3
8	Development of Meter in and Meter out on Hydraulic trainer to understand the concept of flow control.	3
9	Development of Electro pneumatic using PLC & Relay on training kit.	3

Lab Assessment:
Internal Assessment: 25 marks
Term Work:

A. Term work shall consist of minimum Eight Experiments, taken from the list given above.
B. Evaluation of practical examination to be done based on the experiment performed and the output of the experiments during practical examination.
C. Students work along with evaluation reports to be preserved till the next examination.
D. Course projects can be given to individual students to build practical systems for mechatronics / Automation application using arduino / Festo training kit etc.

The distribution of marks for Term work shall be as follows:

Experiments performance : 10 marks
Course Project : 10 marks
Attendance : 5 marks

End Semester Practical/Oral Examination:
Pair of Internal and External Examiners should conduct practical/viva based on contents.
Distribution of marks for practical/viva examination shall be as follows:

Practical Examination : 15 Marks
Oral Examination : 10 Marks

Books/References:

1. Yoram Korean,“Robotics for engineers”, McGrew Hill Co.
2. M.P.Groover,M.Weiss, R.N. Nagel, and N.G. Odrey, “Industrial Robotics Technology programming and Applications”, McGraw-Hill,
3. Robotics: Fundamental Concepts and Analysis by Ashitava Ghosal, Oxford University Press

4. R.K. Mittal and I.J. Nagrath, “Robotics and Control”, TMH Publications
5. Robert J. Schilling,“Fundamentals of Robotics Analysis and Control”, PHI Learning
6. Bijay K. Ghosh, Ning Xi, T.J. Tarn, Control in Robotics and Automation Sensor – Based integration, Academic Press.
7. Getting Started with the Internet of Things: Connecting Sensors and Microcontrollers to the Cloud by Cuno Pfister.
8. Beginning C for Arduino, Second Edition: Learn C Programming for the Arduino Book by Jack J Purdum.

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ME516L	Dissertation-I	Contact Hours	2	-	-	2
		Credits	1	-	-	1

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal Assessment			End Sem Exam				
		IA 1	IA 2	Average					
ME516L	Dissertation-I	-	-	-	-	25	-	25	50

Guidelines for Dissertation-I

Students should do literature survey and identify the problem for Dissertation and finalize in consultation with the Guide/Supervisor. Students should use multiple literatures and understand the problem. Students should attempt to solve the problem by analytical/simulation/experimental methods. The solution to be validated with proper justification and compile the report in standard format.

Guidelines for Assessment of Dissertation-I

- Dissertation I should be assessed based on following points
- Quality of Literature survey and Novelty in the problem
- Clarity of Problem definition and Feasibility of problem solution
- Relevance to the specialization
- Clarity of objective and scope
- Quality of Written and Oral Presentation

Dissertation I should be assessed through a presentation by a panel of Internal examiners appointed by the Head of the Department/Institute of respective Programme.

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ME517T	Computer Aided Manufacturing	Contact Hours	3	-	-	3
		Credits	3	-	-	3

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal Assessment			End Sem Exam				
		IA 1	IA 2	Average					
ME517T	Computer Aided Manufacturing	40	40	40	60	-	-	-	100

Course Objectives:

This course will help the students to learn

1. To familiarize with concepts of computer aided machining and its significance.
2. To familiarize with the operation and programming of CNC machines.
3. To familiarize with the advanced machining techniques used for micro fabrication.
4. To familiarize with the additive manufacturing process.

Course Outcomes:

On successful completion of course learner/student will be able to:

1. Understand the structure of a CNC machine
2. Understand the tooling used in a CNC machine
3. Understand the functioning of CNC machine
4. Develop a part program for various machining operations.
5. Understand the various micromachining and microfabrication processes.
6. Identify the additive manufacturing process for development of a component.

Detailed Theory Syllabus:

Module No.	Detailed Content	Hours	CO Mapping
1	**Introduction**: Introduction: CAM system, NC & CNC Machines, Machining Centers **CNC Hardware:** Structure of CNC machine tools, Spindle design, Spindle and axis drives, Various actuation systems and feedback devices like encoder, tachogenerator, etc.	6	CO1, CO3
2	**CNC Tooling:** Latest CNC tool materials and manufacturing, Turning and milling tool geometry, Tool probing and presetting, Automatic Pallet Changer (APC) and Automatic Turret Changer (ATC), Study of various probes and special tools.	7	CO1,CO, CO3

3	**CNC Control System:** CNC motion controller, Linear, circular, helical interpolator, Positioning and contouring control loops, MCU, adaptive control system	6	CO1, CO3
4	**CNC Programming:** Part programming fundamentals, Manual part programming methods, Programming of turning, machining centre, Use of canned cycles for facing, pocketing etc.	6	CO3, CO4
5	**Micro Machining & Microfabrication** Introduction to microfabrication for MEMS, bulk micromachining of silicon, surface micromachining of MEMS, wafer bonding for MEMS, LIGA process, micromachining of polymeric MEMS devices, 3D microfabrication.	6	CO5
6	**Additive Manufacturing Processes** Introduction, Classification of AM processes, Materials for AM processes. Principle of operation, possible approaches, steps, advantages and limitations of at least one Additive manufacturing techniques of each type.	8	CO6

Theory Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation: Class Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum

Books and References:

1. CNC Programming for Machining, Kaushik Kumar, Chikesh Ranjan, J. Paulo Davim, Springer Publication.
2. Manufacturing Science by Ghosh and Malik
3. CAD/CAM Computer Aided and Manufacturing, Mikell P. Groover and Emory W. Zimmers, Jr., Eastern Economy Edition
4. CNC Technology and Programming, Krar, S., and Gill, A., McGraw Hill Publishers.
5. CAD/CAM Principles and Applications, P. N. Rao, Tata McGraw Hill Publications
6. Micromachining Methods by J.A. Mc Geough, Chapman And Hall, London
7. Introduction To Micromachining , V. K. Jain, Published By Narosa Publishers, New Delhi.
8. Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, I. Gibson l D. W. Rosen l B. Stucker, Springer Publication.
9. Rapid Manufacturing –An Industrial revolution for the digital age by N.Hopkinson, R.J.M.Hauge, P M, Dickens, Wiley.
10. Rapid Manufacturing by Pham D T and Dimov, Springer Verlag
11. Rapid Prototyping and Manufacturing, P. F. Jacobs, Society of Manufacturing Engineers

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ME518T	Robotics	Contact Hours	3	-	-	3
		Credits	3	-	-	3

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal Assessment			End Sem Exam				
		IA 1	IA 2	Average					
ME518T	Robotics	40	40	40	60	-	-	-	100

Course Objectives:

1. To familiarize the students with robotic systems and their applications in flexible or agile
2. To make conversant with robotic elements / peripherals, their selection and interface with manufacturing equipment.
3. To explain the basics of robot kinematics.
4. To explain the applicability of machine vision and various image processing methods.
5. Students should have knowledge of path control and trajectory planning.
6. Students are familiar with programming languages

Course Outcomes: Learner will be able to…

1. To know the robot systems and their applications in agile manufacturing.
2. To have knowledge of robotic peripherals, their selection and their utility.
3. To have knowledge of basic robot kinematics.
4. Be acquainted with various image processing techniques.
5. To know path control and different trajectory planning.
6. Understand the various programming languages.

Prerequisite: Basic sensors, controller and programming language

Detailed Syllabus:

Sr. No.	Module	Detailed Content	Hours	CO Mapping
I	Introduction	1.1 Robotic System & Anatomy 1.2 Classification, Robotic Automation 1.3 Future Prospects. Robotic Application in Manufacturing, Automation & robotics, Material transfer, Machine loading & unloading, 1.4 Processing operations, Assembly & Inspectors. 1.5 Social Issues and Economics Issue 1.6 Robotics Drives: Control Loops, Basic Control System Concepts & Models, Control System Analysis, 1.7 Robot Activation & Feedback Components, Actuators, Power Transmission Systems.	8	CO1, CO2

II	Robot & its Peripherals	2.1 End Effectors - types, Mechanical & other grippers, Tool as end effector 2.2 Sensors: Sensors in Robotics, Tactile Sensors, Proximity & Range Sensors, Sensor Based Systems, 2.3 Position & Velocity Sensors, 2.4 Robotic Cell Design & Control	6	CO2
III	Robot Kinematics	3.1 Coordinate Frames, Rotations, Homogeneous Coordinates, 3.2 Arm Equation of Planer Robot, 3.3 Four axis SCARA Robot, TCV, 3.4 Inverse Kinematics of Planer Robot	8	CO3
IV	Trajectory Planning & Robot Dynamics	4.1 Manipulator Path Control- Linear, Quadratic and Cubic Interpolation, 4.2 Work Space Analysis, 4.3 Robot Dynamics –Lagrangian Dynamics of one and two link robot arms.	6	CO3 CO5
V	Machine Vision	5.1 Introduction, Low level & High level vision, 5.2 Sensing & Digitizing, Image processing & analysis, 5.3 Segmentation, Edge detection, Object description & recognition, Interpretation, 5.4 Noises in Image, Applications.	6	CO4
VI	Programming For Robot	6.1 Methods, Robot programme as a path in space, Motion interpolation, level & task level languages, 6.2 Robot languages; Programming in suitable languages Characteristics of robot 6.3 Robot Intelligence & Task Planning	5	CO6

Theory Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation: Class Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum

Text/Reference Books:

1. Yoram Korean, “Robotics for engineers”, McGrew Hill Co.
2. M.P. Groover, M. Weiss, R.N. Nagel, and N.G. Odrey, “Industrial Robotics Technology programming and Applications”, McGraw-Hill,
3. Robotics: Fundamental Concepts and Analysis by Ashitava Ghosal, Oxford University Press
4. R.K. Mittal and I.J. Nagrath, “Robotics and Control”, TMH Publications
5. Robert J. Schilling, “Fundamentals of Robotics Analysis and Control”, PHI Learning
6. Bijay K. Ghosh, Ning Xi, T.J. Tarn, Control in Robotics and Automation Sensor – Based integration, Academic Press

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ME519T	Additive Manufacturing	Contact Hours	3	-	-	3
		Credits	3	-	-	3

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal Assessment			End Sem Exam				
		IA 1	IA 2	Average					
ME519T	Additive Manufacturing	40	40	40	60	-	-	-	100

Course Objectives:

1. To learn the various rapid manufacturing technologies.
2. To familiarize with various software solutions for designing and developing products using rapid.
3. To familiarize with applications of these techniques in various engineering and biomedical fields.

Course Outcomes: Learner will be able to

1. Differentiate the different additive manufacturing technologies
2. Select an appropriate AM technique for printing different materials and their combinations.
3. Understand the parameters that decide the quality of a 3D printed part.
4. Develop 3D printers for specific applications.
5. Develop competency in designing and developing products using rapid manufacturing technology.

Module	Detail Content	Hrs.
1	**Introduction** • Historical Development • Additive, Subtractive and Formative Manufacturing • Applications: Design, Planning, Manufacturing and Tooling • Applications: Automotive, Aerospace, Electronics, Jewelry, BioMedical • Fundamentals of Rapid Prototyping and Manufacturing, Design Process • Rapid Prototyping and Manufacturing Process Chain • Classification of Additive Manufacturing Processes	8
2	**Solid Based Additive Manufacturing Systems** • Materials • LOM (Laminated Object Manufacturing) System • FDM (Fused Deposition Modeling) System • Multi-Jet Modeling (MJM) System • Model Maker and Pattern Master • Shape Deposition Manufacturing Process	6
3	**Liquid Based Additive Manufacturing Systems** • Materials • Stereolithography • Solid Ground Curing • Solid Object UV (Ultra-Violet) Printer • Micro-stereolithography	6
4	**Solid Based Additive Manufacturing Systems** • Materials • LOM (Laminated Object Manufacturing) System • FDM (Fused Deposition Modeling) System • Multi-Jet Modeling (MJM) System • Model Maker and Pattern Master • Shape Deposition Manufacturing Proces	6
5	**System and Methodology**	6

	• Subsystems of RP machine • Optical System • Mechanical Scanning System • Computer Interfacing hardware, DAQs • Signal Flow, 3D Model to RP Prototype • Introduction to 3D Modeling Softwares (Auto-CAD, PROE, CATIA, SOLIDWORKS, IDEAs etc.) • File Formats: IGES, STEP, DXF, STL • Slicing and Scan Path Generation Algorithms • Data Conversion and Transmission • Data Validity and Repair • Preprocessing and Post-processing • Properties of the prototype/part: Material properties, color, dimensional accuracy, stability, surface finish, machinability, environmental resistance, operational properties	
6	**Advances in Additive Manufacturing and Case Studies** Advances in Additive Manufacturing: Resolution & Accuracy issues, Integrated Hardening Process, Reverse Engineering Process and Applications, Metal Additive Manufacturing, Two Photon Process for Micro/Nano Fabrication, Printing with Biocompatible Materials	7

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation: Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum

Text/Reference Books:

1. Chua C.K., Leong K.F., and Lim C.S., "Rapid Prototyping Principles and Applications", World Publishing Co. Pte. Ltd.•
2. Gibson, D.W. Rosen, and B. Stucker, "Additive Manufacturing Technologies Rapid Prototyping to Direct Digital Manufacturing", 2010, Springer Inc.
3. Ali Kamrani, EmadAbouel Nasr, "Rapid Prototyping Theory and Practice", 2006, Springer Inc. •
4. RafiqNoorani, Rapid Prototyping: Principles and Applications, John Wiley & Sons, Inc., 2006, ISBN 0-471-73001-7 •
5. Kenneth G. Cooper, "Rapid Prototyping Technology Selection and Application", 2001, Marcel Dekker Inc, New York.
6. BopayaBidanda, Paulo J. Bartolo, "Virtual Prototyping and Bio Manufacturing in Medical Applications", 2008, Springer Inc.

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ME520T	Mirco Electro Mechanical Systems	Contact Hours	3	-	-	3
		Credits	3	-	-	3

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal Assessment			End Sem Exam				
		IA 1	IA 2	Average					
ME520T	Mirco Electro Mechanical Systems	40	40	40	60	-	-	-	100

Course Objectives:

1. To understand the basic characteristics of MEMS and its processing steps.
2. To demonstrate the use of semiconductor based processing modules used in the fabrication of a variety of sensors and actuators (e.g. pressure sensors, accelerometers, etc.) at the micro-scale.
3. To understand the basic of design and operation of MEMS sensors and actuators with proper characterization.
4. To make use of the MEMS devices for real time applications

Course Outcomes: Learner will be able to

1. Understand the underlying fundamental principles of MEMS devices including physical operation, mathematical modeling
2. Select the appropriate material and processes while fabrication of MEMS devices
3. Design and simulate MEMS devices and systems using standard simulation tools.
4. Develop different concepts of micro system sensors and actuators for real-world applications.

Module	Detail Content	Hrs.
1	Introduction to MEMS 04 Introduction to MEMS & its characteristics, Real world Sensor/Actuator examples (DMD, Air-bag, pressure sensors). MEMS Sensors in Internet of Things (IoT), BioMedical Applications	5
2	MEMS Materials and their Properties 10 Materials (eg. Si, SiO2, SiN, Cr, Au, Ti, SU8, PMMA, Pt); Important properties:Young modulus, Poisson's ratio, density, piezoresistive coefficients, TCR, Thermal Conductivity, Material Structure. Understanding Selection of materials based on applications	7
3	Fabrication Processes common to MEMS 10 Understanding MEMS Processes & Process parameters for: Cleaning, Growth & Deposition, Ion Implantation & Diffusion, Annealing, Lithography. Understanding selection of Fab processes based on Applications	7
4	MEMS Specific Fabrication Processes 08 Understanding MEMS Processes & Process parameters for: Wet & Dry etching, Bulk & Surface Micromachining, Die, Wire & Wafer Bonding, Dicing, Packaging. Understanding selection of Fab processes based on Applications	7

5	MEMS Devices: Architecture and working 10 basic quantitative behaviour of Cantilevers, Micro-heaters, Accelerometers, Pressure Sensors, Micro-mirrors in DMD, Inkjet printer-head. Understanding steps involved in Fabricating above devices. Piezoresistance, TCR, Stiffness, Adhesion, Vibration, Resonant frequency, & importance of these measurements in studying device behavior, MEMS Reliability	8
6	Applications of MEMS devices Industrial applications with detailed understanding of role of MEMS as sensors and 10 actuators with proper case studies.	5

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation: Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum

Text/Reference Books:-

1. An Introduction to Microelectromechanical Systems Engineering; 2nd Ed - by N.Maluf, K Williams; Publisher: Artech House Inc
2. Practical MEMS - by Ville Kaajakari; Publisher: Small Gear Publishing
3. Microsystem Design - by S. Senturia; Publisher: Springer
4. Analysis and Design Principles of MEMS Devices - MinhangBao; Publisher:Elsevier Science
5. Fundamentals of Microfabrication - by M. Madou; Publisher: CRC Press; 2 edition
6. Micro Electro Mechanical System Design - by J. Allen; Publisher: CRC Press
7. Micromachined Transducers Sourcebook - by G. Kovacs; Publisher: McGraw-Hill

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ME521T	Manufacturing Analytics	Contact Hours	3	-	-	3
		Credits	3	-	-	3

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal Assessment			End Sem Exam				
		IA 1	IA 2	Average					
ME521T	Manufacturing Analytics	40	40	40	60	-	-	-	100

Course Objectives:

1. To understand different manufacturing systems and its performance measures
2. To acquaint students with cellular manufacturing system
3. To familiarize students with flexible manufacturing system
4. To understand synchronous manufacturing and theory of constraints
5. To understand discrete and continuous manufacturing
6. To familiarize students with modelling and simulation of manufacturing systems and softwares used

Course Outcomes: Upon successful completion of this course, the learner will be able to

1. Analyse different manufacturing systems for its performance measures
2. Design of cellular manufacturing system
3. Illustrate loading and scheduling problems in FMS
4. Apply theory of constraints to improve the process performance
5. Develop simulation models of the manufacturing system

Module	Detail Content	Hrs.
1.	Models of manufacturing systems, including transfer lines and flexible manufacturing systems, multistage manufacturing process Calculation of performance measures, including throughput, in-process inventory, and meeting production commitments; real-time control of scheduling; effects of machine failure, set-ups, and other disruptions on system performance. Data analytics tools	06
2.	Cellular manufacturing, cell formation methods: Rank order clustering, similarity coefficient and optimization based,	06
3.	Flexible Manufacturing Systems, Concepts, FMS loading problems, FMS scheduling problems	06
4.	Synchronous Manufacturing, Principles of SM, Theory of Constraints and Linear Programming, Scheduling	06
5.	Event verses activity, General principles of event-driven simulation, Use of Pseudo-Random numbers in simulation of queuing systems, Simulation of manufacturing systems and other examples	08

6.	Introduction to modeling and simulation concepts, System analysis and components, Simulation terminology, Model of a system and types of models, Discrete *verses* continuous systems, Static and Dynamic System simulation, Pros and cons of simulation. Simulation of manufacturing and material handling systems, Modeling downtime and failures, Case studies Introduction to simulation software and languages for manufacturing and material handling like Extend, Areana, Technomatix etc	10

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests - 40 Marks
2. Continuous evaluation- Class Test/ Assignments /Quiz/Case studies/Seminar presentation- 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Books/References:-

1. Modeling and Analysis of Manufacturing Systems by Ronald G. Askin, Charles R. Standridge
2. Production Planning and Inventory Control by Seetharama L Narasimhan, Dennis W.McLeavey and Peter J Billington
3. Discrete-Event System Simulation by Jerry Banks, Carson and Nelson, Prentice Hall of India Pvt. Ltd.
4. Simulation Modelling and Analysis by Law and Kelton, McGraw Hill, New York.

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ME522T	Product Design & Development	Contact Hours	3	-	-	3
		Credits	3	-	-	3

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal Assessment			End Sem Exam				
		IA 1	IA 2	Average					
ME522T	Product Design & Development	40	40	40	60	-	-	-	100

Course Objectives:

1. To familiarize with fundamental product design concepts
2. To acquaint with product design methodologies
3. To understand product design needs and issues in industry

Course Outcomes: Learner will be able to

1. Demonstrate product design and development process.
2. Analyze a product in perspective of aesthetic and ergonomic considerations.
3. Illustrate considerations of Design for Manufacturing and Assembly in product development.
4. Apply appropriate tools and techniques in the design of solutions that are usable and functional for various applications.
5. Design the products as per the customer/industry requirements
6. Apply principles of economy and demonstrate legal and social issues pertaining to product development.

Module	Detail Content	Hrs.
1	Product definition, specification, Phases of product development: conceptual, embodiment and detailed design, product and technology development cycle, Concept generation and evaluation methods, product architecture, Product life cycle Management with case studies, Product analysis. Creativity and Idea generation technique, importance of Quality Dimensions: Performance, Features, aesthetics, Ergonomics, Reliability, Sustainability, Serviceability, Brand value, Value Vs cost, Importance of shape, color, feature & Resemblance.	05
2	Design Factors: Ergonomics, Aesthetics, Anthropometry, Comforts, Economic factors Axiomatic design principles and case studies. Design Thinking, Design by Innovation and collaboration Material and Process selection Methods, Expert systems. Computer Database Approach, performance indices decision matrix, AHP and fuzzy approach Introduction to material and process selection software.	06

3	Design for Manufacturing (DFM) and Design for Assembly (DFA) Designs for Maintainability and Reliability and some methods for reliability assessment, Designs for Environment, Design for Robustness: Taguchi Designs & Design of Experiments (DOE).	08
4	Product Design Tools and Techniques: Value Engineering / Value Analysis: definition, methodology- FAST, Benchmarking, Supplier involvement robust design, QFD, Design & process FMEA. Reverse Engineering, Concurrent engineering & Sequential engineering, Case studies.	08
5	Product Development Cycle and Importance of Prototyping. Types of prototypes. Principal and advantages & Different Type of Generative Manufacturing process, Viz. Stereolithography. FDM, SLS etc. Factors Concerning RP: Consideration for Adoptions, Advantages, Accuracy and Economic Consideration.	06
6	Economics of Product Development: Product costing, Principles of Economy, Engineering Economy and Design Process, Economic Analysis, Inflation, Time Value of Money, Numerical on Internal Rate of Return and Net Present Value (NPV) method.	06

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation: Test/Assignments /Quiz/Case studies/Seminar presentation/ Mini Project on product design from idea generation to prototyping of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum

Books/References:

1. Product Design and Manufacturing by A.K.Chitale, R.C.Gupta, PHI.
2. Product Design and Development by Ulirich Karl T. and Eppinger Steven D, McGraw Hill.
3. Engineering Design by Dieter George E., McGraw Hill.
4. Handbook of Product Design for Manufacturing by Bralla, James G, McGraw Hill.
5. Product Design by Kevin Otto & Kristin Wood

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ME523T	Quality Engineering	Contact Hours	3	-	-	3
		Credits	3	-	-	3

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal Assessment			End Sem Exam				
		IA 1	IA 2	Average					
ME523T	Quality Engineering	40	40	40	60	-	-	-	100

Course Objectives:

1. To understand the concept of Quality.
2. Demonstrate the approaches and techniques to assess and improve process and/or product quality and reliability
3. Introduce the principles and techniques of Statistical Quality Control

Course Outcomes: Upon successful completion of this course, learner will be able to:

1. To realize the importance and significance of quality
2. Illustrate basic concepts and statistical methods in quality control
3. Illustrate the different sampling techniques in quality control
4. Use control charts to analyze for improving the process quality
5. Acquire basic knowledge of total quality management

Module	Detail Content	Hrs.
1.	**Introduction** Different Definitions and Dimensions of Quality, Historical Perspective (From Evolution of Quality Control, Assurance and Management to Quality as Business Winning Strategy), Contribution of Renowned Quality Gurus (Their Philosophies and Impact on Quality).Introduction to Quality, Classification of Quality Tools, Quality of Design, Quality of Conformance, Compromise between Quality and Cost,	4
2.	**Quality Engineering and Management Tools, Techniques & Standards** 7 QC tools, 7 New Quality Management Tools, 5S Technique, Kaizen, Poka-Yoke, Quality Circle, Cost of Quality Technique, Introduction to Quality Management Standards – ISO : 9000, ISO:14000, QS:9000 (Concept, Scope, Implementation Requirements & Barriers, and Benefits), Introduction to National and International Quality Awards (Malcolm Baldrige National Quality Award – MBNQA, The Deming Prize Rajiv Gandhi National Quality Award)	8
3.	**Total Quality Management** Basic Philosophy, Approach, Implementation Requirements & Barriers. **Designing for Quality**	8

	Introduction to Concurrent Engineering, Quality Function Deployment (QFD) and Failure Mode and Effect Analysis (FMEA) – Concept, Methodology and Application (with case studies).	
4.	**Introduction to Design of Experiments** Introduction , Methods, Taguchi approach, Achieving robust design, Steps in experimental design **SQC & SQC tools** Statistics in Quality control, Variables and Attributes data, Process Capability, Control charts for variables and for attribute data($\bar{X}$ and R-Chart, p-chart np-chart, c-chart, Uchart), Applications of SQC in engineering – case studies **Sampling Techniques** Advantages of Sampling Inspection, operating characteristic (OC) curve. Choosing OC curve for appropriate sampling plan, acceptance sampling	8
5.	**Contemporary Trends in Quality Engineering & Management** Just in time (JIT) Concept, Lean Manufacturing, Agile Manufacturing, World Class Manufacturing, Total Productive Maintenance (TPM), Bench 10 20 Marking, Business Process Re-engineering (BPR), Six Sigma - Basic Concept, Principle, Methodology, Implementation, Scope, Advantages and Limitation of all as applicable.	8
6.	**Quality in Service Sectors** Characteristics of Service Sectors, Quality Dimensions in Service Sectors, Measuring Quality in Different Service Sectors.	4

Theory Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation : Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Books/References:

1. Quality Assurance and Total Quality Management (ISO 9000, QS 9000 ISO 14000) by K C Jain and A K Chitale, Khanna Publishers
2. Quality Control & Application by B. L. Hanson & P. M. Ghare, Prentice Hall of India
3. Total Quality Management by Dale H. Besterfield, Carol Besterfield-Michna, Glen H. Besterfield and Mary Besterfield-Sacre, Pearson Educaiton
4. Quality Management by Kanishka Bedi
5. Total Quality Management – Dr. S. Kumar, Laxmi Publication Pvt. Ltd.
6. Total Quality Management by K C Arora, S K Kataria & Sons
7. Statistical Quality Control by M. Mahajan, Dhanpat Rai & Co. (P) Ltd.

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ME524T	Optimization Techniques	Contact Hours	3	-	-	3
		Credits	3	-	-	3

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal Assessment			End Sem Exam				
		IA 1	IA 2	Average					
ME524T	Optimization Techniques	40	40	40	60	-	-	-	100

Course Objectives:

1. To Understand the need and origin of the optimization methods.
2. To understand various linear, nonlinear and other optimization techniques.
3. To understand various multi criterion and multi-objective decision making methods.
4. To understand recent tools in optimization

Course Outcomes: Upon successful completion of this course, the learner will be able to

1. Identify and apply calculus method to single variable problem
2. Formulate the problem as LPP and analyse the sensitivity of a decision variable.
3. Apply various linear and non-linear techniques for problem solving in various domains.
4. Apply multi-objective decision making methods for problems in the manufacturing environment and other domains.
5. Apply multi criterion decision making methods for problems in the manufacturing environment and other domains.
6. Apply Taguchi's Design of Experiments for Optimization

Module	Detail Content	Hrs.
1.	Basic Concepts: Statement of the Optimization Problem, Basic Definitions, Optimality Criteria for Unconstrained Optimization, Optimality Criteria for Constrained Optimization, Engineering Application of Optimization, Classification of Optimization Problems Classical Optimization Techniques: Single variable optimization	6
2.	Linear Programming Problem: Formulation, Simplex method, Big M Method, Primal to Dual, Dual Simplex method, Sensitivity Analysis and applications of LP (Transportation and Assignment Models)	6
3.	Integer Programming, Model: Gomory's cutting plane method, Branch & Bound Technique. Non L.P. Model: Lagrangian method & Kuhn tucker Method, Newton's method Discrete Event Simulation: Generation of Random Variable, Simulation Processes, Monte-Carlo Technique.	8

4.	Multi Objective Decision making (MODM) Methods: Introduction to Multi objective optimization, Traditional Techniques such as, quadratic programming, geometric programming, Numerical on goal programming and dynamic programming. **Introduction to** Non-traditional optimization Techniques such as Genetic Algorithm, particle swarm, genetic algorithms, simulated annealing and Techniques based on Neural network & Fuzziness.	8
5.	Multi Criterion Decision-making (MCDM) Methods: Introduction to multi criterion optimization Simple Additive Weighting (SAW) Method Weighted Product Method (WPM) Analytic Network Process (ANP) Analytic Hierarchy Process (AHP) Method TOPSIS Method	6
6.	Robust Design Methods: DOE and Taguchi techniques Full Factorial Design: The basics of "full factorials", ANOVA, Factorial effects and plots, and Model evaluation Fractional Factorial Design: The one-half fraction and one-quarter of the 2^k design, The general 2^{k-p} fractional factorial design Application of related software (Mini Tab or MATLAB)	6

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation: Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum

Text/Reference Books:

1. S.S. Rao, "Engineering Optimization - Theory and Practice", John Wiley and Sons Inc.
2. Ranjan Ganguli, "Engineering Optimization - A Modern Approach" Universities Press
3. Pablo Pedregal, "Introduction to Optimization", Springer
4. L.C. Jhamb, "Quantitative Techniques Vol. 1 and 2", Everest Pub. House
5. Pierre D.A., "Optimization, Theory with Application", John Wiley & sons.
6. Decision Making in the Manufacturing Environment Using Graph Theory and Fuzzy Multiple Attribute Decision Making by R V Rao (Springer Publication).
7. Neural Computation and Self-Organizing Maps by Ritter, H., Martinetz, T., & Schulten, K., Addison-Wesley Publishing Company
8. Design and analysis of experiments by Douglas C.Montgomery (John Wiley & Sons Inc.)

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ME525T	Data Science & Expert Systems	Contact Hours	3	-	-	3
		Credits	3	-	-	3

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal Assessment			End Sem Exam				
		IA 1	IA 2	Average					
ME525T	Data Science & Expert Systems	40	40	40	60	-	-	-	100

Course Objectives:

1. Building the fundamentals of data science.
2. To introduce core programming basics required for data science using Python language.
3. To read and write simple Python programs.
4. To develop Python programs with conditionals and loops.
5. Imparting design thinking capability to build big-data.
6. Developing design skills of models for big data problem.

Course Outcomes: Learner will be able to

1. Apply data visualisation in big-data analytic.
2. Read, write, execute simple Python programs and decompose a Python program into functions.
3. Read and write data from/to files in Python programs.
4. Develop algorithmic solutions to data science related problems.
5. Utilise EDA, inference and regression techniques.
6. Apply data pre-processing techniques.

Module	Detail Content	Hrs.
1	**Introduction:** Big Data and Data Science - Big Data Analytics, Business intelligence vs Big data, big data frameworks, Current landscape of analytics, data visualisation techniques, visualisation software	4
2	**Algorithmic Problem Solving:** Algorithms, building blocks of algorithms (statements, state, control flow, functions); algorithmic problem solving; iteration, recursion. Illustrative problems: finding minimum in a list, guess an integer number in a range, factorial of a number.	6
3	**Data, Expressions, Statements in Python:** Python Strengths and Weakness; Installing Python; IDLE - Spyder – Jupyter; Mutable and Immutable Data Types, Naming Conventions; String Values; String Operations; String Slices; String Operators; String functions – split, join, chr, ord; Numeric Data Types; Arithmetic Operators and Expressions; Comments in the Program; Understanding Error Messages	6
4	**Data Collection and Language Component of Python:**	7

	List; Tuples; Sets; Dictionaries; Sorting Dictionaries; Control Flow and Syntax; Indenting; The if statement; Relational Operators; Logical Operators; Bit-wise Operators; The while Loop – break and continue statements; The for Loop; List Comprehension	
5	**EDA:** Exploratory Data Analysis (EDA), statistical measures, Basic tools (plots, graphs and summary statistics) of EDA, Data Analytics Lifecycle, Discovery. Developing Initial Hypotheses, Identifying Potential Data Sources, EDA case study, testing hypotheses on means, proportions and variances	7
6	**Data Pre-processing and Feature Selection**: Data cleaning - Data integration - Data Reduction - Data Transformation and Data Discretization, Feature Generation and Feature Selection, Feature Selection algorithms: Filters- Wrappers - Decision Trees - Random Forests	6

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation: Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum

Text/Reference Books:

1. Mining of Massive Datasets. v2.1, Jure Leskovek, Anand Rajaraman and Jefrey Ullman., Cambridge University Press. (2019). (free online).
2. Big Data Analytics, paperback 2nd ed., Seema Acharya, Subhasini Chellappan, Wiley (2019).
3. Robert Sedgewick, Kevin Wayne, Robert Dondero, Introduction to Programming in Python: An Inter-disciplinary Approach, Pearson India Education Services Pvt. Ltd., 2016.
4. Data Mining: Concepts and Techniques", Third Edition, 2 Jiawei Han, Micheline Kamber and Jian Pei, ISBN 0123814790,(2011).
5. Big Data and Business Analytics, Jay Liebowitz, CRC press (2013)

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ME526T	Computer Aided Design	Contact Hours	3	-	-	3
		Credits	3	-	-	3

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal Assessment			End Sem Exam				
		IA 1	IA 2	Average					
ME526T	Computer Aided Design	40	40	40	60	-	-	-	100

Prerequisites:

1. Linear Algebra – Basics of Matrix Multiplication and Coordinate Geometry
2. Good programming skills

Course Objectives:

1. Learn the rudiments of Computer Aided Design (CAD) and CAD systems.
2. Use 3D modeling software to accurately generate and easily modify graphical representations of the product
3. Enable the use of efficient product data management techniques.
4. Enable the use of programming languages to program various algorithms for problem solving—related to generation of computer graphics and application to engineering design process.

Course Outcomes: Upon completion of the course, learner will be able to

1. Integrate the role of graphic communication in the engineering design process.
2. Use algorithmic foundation for solving problems by writing computer programs.
3. Implement 2D and 3D transformations for positioning/shaping objects, or to change viewing positions, or even to change how something is viewed (e.g. perspective projections)
4. Formulate the parametric representation of standard conic shapes, 2D and 3D freeform curves and surfaces in the most efficient manner—required for creating complex profiles and geometries.
5. Describe various techniques of computer simulated reality i.e. virtual realism.

Module	Detail Content	Hrs.
1.	**Introduction to Computer Graphics (ICG):** Definitions, Classification, Architecture of ICG, Applications; Display & Interactive devices. **Scan Conversion:** Pixel plotting, Scan Conversion of Line, Circle, Ellipse, Parabola, Hyperbola; Effects of Scan conversion. **Polygons:** Types, Polygon filling using Boundary fill, Edge fill, Flood fill algorithm.	6
2.	**Object Transformations:** 2D & 3D (Translation, Rotation, Reflection, Scaling, Shearing); Homogeneous Coordinates, Decomposition of combined transformation matrix into basic transformation matrices (limited to three matrices) taken in order.	6

3.	**Viewing & Clipping:** 2D and 3D types. **Projections:** Parallel & Perspective Projections.	6
4.	**Curves:** Spline curve, Bezier curve, DeCasteljau Algorithm for generating Bezier curves (limited to cubic curves), B-Spline curve, NURBS curve **Surfaces:** Hermite, Bezier & B-Spline surfaces	6
5.	**Virtual Reality:** Hidden Lines & Hidden Surfaces: Z-Buffer, Painters, Area-Subdivision, Scan Line algorithm; Light, Color & Shading Models, Animation	6
6.	**CAD & Geometric Modeling:** Features of Modeling & Assembly Packages, Types of Geometric Modeling, Data Structures, Product Data Exchange Formats.	6

Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation: Class Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum

Text/Reference Books:

1. Computer Grahics –F.S Hill. Jr
2. Computer Graphics—Zhigang Xiang & Roy Plastock (Schaum's Outlines)
3. Computer Graphics—Hearn & Baker
4. Mathematical Elements for Computer Graphics—David F. Rogers, James Alan Adams
5. Procedural Elements for Computer Graphics—David F. Rogers, James Alan Adams
6. Mastering CAD/CAM—Ibrahim Zeid
7. Geometric Modelling—Mortenson, M.E.
8. Computer Graphics—Amarendra Sinha, ArunUdai
9. Fundamentals of Computer Graphics—Peter Shirley
10. CAD/CAM - Theory and Practice—Ibrahim Zeid, R Sivasubramanian
11. CAD/CAM—MikellGroover, Emory Zimmers Jr.
12. CAD CAM - Principles, Practice, and Manufacturing Management—Chris McMahon, Jimmie Browne
13. Curves and Surfaces in Computer Aided Geometric Design—Fujio Yamaguchi
14. Computer Graphics – Principles & Practice—Foley, van Dam, Feiner, Hughes
15. Computer Aided Engineering Design—AnupamSaxena, Birendra Sahay

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ME527T	Reliability Engineering	Contact Hours	3	-	-	3
		Credits	3	-	-	3

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal Assessment			End Sem Exam				
		IA 1	IA 2	Average					
ME527T	Reliability Engineering	40	40	40	60	-	-	-	100

Prerequisites:

1. Industrial Engineering and Management

Course Objectives:

1. Demonstrate the approaches and techniques to assess and improve process and/or product quality and reliability.
2. Illustrate the basic concepts and techniques of modern reliability engineering tools.

Course Outcomes: Upon successful completion of this course, learner will be able to

1. Understand and apply the concept of Probability to engineering problems
2. Apply various reliability concepts to calculate different reliability parameters
3. Estimate the system reliability of simple and complex systems
4. Carry out a Failure Mode Effect and Criticality Analysis

Theory Syllabus:

Module	Detailed Content	Hrs.
1	**Probability theory:** Probability: Standard definitions and concepts; Conditional Probability, Baye's Theorem. Probability Distributions: Central tendency and Dispersion; Binomial, Normal, Poisson, Weibull, Exponential, relations between them and their significance. Measures of Dispersion: Mean, Median, Mode, Range, Mean Deviation, Standard Deviation, Variance, Skewness, Kurtosis.	06
2	**Reliability Concepts:** Reliability definitions, Reliability functions, Importance of Reliability, Quality Assurance and Reliability. Failure Data Analysis: Hazard rate, failure density, Failure Rate, Mean Time To Failure (MTTF), MTTF in terms of failure Density, Mean time in failure in integral form. Mean time between failure (MTBF).	06
3	**Reliability Hazard Models**: Hazard rate, derivative of the Reliability functions in terms of the hazard rate, Hazard Models – Bathtub curve Constant Failure Rate, linearly increasing, Time Dependent Failure Rate, Weibull Model.	08

	Distribution MTTF in terms of failure Density, Mean time in failure in integral form functions and reliability analysis.	
4	**System Reliability:** System Configurations: Series, parallel, mixed configuration, k- out of n structure, Complex systems, Markov models.	06
5	**Reliability Improvement:** Reliability improvement of component, Redundancy Techniques: Element redundancy, Unit redundancy, Standby redundancies. Markov analysis. System Reliability Analysis – Enumeration method, Cut-set method, Success Path method, Decomposition method	06
6	**Maintainability and Availability:** Design for Maintainability: Maintenance requirements, Design methods: Fault Isolation and self-diagnostics, Parts standardization and Interchangeability, Modularization and Accessibility, Repair Vs Replacement. Availability – qualitative aspects.	08

Theory Assessment:

Internal Assessment: 40 marks

1. Consisting of One Compulsory Class Tests of 40 Marks
2. Continuous evaluation : Test/Assignments /Quiz/Case studies/Seminar presentation of 40 Marks

End Semester Examination: 60 Marks

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

Books/References:

1. L.S. Srinath, “Reliability Engineering”, Affiliated East-West Press (P) Ltd., 1985.
2. Charles E. Ebeling, “Reliability and Maintainability Engineering”, Tata McGraw Hill.
3. B.S. Dhillion, C. Singh, “Engineering Reliability”, John Wiley & Sons, 1980.
4. P.D.T. Conor, “Practical Reliability Engineering”, John Wiley & Sons, 1985.
5. K.C. Kapur, L.R. Lamberson, “Reliability in Engineering Design”, John Wiley & Sons.
6. Murray R. Spiegel, “Probability and Statistics”, Tata McGraw-Hill Publishing Co. Ltd.

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ME532L	Modelling and Simulation Lab	Contact Hours	2	-	-	2
		Credits	1	-	-	1

Course Code	Course Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal Assessment			End Sem Exam				
		IA 1	IA 2	Average					
ME532L	Modelling and Simulation Lab	-	-	-	-	25	25	-	50

Course Objectives:

1. To impart skills to develop CAD models of complex shapes and assemblies.
2. To provide knowledge to perform finite element analysis of systems.
3. To study concept of mathematical modelling of the control system
4. To acquaint with control system under different time domain
5. To understand modelling and simulation of a process /assembly line

Course Outcomes: Learner will be able to

1. Develop 3D model of mechanical components and assemblies
2. Model and perform finite element analysis of real life systems.
3. Understand and study basics of control systems though simulation
4. Design and develop a control system for specific use
5. Model and simulate a assembly line using simulation software

Exercise	Detail Contents	Hrs
1	Develop 3D model	4
2	Structural Analysis of CAD model	4
3	Modeling and design of control system for quarter car suspension model using any suitable modeling and analysis software	4
4	System Identification of Spring Mass Damper System for step input & harmonic input and determination of poles and zeros of system. (Spring Mass Damper setup with all required position sensors mounted is to be characterized for step input, it is suggested to determine transfer function (i.e. input output relation) of the setup and plotting its transient and frequency response (Bode plot, root locus etc.	4
5	Modelling and simulation of discrete event process or assembly line using simulation software (ExtendSim, Arena etc)	4
6	CNC Tool Path Generation/Simulation using CAD and CAM Packages.	4

Assessment Scheme:

Term Work:

The distribution of marks for term work shall be as follows:

Exercises : 20 Marks

Attendance : 05 Marks

Practical/Oral examination

1. Each student will be given a practical assignment on the basis of the above exercises which will be completed within a given time and assessed by examiners during the oral examination.
2. The distribution of marks for oral-practical examination shall be as follows:

   Practical Assignment : 15 marks

   Oral : 10 marks
3. Evaluation of practical/oral examination to be done based on the performance of practical assignment.
4. Students work along with evaluation report to be preserved till the next examination

Text Books/References:

1. Daryl Logan, A First course in Finite Element Method, Thomson Learning
2. David V Hutton, Fundamentals of Finite Element Analysis, Tata McGraw Hill
3. Gokhale, N. S. (2008). Practical finite element analysis. Pune: Finite To Infinite.
4. I. J. Nagrath, M. Gopal, “Control System Engineering”, New Age International, 2009.
5. Norman Nise, “Control Systems Engineering”, Wiley, 8th edition, 2019.