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 2025-26

First Year - Effective from Academic Year **2025-26**

Second Year - Effective from Academic Year **2026-27**

as per

Choice Based Credit and Grading System

Mahatma Education Society's

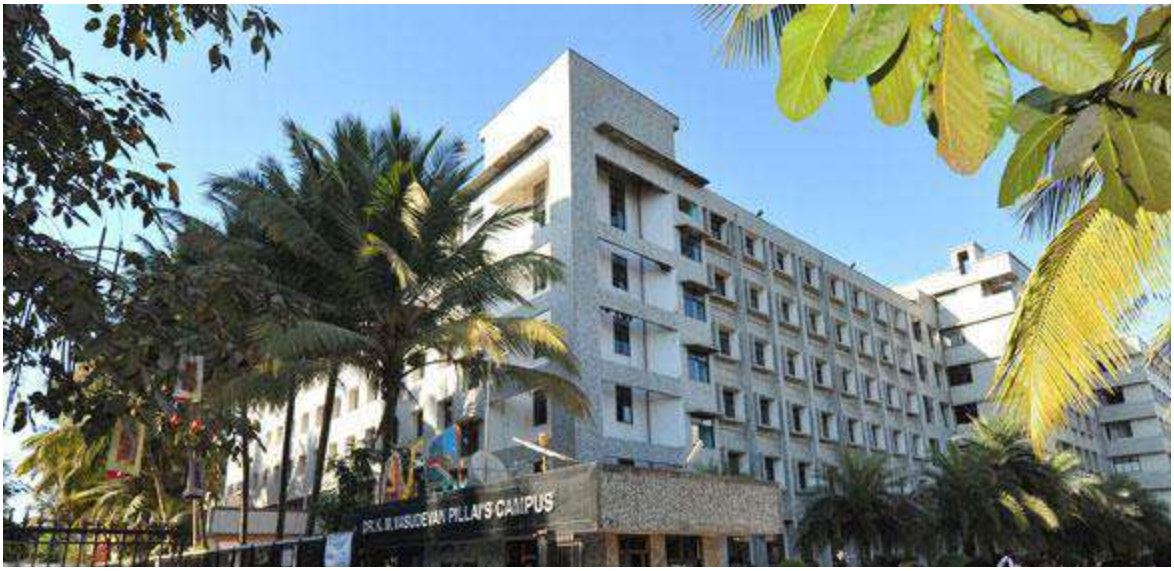
Pillai College of Engineering

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 Engineering

Semester I

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract	Theory	Practical	Total
CE 500	Computer Programming Paradigms	03	--	03	--	03
COMM 501	Business Communication and Intellectual Property	03	--	03	--	03
MECH 5xx	Department Level Optional Course I	03	--	03	--	03
MECH 5xx	Department Level Optional Course II	03	--	03	--	03
MECH 5xx	Department Level Optional Course III	03	--	03	--	03
MECH 5xx	Specialization Lab I	--	02	--	01	01
ENGG 597	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					
CE 500	Computer Programming Paradigms	40	40	40	60	3	-	-	100
COMM 501	Business Communication and Intellectual Property	40	40	40	60	3	-	-	100
MECH 5xx	Department Level Optional Course I	40	40	40	60	3	-	-	100
MECH 5xx	Department Level Optional Course II	40	40	40	60	3	-	-	100
MECH 5xx	Department Level Optional Course III	40	40	40	60	3	-	-	100
MECH 5xx	Specialization Lab I	--	--	--	--	--	25	25	50
ENGG 597	Dissertation I	--	--	--	--	--	25	25	50
TOTAL		**200**	**200**	**200**	**300**	**15**	**50**	**50**	**600**

Department Specialization:

Course	Course Code	Course Name
CAD CAM and Robotics		
DLOC I	MECH 501	Computer Aided Synthesis of Mechanisms
	MECH 502	Advanced Finite Element Analysis
	MECH 503	Artificial Intelligence and Neural Network
DLOC II	MECH 504	Smart Materials
	MECH 505	Fatigue and Fracture Analysis
DLOC III	MECH 506	Microprocessor and Controllers
	MECH 507	Advanced Mechatronics
	ENGG 510	Control Engineering
Specialization Lab I	MECH 508	Robotics and Mechatronics Lab

Course	Course Code	Course Name
Thermal Engineering		
DLOC I	MECH 521	Numerical Methods and Computational Techniques
	MECH 522	Advanced Fluid Mechanics
	MECH 523	Experimental Methods for Thermal and Fluid Systems
DLOC II	MECH 524	Solar Energy Engineering
	MECH 525	Cryogenics
	ENGG 383	Energy Audit and Management
DLOC III	MECH 526	Refrigeration and Air conditioning System Design
	MECH 527	Wind Energy and Conversion Systems
Specialization Lab I	MECH 528	Renewable Energy Lab

Course	Course Code	Course Name
Electric Vehicle		
DLOC I	MECH 541	Electric Vehicles
DLOC II	MECH 542	Vehicle Dynamics for EV's
DLOC III	MECH 543	Power electronics for EVs
Specialization Lab I	MECH 544	Electric Vehicles Lab

Program Structure for
Master of Technology in Mechanical Engineering

Semester II

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract	Theory	Pract	Total
MECH 5xx	Specialization Core Course I	03	--	03	--	03
MECH 5xx	Specialization Core Course II	03	--	03	--	03
MECH 5xx	Department Level Optional Course IV	03	--	03	--	03
MECH 5xx	Department Level Optional Course V	03	--	03	--	03
MECH 5xx	Department Level Optional Course VI	03	--	03	--	03
MECH 5xx	Specialization Lab II	--	02	--	01	01
ENGG 598	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					
MECH 5xx	Specialization Core Course I	40	40	40	60	3	--	--	100
MECH 5xx	Specialization Core Course II	40	40	40	60	3	--	--	100
MECH 5xx	Department Level Optional Course IV	40	40	40	60	3	--	--	100
MECH 5xx	Department Level Optional Course V	40	40	40	60	3	--	--	100
MECH 5xx	Department Level Optional Course VI	40	40	40	60	3	--	--	100
MECH 5xx	Specialization Lab II	--	--	--	--	--	25	25	50
ENGG 598	Dissertation II	--	--	--	--	--	25	25	50
TOTAL		**200**	**200**	**200**	**300**	**15**	**50**	**50**	**600**

Department Level Optional Course:

Course	Course Code	Course Name
CAD CAM and Robotics		
Specialization Core Course I	MECH 509	Computer Aided Manufacturing
Specialization Core Course II	MECH 510	Advanced Robotics
DLOC IV	MECH 511	Additive Manufacturing
	MECH 512	Micro Electro Mechanical Systems
	MECH 308	Manufacturing Analytics
DLOC IV	DES 382	Product Design
	ENGG 402	Quality Engineering
	MECH 320	Optimization Techniques
DLOC VI	MECH 513	Data Science and Expert Systems
	MECH 514	Computer Aided Design
	ENGG 301	Reliability Engineering
Specialization Lab II	MECH 515	Modelling and Simulation Lab

Course	Course Code	Course Name
Thermal Engineering		
Specialization Core Course I	MECH 529	Modeling and Analysis of Thermal System
Specialization Core Course II	MECH 530	Advanced Heat Transfer
DLOC IV	MECH 314	Computational Fluid Dynamics
	MECH 531	Thermal Design of Electronic Equipment
DLOC IV	MECH 532	Heat Exchanger Design and Performance
	MECH 533	Advanced Turbo Machinery
DLOC VI	MECH 534	Thermal Energy Storage Systems and Applications
	MECH 304	Sustainable/Zero Energy Buildings
Specialization Lab II	MECH 535	Computational Fluid Dynamics Lab

Course	Course Code	Course Name
Electric Vehicle		
Specialization Core Course I	MECH 546	Energy Storage systems for EV applications
Specialization Core Course II	MECH 547	Introduction to EV charging station system design
DLOC IV	MECH 548	Thermal Management for Electric Vehicles
DLOC IV	MECH 549	Testing and Certification of EVs
DLOC VI	MECH 550	Motor Drives and Control Systems for EV/HEVs
Specialization Lab II	MECH 551	EV Charging Station System Design Lab

Program Structure for
Master of Technology in Mechanical Engineering

Semester III

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract	Theory	Pract	Total
ENGG 695	Internship / Relevant Certification	-	-	-	03	03
ENGG 697	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					
ENGG 695	Internship / Relevant Certification	-	-	-	-	-	50	50	100
ENGG 697	Dissertation III	-	-	-	-	-	100	-	100
TOTAL		-	-	-	-	-	150	50	200

Program Structure for
Master of Technology in Mechanical Engineering

Semester IV

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract	Theory	Pract	Total
ENGG 698	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
		IA 1	IA 2	Avg					
ENGG 698	Dissertation IV	-	-	-	-	-	100	100	200
TOTAL		-	-	-	-	-	100	100	200

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
CE 500	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					
CE 500	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

Back to Scheme

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
COMM 501	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					
COMM 501	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, Licensing of copyrights, Infringement of copyrights, Remedies and actions, Copyright for digital media, Software/ Internet **Patents**- Concept of patent, Product/Process	8	CO5

		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

Back to Scheme

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
MECH 501	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					
MECH 501	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.

Back to Scheme

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
MECH 502	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					
MECH 502	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,	04

	higher order one-dimensional and two-dimensional elements in terms of classical interpolation polynomials, Isoparametric elements, numerical integration.	
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.

Back to Scheme

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
MECH 503	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					
MECH 503	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 curves, Learning rate annealing techniques, perceptron — convergence theorem,	8

	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.

Back to Scheme

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
MECH 504	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					
MECH 504	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/

Back to Scheme

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
MECH 505	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					
MECH 505	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.

Back to Scheme

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
MECH 506	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					
MECH 506	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

Back to Scheme

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
MECH 507	Advanced 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					
MECH 507	Advanced 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

Back to Scheme

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
MECH 508	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					
MECH 508	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.

Back to Scheme

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
MECH 509	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					
MECH 509	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.

Back to Scheme

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
MECH 521	Numerical Methods and Computational 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					
MECH 521	Numerical Methods and Computational Techniques	40	40	40	60	-	-	-	100

Course Objectives:

1. To impart knowledge on numerical methods that will come in handy to solve the problems that arise in Thermal Engineering.
2. To study and apply numerical solution techniques for the ordinary and partial differential equations governing the Thermal engineering problems.
3. To study the mathematical structure which could be used to describe the behaviour and results of most numerical methods commonly used in Thermal Engineering problems.
4. To write code for some real-lifeThermal Engineering problems.

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

1. Solve governing equations in thermal Engineering using numerical methods.
2. Identify live Initial value problems and boundary value problems arise in thermal engineering
3. and use suitable numerical methods to solve them.
4. Write codes for thermal engineering problems in MATLAB, C, C++ and also to solve thermal
5. engineering problems.

Detailed Theory Syllabus:

Module	Details Content	Hrs
01	**High speed computation:** Introduction, Errors and Analysis- Accuracy of Numbers, Types of errors, Machine Computation, Brief introduction of computer software which can be used in solving the problems numerically.	02
02	**Root finding for polynomial and transcendental equation:** Bisection method, Iteration Method-Successive Approximation, Iteration method for system of non-linear equations,Secant method, Regula-Falsi method, Newton-Raphson methodMethods for multiple roots, Muller's method, Methods for complex roots,Bairstow method, Rate of convergence, Merits, and demerits of methods	07
03	**Solution of simultaneous Linear Algebraic Equations:** Direct Methods-Gauss elimination, Pitfalls of Gauss Elimination method, LU factorizationCholeski Decomposition method, Iterative methods-Jacobi method, Gauss-Seidel method	07

04	**Interpolation and Curve Fitting:** Lagrange and Newton interpolation,Finite difference operators, interpolating polynomials using finite differences, Hermite Interpolation, Bivariate Interpolation, Piecewise and Spline interpolation, Least-squares approximation, Fitting of non-linear curves, Polynomial functions, Multiple linear regression. Significance of interpolating polynomials in numerical differentiation and in numerical integration methods which are studied at the lower semesters.	10
05	**Numerical Solution of Ordinary Differential Equations:** Initial Value Problems- Single step methods and Multi step methods, Milne's Method, Runge-Kutta methods, Solution of simultaneous differential equations and higher order equations, Boundary Value Problems- Shooting method, Finite difference method, Finite difference representation of differential equations	07
06	**Numerical Solution of Partial Differential Equations:** Elliptic, Parabolic and Hyperbolic Partial Differential Equations and their solutions using finite difference schemes, Explicit and Implicit schemes. Stability, Applications of finite difference method to thermal engineering problems like temperature distribution in a rod etc.	08

Students must understand the practical applications of Numerical methods by writing codes for 1-d and 2-d steady and unsteady thermal problem in MATLAB, C, C++ as part of assignments in Term Work:

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 50 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/Reference Books:

1. Computer Based Numerical and Statistical Techniques, Manish Goyal, Laxmi Publications (P) Ltd, New Delhi
2. Numerical Methods for Engineers, Chapra S C, Candle R P, 2nd Ed, NcGraw-Hill, New York
3. Applied Numerical Analysis, Gerald CF, Wheatley PO, 6thedition, Pearson Education, 1999
4. Numerical Mathematics and Computing, Cheney W., Kincaid D., 5thedition, Thomson / BrooksCole, 2004.
5. Numerical Methods for Partial Differential Equations, William F. Ames, 2nd Edition, Academic Press, 1977
6. Numerical Methods for Scientific and Engineering Computation, M.K. Jain, S.R.K. Iyengar, R.K.Lain, New Age International (P) Limited.
7. Numerical Methods in Engineering, Salvadori M G, Baron M L, Prentice-Hall

Back to Scheme

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
MECH 522	Advanced Fluid Mechanics	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					
MECH 522	Advanced Fluid Mechanics	40	40	40	60	-	-	-	100

Objectives:

1. To study application of mass, momentum and energy equations in fluid flow.
2. To study different types of turbulent model
3. To study incompressible and compressible fluid flow
4. To familiarize with dimensional analysis of Thermal and Fluid systems.

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

1. Formulate and solve equations of the control volume for fluid flow systems
2. Calculate resistance to flow of incompressible fluids through closed conduits and over surfaces.
3. Select suitable turbulent model for fluid flow problem
4. Apply fundamentals of compressible fluid flows to relevant systems
5. Illustrate understanding of dimensional analysis of Fluid systems.

Detailed Theory Syllabus:

Module	Details Content	Hrs
01	Eulerian & Lagrangian coordinates, Definition and equations for source, sink, irrotational vortex, circulation concept of circulation. Navier-Stokes equations-differential & integral approach, energy equations, governing equations for Newtonian fluids, boundary conditions Momentum of fluid in motion: impulse momentum relationship and its applications for determination of thrust for pipe bend	08
02	Viscous Incompressible Flows: Exact solutions for Couette flow, Poiseuille flow, flow between rotating cylinders, Stokes first problem, Stokes second problem, pulsating flow between parallel surfaces, stagnation-point flow, flow over porous wall. Stokes approximation,	06
03	Introduction to dimensional analysis of thermal and fluid systems, Methods of dimensional analysis - Buckingham π Theorem and Rayleigh's Method (Only derivations, no numerical) Boundary Layer Theory: Review of boundary layers: laminar and turbulent boundary layers; transition; separation, Blasius' solution for boundary layer	06

04	Potential Flows: Stokes stream functions, solution of potential equation, flow in a sector, flow around a sharp edge, flow near a blunt nose force and moment on a circular cylinder and sphere, conformal transformations, Joukowski transformations, Elements of airfoil and wing theory.	06
05	Introduction to turbulence: Transition of flows, Origin of turbulence- its consequences; Physics of turbulent motion- concept of Reynolds stress, mean flow equations, Turbulence models RANS, LES. DNS	06
06	Compressible Fluid flow: Propagation of sound waves through compressible fluids, Sonic velocity and Mach number; Stagnation properties, Application of continuity, momentum and energy equations for steady-state conditions; Steady flow through the nozzle, Isentropic flow through ducts of varying cross-sectional area, Effect of varying back pressure on nozzle performance, Critical pressure ratio.. Application to subsonic, transonic and supersonic flow around a two-dimensional aerofoil.	07

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/ReferenceBooks:

1. Advanced Fluid Mechanics, K. Muralidhar& G. Biswas, Narosa Publishing, 2005.
2. Boundary Layer Theory, H. Schlichting, 6th Edition, McGraw-Hill Inc., 1986.
3. Turbulent Flow, R. J. Garde, 2nd Edition, New Age International Publishers.
4. Foundations of Fluid Mechanics, S.W. Yuan, Prentice-Hall India Pvt. Ltd, New Delhi.
5. Modern Compressible Flow with Historical Perspective, John D. Anderson, McGraw Hill.
6. Fundamentals of Aerodynamics (2nd ed), J. D. Anderson, McGraw Hill.
7. Viscous Fluid Flow, F. M. White, 2nd Edition, McGraw-Hill, 1991.
8. Fundamentals of Fluid Mechanics , B.R. Munson, D.F. Young & T.H. Okiishi, 2nd Ed., John
9. Wiley.
10. Introduction to Fluid Mechanics, R.W. Fox & A.T. McDonald, 5th Edition, John Wiley, 2001.

Back to Scheme

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
MECH 523	Experimental Methods for Thermal & Fluid 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					
MECH 523	Experimental Methods for Thermal & Fluid Systems	40	40	40	60	-	-	-	100

Objectives:

1. To convince the importance of experimentation
2. To familiarize the various instruments
3. To enable the students to design the experiments
4. To develop the instrument selection skill.

Outcomes:

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

1. Plan and execute the experiment.
2. Learn the different strategies of experiments.
3. Select the electrical measurements and sensing devices.
4. Select and measure the flow, pressure and thermal conductivity.
5. Calibrate the instruments.
6. Measure the heat flux.

Detailed Theory Syllabus:

Module	Details Content	Hrs
01	Experiment versus simulation, need of experimentation, Experimental planning and analysis of results:Importance of experiments in engineering and science, stages of typical experiment, Experimental planning, literature survey and equipment identification, test section design, fabrication and instrumentation, test facility calibration and measurements, Analysis of Results: and Data reduction,Using Excel to present and analyse data, spreadsheets for data analysis.	06
02	Design of experiments: Strategy of experimentation, Typical applications of experimental design, Types of experiments, guidelines for designing experiments, experiment design factors & protocol and examples.Analysis of Experimental Data, Causes and Types of Experimental Errors, Error Analysis on a Commonsense Basis, Uncertainty Analysis and Propagation of Uncertainty Graphical Analysis and Curve Fitting, Choice of Graph Formats	07

03	Basic electrical measurements and sensing devices, basic analog & digital meters, power supplies, signal conditioning, digital voltmeter, output recorders, counters-time and frequency measurements, difference between analog and digital instruments. Temporal response of probes and transducers: measurement system model, system response, amplitude response, frequency response, zeroth, first, and second order systems; examples of thermocouple response, anemometer. Probe compensation in the frequency domain.	06
04	Flow measurements: Positive displacement and flow obstruction methods, flow measurement by drag effects, magnetic flow meters, flow visualisation methods, the shadowgraph. Thermal conductivity measurements, thermal conductivity of liquids and gases, heat flux meters, detection of thermal radiation, detection of nuclear radiation.	06
05	Probes and transducers: Pressure transducers; noise measurement, Velocity - Pitot static tube (low as well as high speeds), 5-hole probe, Hotwire anemometer, CCA, CTA, Laser Doppler velocimetry, Particle image velocimetry. Temperature measurement: thermocouples, RTD, thermistor, infrared thermography, Heat flux measurement.	06
06	Calibration of measuring sensors and instruments Principles of calibration, control of calibration environment, calibration chain and traceability, calibration records,	06

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. C. Tropea, A.L. Yarin, and J.F. Foss, Editors, Springer Handbook of Experimental Fluid Mechanics, 2007.
2. T.G. Beckwith and N.L. Buck, Mechanical Measurements, Addison-Wesley, MA (USA), 1969.
3. H.W. Coleman and W.G. Steele Jr., Experiments and Uncertainty Analysis for Engineers, Wiley & Sons, New York, 1989.
4. E.O. Doeblin, Measurement Systems, McGraw-Hill, New York, 1986.
5. R.J. Goldstein (Editor), Fluid Mechanics Measurements, Hemisphere Publishing Corporation, New York, 1983; second edition, 1996.
6. J. Hecht, The Laser Guidebook, McGraw-Hill, New York, 1986.
7. B.E. Jones, Instrumentation Measurement and Feedback, Tata McGraw-Hill, New Delhi, 2000.
8. M. Lehner and D. Mewes, Applied Optical Measurements, Springer-Verlag, Berlin, (1999).
9. F. Mayinger, Editor, Optical Measurements: Techniques and Applications, SpringerVerlag, Berlin, 1994.
10. D.C. Montgomery, Design and Analysis of Experiments, John Wiley, New York, 2001.
11. A.S. Morris, Principles of Measurement and Instrumentation, Prentice Hall of India, New Delhi, 1999.

12. F. Natterer, The Mathematics of Computerized Tomography, John Wiley & Sons, New York, 1986.
13. P.K. Rastogi, Ed., Photomechanics, Springer, Berlin, 2000.
14. M. Van Dyke, An Album of Fluid Motion, The Parabolic Press, California, 1982
15. Langari, R., Morris, A. S. (2015). Measurement and Instrumentation: Theory and Application. Netherlands: Elsevier Science.
16. Wright, L. M., Han, J. (2020). Experimental Methods in Heat Transfer and Fluid Mechanics. United States: CRC Press.
17. Kirkup, L. (2019). Experimental Methods for Science and Engineering Students: An Introduction to the Analysis and Presentation of Data. United Kingdom: Cambridge University Press.

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Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
MECH 524	Solar Energy 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					
MECH 524	Solar Energy Engineering	40	40	40	60	-	-	-	100

Objectives:

1. To learn the basics of the solar energy spectrum.
2. To learn about types of Solar cells and their ratings.
3. To learn the solar thermal system; an energy efficient approach.
4. To learn about solar power plants.

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

1. Get knowledge of the competing demands and requirements of the various solar operated
2. electrical power network.
3. Understand how renewable generation and distributed storage interacts with and is integrated
4. into the power network.
5. Understand Solar energy measurement techniques.
6. Understand Need of solar cooling system to reduce dependency on the mains grid.

Detailed Theory Syllabus:

Module	Details Content	Hrs
01	Introduction to solar energy, World and Indian energy scenario, Solar spectrum,Solar constant, Solar Energy & Environment, Energy scenario and sustainable development through solar energy.	04
02	Solar energy measurement: Estimation of solar energy on earth's surface, characteristics of solar radiation, Sun –earth geometry and its effect on solar energy reaching on earth's surface, Depletion of solar radiation - Absorption, scattering, Solar day length – Sun path diagram – Shadow determination. Estimation of Sunshine hours, Calculation of total solar radiation on horizontal and tilted surfaces.	07
03	Solar Photovoltaic system : Solar Cell, PV Module and Solar arrays:- Parameters of solar cell, Effect of conversion efficiency, change in amount of input light, change in solar cell area, change in angle of light falling on PV Panel, Change in solar cell operating temperature, I-V characteristics of solar cell PV Module parameters, Measuring PV Module parameters, Series connection of PV Modules, Parallel connection of PV Modules, Mixed Combination of connections	07
04	Solar thermal system: Flat Plate Collector, Hot Air Collector, Evacuated Tube	07

	Collector, Parabolic, Compound Parabolic and Fresnel Solar Concentrators, Central Receiver System, Performance and Thermal Analysis of Solar Collectors, Solar Water Heating Systems (Active & Passive), Solar Dryers & Desalination Systems	
05	Electrical energy conversion from solar energy: Solar Power plant, Estimating power and energy demand, site selection, land requirements, choice of modules, economic comparison, off grid systems, grid interface, economic analysis.	07
06	Solar Cooling: Potential and scope of solar cooling. Types of solar cooling systems, Solar refrigeration and air conditioning. Solar desiccant cooling system. Solar cooling alternatives. Advanced solar cooling systems. Solar thermoelectric refrigeration and airconditioning. Economics of solar cooling.	07

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.

Text/Reference Books:

1. Foster .R, Ghassemi M., Cota A., "Solar Energy", CRC Press, 2010.
2. Duffie .J.A, Beckman W.A. "Solar Engineering of Thermal Processes", 3rd ed., Wiley, 2006.
3. De Vos .A, "Thermodynamics of Solar Energy Conversion", Wiley-VCH, 2008.
4. Garg .H.P, Prakash .J, "Solar Energy Fundamentals and Applications", Tata McGraw-Hill, 2005.
5. Kalogirou .S, "Solar Energy Engineering", Processes and Systems, Elsevier, 2009.
6. Petela .R, "Engineering Thermodynamics of Thermal Radiation for Solar Power", McGraw-Hill Co., 2010.
7. Yogi Goswami .D, Frank Kreith, Jan F. Kreider, "Principles of Solar Engineering", Second Edition, Taylor & Francis, 2003.
8. Andrews .J, Jelley .N, "Energy Science", Oxford University Press, 2010.
9. Renewable Energy: Power for a Sustainable Future, Edited by Godfrey Boyle, 3rd Edition, Oxford University Press
10. Solar Energy: Principles of Thermal Collection and Storage by SP Sukhatme and J K Nayak, TMH
11. Solar Energy: Fundamentals and Applications by H.P. Garg& Jai Prakash, Tata McGraw Hill.
12. Solar Photovoltaic's: Fundamentals, Technologies and Applications, C S Solanki, 2ndEdition, PHI Learning
13. Renewable Energy Technologies: A Practical Guide For Beginners, PHI Learning
14. Solar Energy: The Physics and Engineering of Photovoltaic Conversion, Technologies
15. By ArnoSmets, Klaus Jäger Olindo Isabella René van Swaaij , UIT Cambridge LTD
16. Solar Photovoltaic Technology And Systems - A Manual For Technicians,Trainers And Engineers, PHI Learning

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Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
MECH 525	Cryogenics	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					
MECH 525	Cryogenics	40	40	40	60	-	-	-	100

Objectives:

1. To impact knowledge on cryogenic systems
2. To learn about different process involved for liquefaction and cryocoolers
3. To get the knowledge on the properties of both matter and fluid for better design of the process equipment in cryogenics application
4. To understand the gas liquefaction and refrigeration system
5. Instrumentation in cryogenic system is essential for measuring properties at low temperature
6. Safety in cryogenics is highly important for handling liquids or cryogens environments.

Outcomes: Learners will be able to

1. The knowledge on the properties of both matter and fluid for better design of the process equipment in cryogenics application.
2. Understand about operation and maintenance of cryogenic plants.
3. Analyze the existing systems and creation of new systems.

Detailed Theory Syllabus:

Module	Details Content	Hrs
01	Properties of engineering materials at cryogenic temperatures, mechanical properties, thermal properties, electric & magnetic properties, superconducting materials, thermoelectric materials, composite materials, properties of cryogenic fluids, super fluidity of He3 & He4.	06
02	Measurement systems for low temperatures: Temperature measurements, pressure measurements, flow measurements, liquid level measurements, fluid quality measurements.	06
03	Cryogenic insulation: Various types such as expanded foams, gas filled & fibrous insulation, vacuum insulation, evacuated powder & fibrous insulation, opacified powder insulation, multi-layer insulation, comparison of performance of various insulations.	08
04	Minimum work for liquefaction: Methods to protect low temperature. Liquefaction systems for gases other than Neon. Hydrogen and Helium. Liquefaction Systems	08

	for Neon, Hydrogen and Helium: Components of Liquefaction systems. Heat exchangers. Compressors and expanders. Expansion valve.	
05	Applications of cryogenic systems, Super conductive devices such as bearings, motors, cryotrons, magnets, D.C. transformers, tunnel diodes, space technology, space simulation, cryogenics in biology and medicine, food preservation and industrial applications	06
06	Hazards: Physical hazards, Chemical hazards, Physiological hazards, combustion hazards, oxygen hazards, accidents in cryogenic plants & prevention.	05

Assessment:
Internal Assessment for 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 the number of respective lecture hours mentioned in the curriculum.

Books/References:

1. Cryogenic fundamentals-Haselden, Academic press New York
2. Cryogenic technology –Vance
3. Advance cryogenic –bailey, plenum press
4. Cryogenic engineering –Scott
5. Cryogenic systems-Baron, McGraw-Hill book
6. Cryogenic Systems/ R.F. Barren/ Oxford University Press
7. Cryogenic Engineering- Thomas Flynn- CRC Press-2nd Edition
8. Cryogenic Research and Applications: Marshal Sitting/ Von Nostrand/ Inc. New Jersey
9. Cryogenic Heat Transfer/ R.F.Baron
10. Cryogenic Engineering Edit / B.A. Hands/ Academic Press, 1986
11. Cryogenic Engineering/ R.B. Scott Van Nostrand/ Inc. New Jersey, 1959
12. Experimental Techniques in Low Temperature Physics- O.K. White, Oxford Press, 1968
13. Cryogenic Process Engineering/ K. D. Timmerhaus& T M Flynn/ Plenum Press, 1998
14. HandBook of Cryogenic Engineering – J.G. Weisend –II, Taylor and Francis, 1998

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Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ENGG 383	Energy Audit And Management	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					
ENGG 383	Energy Audit And Management	40	40	40	60	-	-	-	100

Objectives:

1. To impart basic knowledge to the students about current energy scenario, energy conservation, audit and management.
2. To inculcate among the students systematic knowledge and skill about assessing the energy efficiency, energy auditing and energy management.
3. To introduce performance evaluation criteria of various electrical and thermal installations to facilitate the energy management
4. To relate the data collected during performance evaluation of systems for identification of energy saving opportunities.

Outcomes: Learner will be able to....

1. To identify and describe the present state of energy security and its importance.
2. To identify and describe the basic principles and methodologies adopted in energy audit of an utility
3. To describe the energy performance evaluation of some common electrical installations and identify the energy saving opportunities.
4. To describe the energy performance evaluation of some common thermal installations and identify the energy saving opportunities.
5. To analyze the data collected during performance evaluation and recommend energy saving measures

Detailed Theory Syllabus:

Module	Details Content	Hrs
01	**Energy Scenario:** Energy needs of growing economy, Long term energy scenario, Energy pricing, Energy sector reforms, Energy and environment: Air pollution, Climate change, Energy security, Energy conservation and its importance, Energy strategy for the future, Energy conservation Act-2001 and its features.	04
02	**Energy Management and Audit:** Definition, Energy audit- need, Types of energy audit, Energy management (audit)	10

	approach-understanding energy costs, Bench marking, Energy performance, Matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution, Energy audit instrument. **Material and Energy balance:** Facility as an energy system, Methods for preparing process flow, Material and energy balance diagrams. **Financial Management:** Investment-need, Appraisal and criteria, Financial analysis techniques- Simple payback period, Return on investment, Net present value, Internal rate of return, Cash flows, Risk and sensitivity analysis, Financing options, Energy performance contracts and role of ESCOs.	
03	**Energy Management and Energy Conservation in Electrical System:** Electricity billing, Electrical load management and maximum demand Control; Power factor improvement, Energy efficient equipment and appliances, star ratings. Energy efficiency measures in lighting system, Lighting control: Occupancy sensors, daylight integration, and use of intelligent controllers. Energy conservation opportunities in: water pumps, industrial drives, induction motors, motor retrofitting, soft starters, variable speed drives.	10
04	**Energy Management and Energy Conservation in Thermal Systems:** Review of different thermal loads; Energy conservation opportunities in: Steam distribution system, Assessment of steam distribution losses, Steam leakages, Steam trapping, Condensate and flash steam recovery system. General fuel economy measures in Boilers and furnaces, Waste heat recovery, use of insulation-types and application. HVAC system: Coefficient of performance, Capacity, factors affecting Refrigeration and Air Conditioning system performance and savings opportunities.	09
05	**Energy Performance Assessment:** On site Performance evaluation techniques, Case studies based on: Motors and variable speed drive, pumps, HVAC system calculations; Lighting System: Installed Load Efficacy Ratio (ILER) method, Financial Analysis.	03
06	**Energy conservation in Buildings:** Energy Conservation Building Codes (ECBC): Green Build Building, LEED rating, Application of Non-Conventional and Renewable Energy Sources	03

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. Handbook of Electrical Installation Practice, Geofry Stokes, Blackwell Science
2. Designing with light: Lighting Handbook, By Anil Valia, Lighting System

3. Energy Management Handbook, By W.C. Turner, John Wiley and Sons
4. Handbook on Energy Audits and Management, edited by A. K. Tyagi, Tata Energy Research Institute (TERI).
5. Energy Management Principles, C.B.Smith, Pergamon Press
6. Energy Conservation Guidebook, Dale R. Patrick, S. Fardo, Ray E. Richardson, Fairmont Press
7. Handbook of Energy Audits, Albert Thumann, W. J. Younger, T. Niehus, CRC Press.

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Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
MECH 526	Refrigeration and Air conditioning System 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					
MECH 526	Refrigeration and Air conditioning System Design	40	40	40	60	-	-	-	100

Objectives:

1. To understand industrial refrigeration and air conditioning systems and their analysis
2. Impart knowledge of psychrometry and its application in air conditioning system design
3. Know how about controls in refrigeration and air conditioning

Outcomes: Learner will be able to

1. Analyse performance of various refrigeration cycles and air conditioning systems
2. Identify suitable refrigeration system and propose design of the same
3. Design conventional or non-conventional air conditioning system for specific application

Detailed Theory Syllabus:

Module	Details Content	Hrs
01	Refrigeration: Cycles: Analysis, Multi-pressure Systems, Refrigerants: Classification of Refrigerants, Refrigerant Properties, Oil Compatibility, Blends, System Design Criteria for New Refrigerants, Phase-out Schedule, Natural Refrigerants.	06
02	System Components : Refrigeration Compressors, Different Types, Performance, Capacity Control, Evaporators, Evaporator Circuitry, Applications and Different Types, Condensers, Types, Evaporative Condensers, Optimum Cooling Water Rate and Velocity, Expansion valve.	06
03	Vapour Absorption Systems: LiBr & Aqua Ammonia Systems. Double Effect Chillers. Solar Energy operated m/c's Industrial Refrigeration: Cold Stores, Ammonia Refrigeration Systems, Safety requirement for refrigeration systems.	08
04	Psychrometrics: Introduction, Properties of air and water vapour mixture. Psychrometric chart and its use in air conditioning. ASHRAE Comfort Chart Design of Equipments: Analysis of air conditioning load, load calculation.Equipment selection and balancing.	07
05	Air Conditioning Systems: Window Type, Package Type, Split Type, Central Units – direct and indirect. Construction details. Evaporative cooling system. Air	06

	Distribution: Air Distribution Devices – Air Circuits – Design of Air Supply System.	
06	Controls: Electrical components & controls, starting and running circuits, relay types and controls, Temperature, Pressure, Oil Flow controls, Compressor Motor-Protection Devices, Refrigeration valves.	05

Assessment:

Internal Assessment: 40 marks

3. Consisting of One Compulsory Class Tests of 40 marks
4. 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. Dossat, R.J., Principles of Refrigeration, John Wiley & Sons, 1989.
2. Stoecker W.F., Refrigeration and Air Conditioning, McGraw Hill Book Company, 1985.
3. Jordan and Priester, Refrigeration and Air Conditioning, 1985.
4. Althouse, A.D. and Turnquist, C.H., Modern Refrigeration and Air Conditioning, Good Heart – Wilcox Co.
5. Hains, J.B., Automatic Control of Heating and Air Conditioning, McGraw Hill, 1981.
6. ASHRAE Handbooks (Fundamentals, Equipments and Systems)
7. Ananthanarayanan P N, Modern Refrigeration and Air Conditioning, McGraw Hill.
8. Shan K Wang, Handbook of Refrigeration & Air Conditioning
9. Threlkeld J L, Thermal Environmental Engineering, Prentice-Hall, 1962
10. Gosney W B, Principles of Refrigeration,Cambridge University Press, 1982
11. Stoecker W. F., Industrial refrigeration, Business News Publishing Company

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Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
MECH 527	Wind Energy and Conversion 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					
MECH 527	Wind Energy and Conversion Systems	40	40	40	60	-	-	-	100

Objectives:

1. Understand the technologies that are used to harness the power of the wind.
2. Develop an intuitive understanding of wind turbine design criterion and its conversion system.
3. Discuss the positive and negative aspects of wind energy in relation to natural and human aspects of the environment.

Outcomes: Learner will be able to

1. Explain the existing wind energy potential..
2. Analyze the various aerodynamic loads and its design criterion on wind turbine systems.
3. Describe the existing Wind Energy Conversion System.
4. Analyze the control mechanism of wind turbines.
5. Understand the application of wind energy with case studies and its environmental impacts.

Detailed Theory Syllabus:

Module	Details Content	Hrs
01	**Basics Of Wind Energy Technology** Wind statistics- Measurements and data Presentation, Historical developments, latest developments, state of art of wind energy technology, turbine rating, economic analysis of wind turbine, Indian scenario and worldwide developments, present status and future trends. Wind turbine aerodynamics.	08
02	**Characteristics Of Wind Energy** Nature of atmospheric winds- Wind resource characteristics and assessment– Anemometry, speed frequency distribution, effect of height, wind rose, Weibull distribution, atmospheric turbulence, gust wind speed, effect of topography. Effect of Reynolds's number, actuator disc, Betz coefficient, design of wind turbine blade, effect of stall and blade tip speed ratio and coefficient of torque.	08
03	**Wind Energy Conversion System (WECS)** Rotor Selection, Annual Energy Output, HAWT, VAWT, Rotor Design Considerations-Number of Blades, Blade Profile -2/3 Blades and Teetering, Coning- Upwind/Downwind, Power Regulation, Yaw System- Tower,	10

	Synchronous and Asynchronous Generators and Loads, Integration of Wind Energy Converters to Electrical Networks, Inverters- Testing of WECS, WECS Control System - Requirements and Strategies.	
04	**Control Mechanisms** Pitch control, yaw control, Electrical and Mechanical aerodynamic braking, teeter mechanism. Wind turbine dynamics with DC and AC generators: induction and synchronous generators, variable speed operation, effect of wind turbulence. Case study of design of wind mill.	07
05	**Wind Energy Application** Wind pumps - Performance analysis, design concept and testing, Principle of WEG- Stand alone, grid connected and hybrid applications of WECS, Economics of wind energy utilization, Wind energy in India.	06

Assessment:
Internal Assessment: 40 marks
Consisting of One Compulsory Class Tests of 40 Marks
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

Books/References:

1. Spera D.A., Wind Turbine Technology: Fundamental Concepts of Wind Turbine Engineering, ASME Press, NY 1994.
2. Martin OL Hansen: Aerodynamics of Wind Turbines, 2nd ed. Earthscan, London.
3. B.H.Khan: Non Conventional Energy Sources, Tata McGraw-Hill Education, 2006.
4. Johnson, G.L., Wind Energy Systems, Prentice Hall, 1985.
5. Martin OL Hansen: Aerodynamics of Wind Turbines, 2nd ed. Earthscan, London.
6. L. L. Freris, Wind Energy Conversion systems, Prentice Hall, UK, 1990.
7. Steve Parker, “Wind power”, Gareth Stevens Publishing, 2004.

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Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
MECH 528	Renewable Energy 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					
MECH 528	Renewable Energy Lab	-	-	-	-	25	25	-	50

Course Objectives:

1. To understand the potential & energy extraction through renewable energy sources.
2. To understand challenges in energy generation through renewable sources.
3. To understand the importance of energy security, improve access to energy.

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

1. Understand the sun earth geometry associated with Solar energy and evaluate the amount of solar flux received on earth's surface.
2. Understand the working of Wind machines as a part of renewable energy source.
3. Evaluate the performance of solar thermal concentrators

The laboratory will focus on the following:

1. Measurement of solar radiation and sunshine hours.
2. Measurement of albedo, UV & IR radiation.
3. Measurement of emissivity, reflectivity, transmissivity.
4. Performance testing of solar flat plate water heater (forced flow & thermosyphon systems).
5. Performance testing solar air heater & dryer & desalination unit.
6. Performance testing of solar thermal concentrators.
7. Characteristics of photovoltaic devices & testing of solar PV operated pumps.
8. Energy consumption & lumen measurement of lights & ballasts.
9. Properties of fuel oils & biomass.
10. Testing of Gasifier or Wind machines or Fuel cell

Laboratory Assessment

Internal Assessment

Term Work Marks : 25 Marks
Laboratory Work (Journal Completion) : 20 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:
Oral Examination: 25 Marks

Text/Reference Books:

1. Non-conventional energy sources by G.D. Rai, Khanna Publishers
2. Renewable Energy:Power for a Sustainable Future, Edited by Godfrey Boyle, 3rd Edition, Oxford University Press
3. Solar Energy: Principles of Thermal Collection and Storage by SP Sukhatme and J K Nayak, TMH
4. Solar Energy: Fundamentals and Applications by H.P. Garg& Jai Prakash, Tata McGraw Hill.
5. Wind Power Technology, Joshua Earnest, PHI Learning, 2014
6. Renewable Energy Sources, J W Twidell& Anthony D. Weir. ELBS Pub.
7. Energy Conversion Systems, R D Begamudre, New Age International (P) Ltd., Publishers, New Delhi, 2000.
8. Solar Photovoltaics: Fundamentals, Technologies and Applications, C S Solanki, 2ndEdition, PHI Learning

Back to Scheme

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
MECH 541	Electric Vehicles	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					
MECH 541	Electric Vehicles	40	40	40	60	-	-	-	100

Course Objectives:

1. To appreciate the need for sustainable transportation options available.
2. To familiarize with basic concepts of Electric vehicles.
3. To acquaint with various aspects of electric drive train and Battery Technology

Course Outcomes: Students will be able to learn:

1. Comprehend the history and evolution of electric & hybrid electric vehicles.
2. Analyze performance characteristics of ICE and EV's.
3. Analyze role of power electronics and use of Electric Motors in EV's.
4. Compare various energy sources and storages for EV's
5. Comprehend the need of thermal management in EV's.
6. Illustrate the need of BMS , chargers in EV's and the role of future technologies in the EV domain.

Module	Detail Content	Hrs.
1	**History and Impact of EVs** History of Transportation and Vehicular Electrification,Vehicular Electrification Resurgence, Challenges and Way Forward,Environmental, Social and Economical Impact of Vehicular Electrification,	04
2	**Overview of IC Engine Technology & its performance** Automobile power train, classification of vehicle power plant Performance characteristics of IC engine, electric motor, need of gear box	04
3	**Fundamental of Electric Propulsion System and Constituent Technologies** EV Configurations,Overview of Electric Propulsion System and its ComponentsRole of Power Electronics Converters in Electric Propulsion System,Electronic Control Unit in EV and HEVs, **Electric Motors and their Control**	10

	Induction Motor and Control for EVs, PMSM Motor and Control for EVs, BLDC Motors and Control for EVs, Switched Reluctance Motor and Control for EVs	
4	**Energy Source and Storage System for EVs** Battery Technologies for EVs,Battery Management System,Ultracapacitor and Flywheel, Fuel Cell Technologies	10
5	**Thermal Management of EV** Guidelines for Thermal Management of EV Thermal Management of Battery,Thermal Management of Power Converter and Electric Motors Policies and Economics for Grid Integration in EV Charging, Specification & Guidelines of Charging Standards in EV Industry,Safety Standards in EV and Recycling of Batteries	05
6	**Introduction to EVs Charging System** EV Charging Infrastructure in India,Types of EV charging,Architecture and working of EV Charging,Operation and Control of EV charging System **Emerging Trends and Advancement in EV Infrastructure** Business Model and Economics associated with vehicular Electrification, Role of AI and Concept of Vehicle to Everything(V2X) in EV Sector	06

Assessment:

Internal Assessment: 40 marks

End Semester Examination: 60 Marks

Books/References:

1. C.C. Chan and K.T. Chau, *Modern Electric Vehicle Technology*, Oxford University Press.
2. Ehsani, M., Gao, Y., Longo, S., and Ebrahimi, K., “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles,” CRC Press, 2018.
3. Iqbal Husain, “Electric and Hybrid Vehicles: Design Fundamentals,” Third Edition, CRC Press, 2021.
4. Kumar, Lalit, and Shailendra Jain, "Electric Propulsion System for Electric Vehicular Technology: A Review," *Renewable and Sustainable Energy Reviews* 29 (2014): 924-940.
5. F. R. Salmasi, "Control Strategies for Hybrid Electric Vehicles: Evolution, Classification, Comparison, and Future Trends," *IEEE Transactions on Vehicular Technology*, vol. 56, no. 5, pp. 2393–2404, Sep. 2007.
6. G. Pistoia, Ed., *Lithium-Ion Batteries: Advances and Applications*. London, England: Elsevier Science, 2018.
7. Warner, John T., *The Handbook of Lithium-Ion Battery Pack Design: Chemistry, Components, Types, and Terminology*. Elsevier, 2024.
8. https://www.niti.gov.in/sites/default/files/202108/HandbookforEVChargingInfrastructureImplementation081221.pdf

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Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
MECH 542	Vehicle Dynamics for EV's	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					
MECH 542	Vehicle Dynamics for EV's	40	40	40	60	-	-	-	100

Course Objectives:

1. To familiarize with basic concepts of vehicle dynamics.
2. To analyze an Electric vehicle in context of ride, handling and longitudinal dynamics of the vehicle.
3. To get acquainted with simulation processes using software in the domain of vehicle dynamics.

Course Outcomes: Students will be able to learn:

1. Analyze the vehicle directional stability.
2. Enumerate the steering systems & directional stability , roll of the vehicle.
3. Demonstrate the ride characteristic of the vehicle.
4. Enumerate the tire dynamics of EV
5. Comprehend the various trends in Vehicle Dynamics.
6. Use simulation tool to see effect of dynamic behaviour

Module	Detail Content	Hrs.
1	**Introduction** Road Loads, Aerodynamics-Drag, Side force, Lift force, Rolling Resistance Total Road Loads, Longitudinal dynamics, effect on acceleration and braking	4
2	**Lateral Dynamics** Introduction about Lateral vehicle Dynamics, steering system position, roll behaviour, understeer oversteer	8
3	**Ride or Vertical Dynamics** **S**uspension geometry, anti pitch anti dive suspension	8
4	**Tire forces and tire modelling of EV**s	8
5	**Design of Transmission Systems for EVs**	6
6	**Simulation** 1. Simulation for Road loads acting on EV 2. Simulation for suspension / tire of EV	6

Assessment:
Internal Assessment: 40 marks
End Semester Examination: 60 Marks

Books/References:

1. Gillespie T.D, ―Fundamentals of Vehicle Dynamics‖, SAE USA 1992
2. Rajesh Rajamani ―Vehicle Dynamics and Control
3. Colin Campbell - Automobile Suspension and Handling
4. J. Y. Wong, ―Theory of Ground Vehicles‖, 3rd ed., John Willey & Sons, New York, 1997.
5. Mehrdad Ehsani, et al , Modern Electric, Hybrid Electric, and Fuel Cell Vehicles Fundamentals, Theory, and Design, CRC Press, 2004

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Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
MECH 543	Power Electronics for EV's	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					
MECH 543	Power Electronics for EV's	40	40	40	60	-	-	-	100

Course Objectives:

1. Provide fundamental knowledge of power electronics and its critical role in electric vehicle (EV) applications
2. Familiarize students with passive power components and their design considerations for EV power conversion units.
3. Explain the working principles and design of various DC–DC converters, inverters, and on-board chargers used in EV systems.
4. Introduce advanced modulation and control techniques for efficient and reliable EV power conversion
5. Explore emerging technologies such as SiC and GaN devices and their applications in high-efficiency EV systems.
6. Develop the ability to model and simulate power electronic circuits.

Course Outcomes: Students will be able to learn:

1. Explain the architecture of EV powertrains and the significance of power electronics in their operation
2. Analyze the role of capacitors, inductors, and transformers in filtering, energy storage, and isolation for EV applications
3. Design and evaluate DC–DC converters ,Inverters for EV systems considering efficiency and switching performance.
4. Apply modulation strategies such as PWM and Space Vector Modulation for inverter control in EV traction systems.
5. Compare conventional silicon devices with emerging SiC and GaN devices for EV power electronics, emphasizing efficiency, thermal benefits, and compact design.
6. Simulate and evaluate the performance of various power electronics topologies used in EVs

Module	Detail Content	Hrs
1	**Fundamentals of Power Electronics for EVs** Introduction to Power Electronics in Electric Vehicle Application. Overview of EV Powertrain and Role of Power Electronics. Review of Power Semiconductor Switches,Characteristics of Ideal and Practical Switches: Diodes, Thyristors, BJTs, MOSFETs, IGBTs, SiC MOSFETs, Static and Dynamic Characteristics, Gate Drive Requirements for MOSFETs and IGBTs, Gate Drivers: Driving and Protecting IGBTs/MOSFETs,Thermal Management of Power Devices, EMI/EMC Considerations in EV Power Electronics	6
2	**Passive Power Components:** Capacitors-Filtering, Energy Storage, Voltage Stabilization. Inductors- Energy Storage, Current Ripple Reduction Transformers: High-Frequency Isolation in EV Converters & Chargers, Design Considerations of Passive Components in EV Applications	4
3	**Power Conversion Units in EVs** **DC-DC Converters:**Step-Down (Buck), Step-Up (Boost), Buck-Boost, Cuk Converters,Isolated Converters: Forward, Flyback, Full-Bridge, LLC, Dual Active Bridge,Soft Switching Criteria & High-Frequency Magnetics **Inverters:**Voltage Source & Current Source Inverters,Pulse Width Modulation (PWM), Space Vector PWM (SVPWM), and Selective Harmonic Elimination,Rectifier Mode of Operation of PWM Inverter **On-board Chargers (AC-DC Converters):**Single-Phase and Three-Phase Rectifiers,Analysis and Performance with Passive Loads **Auxiliary Power Supplies**; Low-Voltage DC Supplies for Control, Lighting, and Infotainment	8
4	**Advanced Modulation & Control Techniques** Pulse Width Modulated Inverters: Square-Wave and PWM Switching Schemes, Blanking Time Effects, Zero Vector Concept in PWM,Space Vector Modulation (SVM) and Hysteresis Current Control, Modelling of Power Converters, Switched Model, Average Model, Large-Signal & Small-Signal Analysis, State Space Averaging and Linearization, Closed-Loop Control of Power Converters, Voltage and Current Control, Linear Control Approaches – Case Studies	6
5	**Emerging Trends & Case Studies** SiC (Silicon Carbide) and GaN Devices in EV Applications,High Efficiency, Compact Design, and Thermal Benefits,Fast Charging Infrastructure and Converter Design,Case Study: Design of a Dual Active Bridge DC-DC Converter for EV Charger,Case Study: Inverter Design for a Three-Phase EV Traction Motor	6
6	**Simulation and Modelling of Power Electronics for EVs** Simulation Tools Overview: MATLAB/Simulink/Simscape,Modeling Power Electronic Devices,Converter and inverter Simulations,Closed-loop Control Simulation,Simulation Based Case Studies-Design and simulation of an onboard DC-DC converter for EV battery,Inverter simulation for a three-phase PMSM traction system	6

Assessment:

Internal Assessment: 40 marks

End Semester Examination: 60 Marks

Books/References:

1. Mohan, Ned, and Tore M. Undeland. Power electronics: converters, applications, and design. John wiley& sons, 2007
2. Rashid, Muhammad H., ed. Power electronics handbook. Butterworth-Heinemann, 2017
3. Bose, Bimal K. Modern power electronics and AC drives. Vol. 123. Upper Saddle River, NJ: Prentice hall, 2002.
4. Mohan, Ned. Power electronics: a First Course. Wiley, 2011 5. Sen, Paresh Chandra. Thyristor DC drives. John Wiley & Sons, 1981
5. DC-DC Switching Regulator Analysis by Daniel M. Mitchell
6. Voltage Sourced Converters in Power Systems: Modeling, Control, and Applications by Amirnaser Yazdani, Reza Iravani

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Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
MECH 544	Electric Vehicles 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					
MECH 544	Electric Vehicles Lab	-	-	-	-	25	25	-	50

Course Objectives:

1. To familiarize with EV systems and Subsystems
2. To familiarize with simulation to evaluate EV performance.

Course Outcomes: Students will be able to

1. Perform sizing calculations for Electric Vehicle
2. Evaluate performance of Electric vehicle
3. Model and Analyze Electric Vehicle using various toolboxes
4. Model and Analyze performance of Ultracapacitor
5. Comprehend latest technologies used in Electric Vehicles

Module	Detail Content	Hrs.
1	Sizing an Electric Powertrain for 2/3/4 Wheeler EV	02
2	Study of Electric two wheeler powertrain components	02
3	Vehicle Performance Analysis using ADVISOR toolbox	02
4	Modeling Ultracapacitor using Simscape	02
5	Designing EV using QSS toolbox	02
6	Case study on Electric 2/3/4 wheeler	02

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Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ENGG 597	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					
ENGG 597	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.

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Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
MECH 509	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					
MECH 509	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

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Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
MECH 510	Advanced 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					
MECH 510	Advanced 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

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Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
MECH 511	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					
MECH 511	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.

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Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
MECH 512	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					
MECH 512	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

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Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
MECH 308	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					
MECH 308	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.

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Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
DES 382	Product 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					
DES 382	Product Design	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

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Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ENGG 402	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					
ENGG 402	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.

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Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
MECH 320	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					
MECH 320	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.)

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Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
MECH 513	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					
MECH 513	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)

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Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
MECH 514	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					
MECH 514	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

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Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
ENGG 301	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					
ENGG 301	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.

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Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
MECH 515	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					
MECH 515	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.

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Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
MECH 529	Modeling and Analysis of Thermal System	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					
MECH 529	Modeling and Analysis of Thermal System	40	40	40	60	-	-	-	100

Course Objectives:

1. Differentiate design and analysis
2. Understand problem formulation and various modeling and simulation methods to optimize the solution

Course Outcomes: Learner will be able to…

1. Identify design parameters of basic thermal systems
2. Formulate the problem and propose the solution

DETAILED SYLLABUS:

Module No.	Detailed Content	Hours	CO Mapping
I	Introduction, Design versus analysis, need for optimization, basic characteristics of thermal systems, analysis, types and examples: energy systems, cooling systems for electronic equipment, environmental and safety systems, air-conditioning, refrigeration and heating systems, heat transfer equipment	08	CO1
II	Modeling of thermal systems, basic considerations in design, the importance of modeling in design, types of models, mathematical modeling, physical modeling, and dimensional analysis	07	CO2
III	Numerical modeling and simulation, development of a numerical model, solution procedure, merging of different models, accuracy and validation, system simulation, methods of numerical simulation, and numerical simulation versus real systems.	06	CO2
IV	Economic considerations, calculation of interest, worth of money as a function of time, raising capital, economic factors in design, application to thermal systems	06	CO1
V	Problem formulation for optimization, basic concepts, optimization methods, optimization of thermal systems,	06	CO2

	practical aspects in optimal design		
VI	Knowledge-based design and additional considerations, knowledge-based systems, additional constraints, sources of information	06	CO1

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

References:

1. Yogesh Jaluria, Design and Optimization of Thermal Systems, McGraw-Hill international editions, 1998
2. Stoecker W F, Design of Thermal Systems, 3rd Ed. McGraw Hill, 2011
3. Eckert E R G and Drake R M, Analysis of Heat and Mass Transfer, McGraw-Hill, New York, 1972
4. Szucs E, Similitude and Modeling, Elsevier, New York, 1977
5. Wellstead P E, Introduction to Physical System Modeling, Academic Press, New York, 1979
6. Chapra S C and Canale R P, Numerical Methods for Engineers, McGraw-Hill, New York, 1988
7. Atkinson K, An Introduction to Numerical Analysis, Wiley, New York, 1978

Back to Scheme

Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
MECH 530	Advanced Heat Transfer	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					
MECH 530	Advanced Heat Transfer	40	40	40	60	-	-	-	100

Course Objectives

1. Impart the advanced knowledge of heat transfer.
2. Get analytical solutions for Dimensional steady and transient heat conduction problems.
3. Deep understanding on the governing equations for convection heat transfer and its application.
4. Understand the boiling and condensation mechanism.

Course Outcomes: Learner will be able to

1. Able to estimate the thermal contact resistance. .
2. Able to apply lumped system analysis for the solution of transient heat conduction problem..
3. Able to calculate the heat transfer coefficient for the enclosures.
4. Able to apply empirical correlations for the force convection problem.
5. Able to explain the flow patterns in condensation heat transfer.
6. Able to compute the radiation heat transfer in case of gas radiation.

Module	Detailed Contents	Hrs.
01	Introduction to basic laws and general heat conduction equations, boundary and initial conditions. Multidimensional heat transfer. Concept of variable thermal conductivity in plane walls. Thermal contact resistance. Three dimensional heat conduction. Heat transfer enhancement techniques. Active and passive techniques.	07
02	Heat transfer in common configurations, concept of conduction shape factor. Conduction in porous media. Transient heat conduction: Lumped system analysis. Introduction to transient heat conduction in large plane walls and cylinders with spatial effects.	06
03	Natural Convection heat transfer: Solution of convection equation for flat plate. Grashof number. Natural convection over vertical plate, horizontal plate, vertical and horizontal cylinder, spheres. Natural convection cooling of finned surfaces, vertical PCBs. Natural convection inside vertical and horizontal rectangular enclosures, concentric cylinders.	07
04	Forced Convection: Laminar forced convection in long tube, correlations for laminar forced convection. Correlations for coiled tubes, Empirical	06

	correlations for turbulent forced convection for circular ducts and tubes	
05	Introduction to flow boiling, flow patterns in vertical and horizontal tubes, Correlations, post dry-out heat transfer. Condensation: heat transfer correlation for condensation heat transfer for vertical plate. Film condensation inside horizontal tubes and horizontal tubes.	06
06	Gas Radiation, radiation network for an absorbing and transmitting medium, radiation properties of the environment, effect of radiation on temperature measurement, radiation heat transfer coefficient,	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

Books/References:

1. Yunus A Cengel and Afgin J Ghajar, Heat and Mass Transfer: Fundamentals and Applications, 5thEd., McGraw-Hill Education
2. Incropera F.P. and DeWitt. D.P., Fundamentals of Heat & Mass Transfer, John Wiley & Sons
3. S.P. Sukhatme, Heat Transfer, University Press
4. Patankar. S.V.,Numerical heat Transfer and Fluid flow, Hemisphere Publishing Corporation
5. J P Holman, Heat Transfer, 9th Ed., McGraw Hill, Int.
6. Frank Kreith& John S Bohn, Principles of Heat Transfer, Cengage Learning India Pvt Ltd.
7. C P Kothandaraman, Fundamentals of Heat and Mass Transfer, New Age International Publishers.
8. Bejan A and Kraus A, Heat Transfer Handbook, John Wiley & Sons
9. Bejan A, Convective Heat Transfer, Wiley, Third edition, 2004

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Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
MECH 314	Computational Fluid Dynamics	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					
MECH 314	Computational Fluid Dynamics	40	40	40	60	-	-	-	100

Objectives:

1. Understand the laws of fluid flow for ideal and viscous fluids.
2. Develop finite difference and finite volume discredited forms of the CFD equations.
3. Formulate explicit & implicit algorithms for solving the Euler Equation & Navier Stokes Equation.

Outcomes:

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

1. Explain the fundamental principles of fluid motion and their application to the analysis and solution of problems in fluid flow engineering.
2. Solve Fluid dynamic & Heat transfer problem using computational fluid dynamics.

Detailed Theory Syllabus:

Module	Details Content	Hrs
01	**Introduction:** Definition and overview of CFD, Advantages and disadvantages, applications, CFD methodology, Working of Commercial CFD Softwares	05
02	**Governing Differential Equations**: Governing equations for mass, momentum and energy; Navier-Stokes equations; Mathematical behavior of PDE's viz. parabolic, elliptic and hyperbolic, Initial and boundary conditions, Initial and Boundary value problems. Selection criteria for BC	08
03	**Grid Generation:** Structured and unstructured Grids: O-type, H-type, C-type of Structured Grid Generation,General transformations of the equations; body fitted coordinate systems; Algebraic and Elliptic Methods; adaptive grids	05
04	**Discretization Techniques:** Introduction to Finite difference Method, Finite Volume method and Finite Element method Finite difference methods; Finite difference representation of	08

	PDE's; Solutions to Finite Difference Equations; Implicit, semi-implicit and explicit methods; Errors and stability criteria	
05	**Turbulence Modeling:** Introduction to Turbulence, Modeling Effect of turbulence on governing equations; RANS, LES and DNS Models	06
06	**Finite Difference & Finite Volume Methods:** FDM & FVM solutions to steady and unsteady one-, two- and three-dimensional problems and, FVM solution to steady & unsteady one- and two-dimensional diffusion, convection-diffusion (no numerical); Advection schemes; Pressure velocity coupling; SIMPLE family of algorithms.	07

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

Text/Reference Books:

1. Modern Compressible Flow with Historical Perspective, John D. Anderson, McGraw Hill.
2. Fundamentals of Aerodynamics, J. D. Anderson, 2nd Ed, McGraw Hill.
3. An introduction to computational fluid dynamics-The finite volume method, Versteeg.H.K., Malalasekera.W., Prentice Hall
4. Computational Fluid Mechanics and Heat Transfer, Anderson, D.A., Tannehill, I.I., and Pletcher, R.H., Hemishphere Publishing Corporation, New York, USA, 1984.
5. Introduction to Computational Fluid Dynamics, Niyogi P. ,Laha M.K., Chakrabarty S.K., Pearson Education, India.
6. Computational Fluid Flow and Heat Transfer, Muralidhar, K., and Sundararajan,T., Narosa Publishing House ,New Delhi1995.
7. Computer Simulation of flow and heat transfer, Ghoshdasdidar, P. S., Tata McGrawHill Publishing Company Ltd., 1998.
8. Finite Element Programming of the Navier Stock Equation, Taylor, C and Hughes J.B., Pineridge Press Ltd.U.K.1981.
9. Computational Techniques for Fluid Dynamics: Fundamental and General Techniques, Fletcher, C.A.J., Springer-Verlag, 1987.
10. Numerical Fluid Dynamics, Bose, T. K., Narosa Publishing House, 1997
11. Turbulent Flow, R. J. Garde, 2ndEd., New Age International Publishers.

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Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
MECH 531	Thermal Design of Electronic Equipment	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					
MECH 531	Thermal Design of Electronic Equipment	40	40	40	60	-	-	-	100

Objectives:

1. To teach students about modes of heat transfer in electronic devices.

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

1. Gain in depth knowledge of designing cooling systems for electronic equipment.
2. Design a system that withstands high pressure.
3. Understand fluid dynamics in electronic equipment design.
4. Understand the effect of various modes of heat transfer on designing a system.

Detailed Theory Syllabus:

Module	Details Content	Hrs
01	**Introduction:**Introduction to modes of heat transfer in electronic equipment conduction, convection and radiation. Theoretical power dissipation in active devices like CMOS device, Junction FET, Power MOSFET. Theoretical power dissipation in passive devices like Interconnect , resistor, capacitor	07
02	**Steady state conduction:** Conduction in simple geometry like plain wall without heat generation, conduction through cylinder and spheres without heat generation. Conduction in complex geometries like multidimensional analytic method, multidimensional graphical method. **Conduction:** Transient-lumped capacitance method. **Thermal Contact Resistance in Electronic Equipment Interfaces:** Simplified contact resistance model, geometry of contacting surface.	06
03	**Fluid dynamics for electronic equipments:** Introduction. **Hydrodynamics properties of fluid:** compressibility, viscosity and surface tension. **Fluid statistics:** Relationship between pressure and density. **Fluid dynamics:** streamline & flow fields, One and two dimensional flow. **Incompressible fluid flow:** One dimensional flow-Euler and Bernoulli's equation. **Incompressible fluid flow:** laminar and turbulent flow. **Electronic chassis flow**	06
04	**Convection heat transfer in electronic equipment:** boundary layer theory, Forced convection laminar flow, forced convection in turbulent flow:- circular and	07

	non circular tubes. **Forced convection external flow:** Laminar and forced convection flow over flat plate. **Forced convection flow along populated circuit boards.** **Natural convection:** flat plate, vertical fins, horizontal and vertical cylinder, spheres	
05	**Radiation heat transfer in electronic equipment:** Introduction, radiation equations, surface characteristics like absorptance, emittance and reflectance. Calculation of view factors, Environmental effects:- solar radiation and atmospheric radiation.	06
06	**Heat transfer with phase change and combined mode of heat transfer & Experimental verification:** **Introduction:** dimensionless parameters in boiling and condensation, modes of boiling liquids, evaporation.Conduction in series and parallel, conduction and convection in series, radiation and convection in parallel, Overall heat transfer coefficient. **Experimental verifications:** The use of measurement and testing in verification, measurements and verification ,Surface temperature: Selection of verification objects, choice of measurement timings, Exterior surface temperature of device,surface temperature of interior parts of the device. **Measurement of sir flow:** Principle of flow measurement, factors affecting selection of flow measurement methods, Flow measurement techniques.	07

Assessment:
Internal Assessment: 40 marks
Consisting of One Compulsory Class Tests of 40 Marks
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. YounesShabany, Heat Transfer: Thermal Management of Electronics, CRC Press Inc, 2010.
2. Ravi Kandasamy and Arun S. Mujumdar, Thermal Management of Electronic Components, Lambert Academic Publishing, 2010.
3. Dave S. Steinberg, Cooling Techniques for Electronic Equipment, Wiley, 1991.
4. Sung Jin Kim, Sang Woo Lee, Air Cooling Technology for Electronic Equipment, Taylor & Francis, 1996.
5. Rao R. Tummala, Fundamentals of Microsystems Packaging, McGraw-Hill, 2001.
6. Yunus A. Cengel, Heat Transfer: A Practical Approach. McGraw-Hill, 2003.
7. Thermal Design of Electronic Equipment by Ralph Remsburg , CRC Press
8. Richard K. Ulrich & William D. Brown Advanced Electronic Packaging - 2nd Edition : IEEE Press, 1995.

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Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
MECH 532	Heat Exchanger Design and Performance	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					
MECH 532	Heat Exchanger Design and Performance	40	40	40	60	-	-	-	100

Course Objectives:

1. Impart knowledge of sizing and designing of various heat exchangers using various methods
2. Learn performance analysis and maintenance aspects of heat exchanging equipments

Course Outcomes: Learner will be able to

1. Customize sizing and/or designing of heat exchangers
2. Identify efficacy of conventional or compact heat exchangers for specific purpose

Detailed Theory Syllabus:

Module	Details Content	Hrs
01	**Constructional Details and Heat Transfer:** Types - Shell and Tube Heat Exchangers - Regenerators and Recuperators - Industrial Applications, Methodology, Design consideration, Temperature Distribution and its Implications - LMTD –Effectiveness	08
02	**Flow Distribution and Stress Analysis:** Effect of Turbulence –Effect of Fouling Friction Factor - Pressure Loss - Channel Divergence Stresses in Tubes Types of Failures	06
03	**Design Aspects:** TEMA standard, FlowConfiguration - Effect of Baffles - Effect of Deviations from Ideality - Design of Typical Liquid - Gas-Gas-Liquid Heat Exchangers	08
04	**Condensers and Evaporators Design:** Design of Surface and Evaporative Condensers - Design of Shell and Tube - Plate Type Evaporators	07
05	**Cooling Towers:** Types- Spray Design - Selection of Fans- Testing and Maintenance of cooling towers, Compact cooling towers, cooling tower performance variable	06
06	**Design of Special Purpose Heat Exchangers:** Corrosive environment. Marine/space applications, compact heat exchanger	04

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

Books/References:

1. Shah R K, Sekulic D P, Fundamentals of Heat Exchanger Design, John Wiley, 2003
2. KakacSadik, Liu Hongtan, Heat exchangers : selection, rating and thermal design, 2nd ed, CRC Press, 2002
3. D Q Kern, Precess Heat Transfer, McGraw Hill
4. W. M. Kays and A. L. London,Compact heat exchanger, 3 Sub Edition, Krieger Pub Co
5. MojtabaSabet,Cooling tower fundamentals and best design practices, Outskirts Press, 2014
6. T. Taborek, G.F. Hewitt and N.Afgan, Heat Exchangers, Theory and Practice, McGraw Hill Book Co., 1980
7. Walker, Industrial Heat Exchangers - A Basic Guide, McGraw Hill Book Co., 1980
8. Nicholas Cheremisioff, Cooling Tower, Ann Arbor Science Pub 1981
9. Arthur P. Fraas, Heat Exchanger Design, John Wiley & Sons, 1988

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Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
MECH 533	Advanced Turbo Machinery	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					
MECH 533	Advanced Turbo Machinery	40	40	40	60	-	-	-	100

Course Objectives

1. Study basic concepts and principles of turbomachinery
2. Learn performance analysis of centrifugal as well as axial machines like fans, blowers and compressors

Course Outcomes: Learner will be able to

1. Read and understand performance characteristic curves of various turbo machines
2. Design blowers and fans for specified applications
3. Identify suitable control and testing methods for blowers and fans

Detailed Theory Syllabus:

Module	Details Content	Hrs
01	**Basic concepts of turbo machines:** Definition of Turbo machine, classification; Euler's pump equation and Euler's turbine equation, dimensional analysis applied to hydraulic machines and compressible flow machines.	07
02	**Principles of turbomachinery:** Transfer of energy to fluids, Performance Characteristics, fan laws, selection of centrifugal, axial, mixed flow, Axial flowMachines	06
03	**Analysis of centrifugal Machines:** Centrifugal Compressors and Blowers:Theoretical characteristic curves, Euler's characteristics and Euler's velocity triangles, losses and hydraulic efficiency, flow through inlet nozzle, impeller,diffusers, casing	07
04	**Analysis of axial flow Machines:** Axial flow fans and compressors: Rotor design airfoil theory, vortex theory, cascade effects, degree of reaction, blade twist, stage design, surge, choking and stall, stator and casing, mixed flow impellers. Design Considerations for supersonic flow	07
05	**Design and applications of blowers and Fans:**	07

	Special design and applications of blower induced and forced draft fans for air-conditioning plants and cooling towers,ventilation systems	
06	**Testing and control of Blowers and Fans:** Performance testing, noise control,speed control, throttling control at discharge and inlet	05

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

Books/References:

1. Stepanoff A.J. Turboblowers, John Wiley & sons, 1970.
2. Brunoeck, Fans, Pergamon Press, 1973.
3. Austin H. Chruch, Centrifugal pumps and blowers, John wiley and Sons, 1980.
4. Dixon, Fluid Mechanics, Thermodynamics of turbomachinery, Pergamon Press, 1984.
5. Dixo,Worked examples in turbomachinery, Pergamon Press, 1984.
6. BudugurLakshminarayana, Fluid Dynamics and heat Transfer of Turbomachinery, John Wiley and Sons, Inc
7. Handbook of Turbomachinery, Edited by Earl Logan Jr, Ramendra Roy; Second Edition, Marcel Dekker, Inc, New York
8. Rama S.R.Gorla, Aijaz Khan, Turbomachinery Design and Theory, Marcel Dekker, Inc, New York

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Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
MECH 534	Thermal Energy Storage Systems and Applications	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					
MECH 534	Thermal Energy Storage Systems and Applications	40	40	40	60	-	-	-	100

Course Objectives:

1. Learn various thermal energy storage methods.
2. To understand the impact of various energy storage on the environment.
3. To learn mathematical modelling of thermal storage systems

Course Outcomes:

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

1. Choose the best suited method from available methods of energy storage to reduce impact on the environment.
2. Carry out Energy and Exergy Analysis of Thermal Energy Storage Systems.
3. Understand recent advancements in energy storage technologies.

Detailed Theory Syllabus:

Module	Details Content	Hrs
01	**Energy storage systems:** Introduction, Energy Demand, Energy Storage, Energy Storage Methods, Comparison of Energy Storage Technologies.	05
02	**Thermal Energy Storage (TES) Methods and Environmental Impact:** Introduction to Thermal Energy Storage, Solar Energy and TES Methods, Cold Thermal Energy Storage (CTES), Seasonal TES. Thermal Energy Storage and Environmental Impact: Introduction, Major Environmental Problems, Environmental Impact on TES Systems, Potential Solutions to Environmental Problems.	07
03	**Thermal Energy Storage and Energy Savings:** TES and Energy Savings , Additional Energy Savings Considerations for TES , Energy Conservation with TES: Planning and Implementation , Some Limitations on Increased Efficiency , Energy Savings for Cold TES	05
04	**Energy and Exergy Analyses of Thermal Energy Storage Systems:** Energy and Exergy Analyses, Thermodynamic Considerations in TES Evaluation, Exergy Evaluation of a Closed TES System, Measures for Closed TES Systems, Importance of Temperature in Performance Evaluations for Sensible TES	07

	Systems, Exergy Analysis of Aquifer TES Systems, Thermally Stratified Storages, Cold TES Systems and Solar Ponds.	
05	**Numerical Modeling and Simulation of Thermal Energy Storage Systems:** Approaches and Methods, Selected Applications, Numerical Modeling, Simulation, and Analysis of Sensible TES Systems and Latent TES Systems, Illustrative Application for a Complex System: Numerical Assessment of Encapsulated Ice TES with Variable Heat Transfer Coefficients.	07
06	**Recent Advances in TES Methods, Technologies, and Applications:** Recent developments in TES Types and Performance , Micro- and Macro-Level Advances in TES Systems and Applications, Performance Enhancement Techniques, Innovative Applications of TES Systems, Advanced Applications of Exergy Methods.	08

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 the number of respective lecture hours mentioned in the curriculum.

Text/Reference Books:

1. Thermal Energy Storage: Systems and Applications, 2nd Edition, Ibrahim Dincer, Marc A. Rosen , John Wiley & Sons
2. Exergy Method: Technical and Ecological Applications: No.18 (Developments in Heat Transfer) by J. Szargut , WIT Press
3. Thermal Design and Optimization 1st Edition, by Adrian Bejan, George Tsatsaronis, Michael J. MoranJohn Wiley & Sons, Inc
4. Advances in Thermal Energy Storage Systems , Methods and Applications by Luisa F. Cabeza, Woodhead Publishing,
5. Thermal Energy Storage Technologies for Sustainability: Systems Design, Assessment and Applications by S. KalaiselvamDr. (Author), R. Parameshwaran, Academic Press
6. Thermal Energy Storage Analyses and Designs by Pei-Wen Li (Author), Cho Lik Chan Academic Press.
7. Latent Heat-Based Thermal Energy Storage Systems: Materials, Applications, and the Energy Market, by AmritanshuShukla (Editor), Atul Sharma (Editor), Pascal Henry Biwolé , CRC Press
8. Thermal, Mechanical, and Hybrid Chemical Energy Storage Systems 1st Edition, by Klaus Brun, Timothy C. Allison, Richard Dennis, Academic Press
9. Ibrahim Dincer and Mark A. Rosen, Thermal Energy Storage Systems and Applications, John Wiley & Sons 2002.
10. Schmidt.F.W and Willmott.A.J, Thermal Storage and Regeneration, Hemisphere Publishing Corporation, 1981.
11. Lunardini.V.J, Heat Transfer in Cold Climates, John Wiley and Sons 1981.

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Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
MECH 304	Sustainable/Zero Energy Buildings	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					
MECH 304	Sustainable/Zero Energy Buildings	40	40	40	60	-	-	-	100

Course Objectives:

1. To study fundamental concepts of solar building design and energy systems.
2. To study the process involved in site selection of green buildings.
3. To study various energy efficient materials for green building construction.
4. To study various ASHRAE and IGBC standards.

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

1. Understand the benefits of green building.
2. Understand various heat transfer processes that increase cooling load in a building.
3. Understand various methods adopted for Occupant Comfort and Wellbeing.

Detailed Theory Syllabus:

Module	Details Content	Hrs
01	**Introduction to Green Buildings:** Definition of green buildings and sustainable development, typical features of green buildings, benefits of green buildings towards sustainable development. Green building rating systems – GRIHA, IGBC and LEED, overview of the criteria as per these rating systems.	05
02	**Site selection and planning:** Criteria for site selection, preservation of landscape, soil erosion control, minimizing urban heat island effect, maximizing comfort by proper orientation of building facades, day lighting, ventilation, etc. Water conservation and efficiency: Rainwater harvesting methods for roof & non-roof, reducing landscape, water demand by proper irrigation systems, water efficient plumbing systems, water metering, wastewater treatment, recycle and reuse systems.	05
03	**Energy Efficiency:** Environmental impact of building constructions, Concepts of embodied energy, operational energy and life cycle energy. Methods to reduce operational energy: Energy efficient building envelopes, efficient lighting technologies, energy efficient appliances for heating and air-conditioning systems in buildings, zero	08

	ozone depleting potential (ODP) materials, wind and solar energy harvesting, energy metering and monitoring, concept of net zero buildings.	
04	**Heat transfer processes in buildings:** Thermal conductivity, resistance, transmittance, surface characteristics, surface coefficient, heat capacity, insulation. Calculation of principle building energy gains and losses. Estimation of building energy performance for heating and cooling for different climatic contexts. Importance of energy to human development, conventional and renewable energy sources – supply, uses and environmental impact. Assessment future growth in energy demand, availability, potential for sustainable development. Sustainable issues of planning, design and development.	08
05	**Building materials:** Methods to reduce embodied energy in building materials: A. Use of local building materials B. Use of natural and renewable materials like bamboo, timber, rammed earth, stabilized mud blocks, C. use of materials with recycled content such as blended cements, pozzolana cements, fly ash bricks, vitrified tiles, materials from agro and industrial waste. D. Reuse of waste and salvaged materials.Waste Management: Handling of construction waste materials, separation of household waste.	08
06	**Indoor Environmental Quality for Occupant Comfort and Wellbeing:** Day-lighting, air ventilation, exhaust systems, low VOC paints, materials & adhesives, building acoustics. Codes related to green buildings: NBC, ECBC, ASHRAE, UPC etc, Energy Conservation Act 2001	05

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. IGBC Green Homes Rating System, Version 2.0., Abridged reference guide, 2013, Indian GreenBuilding Council Publishers.
2. GRIHA version 2015, GRIHA rating system, Green Rating for Integrated Habitat Assessment.
3. Alternative building materials and technologies by K.S. Jagadish, B.V. Venkatarama Reddy and K.S. NanjundaRao.
4. Non-Conventional Energy Resources by G. D. Rai, Khanna Publishers.
5. Sustainable Building Design Manual, Vol.1 and 2, TERI, New Delhi 2004.
6. Mike Montoya, Green Building Fundamentals, Pearson, USA, 2010.
7. Charles J. Kibert, Sustainable Construction – Green Building Design and Delivery, John Wiley &Sons, New York, 2008.
8. Regina Leffers, Sustainable Construction and Design, Pearson / Prentice Hall, USA, 2009.

9. Faber, Oscar and Kell, J.R. Heating and air-conditioning of buildings. 2002.
10. Thomas, Randall & Fordham Max Sustainable urban design:an environmental approach" 2003.
11. Edwards, Brian and Hyett, Paul Rough guide to sustainability
12. Langston, Craig A. and Ding, Grace Sustainable practices in the built environment 2001.
13. GivoniBaruch,"Passive and Low Energy Cooling of Buildings",VNR, New YorK, 1994.
14. Martin J Gainsborough, Radford and Helen Bennets, T J Williamson, "Understanding Sustainable architecture", Spon Press, London, 2003.

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Course Code	Course Name	Scheme	Theory	Practical	Tutorial	Total
MECH 535	Computational Fluid Dynamics 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					
MECH 535	Computational Fluid Dynamics Lab	-	-	-	-	25	25	-	50

Course Objectives:

1. Understand the laws of fluid flow for ideal and viscous fluids.
2. Develop finite difference and finite volume discredited forms of the CFD equations.
3. Formulate explicit & implicit algorithms for solving the Euler Equation & Navier Stokes Equation.

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

1. Explain the fundamental principles of fluid motion and their application to the analysis and solution of problems in fluid flow engineering.
2. Solve Fluid dynamic & Heat transfer problem using computational fluid dynamics.

Lab Syllabus:

Sr. No.	Details	Hrs.
1	Simulate and solve 1D steady and unsteady flows problem using any commercial CFD package like Ansys-FLUENT, STAR CCM, FLUIDYNE, Ansys-CFX, etc. or write simple codes in MATLAB, C, C++ etc	2
2	Simulate and solve 2D steady and unsteady flows problem using any commercial CFD package like Ansys-FLUENT, STAR CCM, FLUIDYNE, Ansys-CFX, etc. or write simple codes in MATLAB, C, C++ etc	2
3	Simulate and solve 3D steady and unsteady flows problem using any commercial CFD package like Ansys-FLUENT, STAR CCM, FLUIDYNE, Ansys-CFX, etc. or write simple codes in MATLAB, C, C++ etc	2
4	Simulate and solve 1D steady and unsteady heat transfer problem using any commercial CFD package like Ansys-FLUENT, STAR CCM, FLUIDYNE, Ansys-CFX, etc. or write simple codes in MATLAB, C, C++ etc	2
5	Simulate and solve 2D steady and unsteady heat transfer problem using any commercial CFD package like Ansys-FLUENT, STAR CCM, FLUIDYNE, Ansys-CFX, etc. or write simple codes in MATLAB, C, C++ etc	2
6	Simulate and solve 3D steady and unsteady heat transfer problem using any ommercial CFD package like Ansys-FLUENT, STAR CCM, FLUIDYNE, Ansys-CFX, etc. or write simple codes in MATLAB, C, C++ etc	2

Laboratory Assessment:

Term Work

Laboratory Work (Journal Completion)	: 25 Marks
Laboratory work (Experiments)	: 20 Marks
Attendance	: 5 Marks

End Semester Practical/Oral Examination:

Pair of Internal and External Examiners should conduct viva based on contents.
Distribution of marks for viva examination shall be as follows:
Oral and practical Examination: 25 Marks

Text/Reference Books:

1. Modern Compressible Flow with Historical Perspective, John D. Anderson, McGraw Hill.
2. Fundamentals of Aerodynamics, J. D. Anderson, 2nd Ed, McGraw Hill.
3. An introduction to computational fluid dynamics-The finite volume method, Versteeg.H.K., Malalasekera.W., Prentice Hall
4. Computational Fluid Mechanics and Heat Transfer, Anderson, D.A., Tannehill, I.I., and Pletcher, R.H., Hemishphere Publishing Corporation, New York, USA, 1984.
5. Introduction to Computational Fluid Dynamics, Niyogi P. ,Laha M.K., Chakrabarty S.K., Pearson Education, India.
6. Computational Fluid Flow and Heat Transfer, Muralidhar, K., and Sundararajan,T., Narosa Publishing House ,New Delhi1995.
7. Computer Simulation of flow and heat transfer, Ghoshdasdidar, P. S., Tata McGrawHill Publishing Company Ltd., 1998.
8. Finite Element Programming of the Navier Stock Equation, Taylor, C and Hughes J.B., Pineridge Press Ltd.U.K.1981.
9. Computational Techniques for Fluid Dynamics: Fundamental and General Techniques, Fletcher, C.A.J., Springer-V
10. Numerical Fluid Dynamics, Bose, T. K., Narosa Publishing House, 1997
11. Turbulent Flow, R. J. Garde, 2ndEd., New Age International Publishers.

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