M. TECH. PROGRAM CURRICULUM - 2025

(Applicable for the batches admitted from A.Y 2025-26)

Version 2.0

ENERGY SCIENCE AND TECHNOLOGY

Version 1.0–Approved in the BoS meeting on 17-05-2025 & Academic Council meeting on 14-06-2025

Version 2.0–Approved in the BoS meeting on 06-06-2026 & Academic Council meeting on 20-06-2026

Aditya Nagar, ADB Road, Surampalem - 533 437

VISION & MISSION OF THE UNIVERSITY

VISION :

To be a globally recognized University through excellence in Education, Innovation and Sustainable growth.

MISSION:

Deliver collaboration to prepare students for global challenges through

I. Transformative learning,
II. Vibrant research ecosystem,
III. Sustainable and inclusive community

VISION MISSION OF THE DEPARTMENT

VISION:

To be a pioneer in Mechanical Engineering for promoting excellence in Education, Innovative Research & Solutions for sustainable challenges.

MISSION:

M1: Provide infrastructure for design and development of industrial needs.
M2: Develop innovative research ecosystem for societal transformation.
M3: Integrate Leadership and Teamwork Capabilities for solving inclusive community challenges.

PROGRAM OUTCOMES (POs)

After successful completion of the program, the graduates will be able to

PO 1	Independently carry out research /investigation and development work to solve practical problems
PO 2	Write and present a substantial technical report/document
PO 3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.
PO 4	Learn, keep up with contemporary technologies and ways of working.
PO 5	Communicate effectively as an individual or a team leader in diverse and multidisciplinary groups.
PO 6	Use the principles of project management such as scheduling, work breakdown structure and be conversant with the principles of finance for profitable project management.

PROGRAM SPECIFIC OUTCOMES (PSO's)

After successful completion of the program, the graduates will be able to

PSO 1	Design and develop components for enhancement of manufacturing processes with modern engineering tools
PSO 2	Utilizing renewable energy systems effectively for a variety of technical applications.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

After successful completion of the program, the graduates will be able to

PEO 1	Achieve success in their careers by solving complex problems and contributing to their fields.
PEO 2	Apply professional knowledge to address real-world engineering challenges and contribute to societal development.
PEO 3	Exhibit strong leadership skills and adhere to ethical practices in their professional work.

ADITYA UNIVERSITY

Department of Mechanical Engineering

Master of Technology in Energy Science and Technology

Program Curriculum - 2025

Credit Division:

S.No	Broad Category of Course	Credits
1	Program Core Courses (PCC)	30
2	Program Elective Courses (PEC)	15
3	University Elective Courses (UEC)	03
4	Summer Internship (SI)	02
5	Technical Paper Publication (TPP)	02
6	Project Part- I & II (PROJ)	28
7	Audit Courses (AUC)	0
	Total Credits	**80**

Program Core Courses (PCC):

Course Code	Course Title	L	T	P	C	CIE	SEE	Total	Pre-requisite
2502ME01	Energy Resources concepts & Technology	3	0	0	3	50	50	100	-
2502ME02	Electric and Hybrid Vehicles	4	0	0	4	50	50	100	-
2502ME03	Fundamentals of Solar Photovoltaics	3	0	0	3	50	50	100	-
2502ME04	Computational Fluid Dynamics	4	0	0	4	50	50	100	-
2502ME05	Wind and Hydro Energy Systems	3	0	0	3	50	50	100	-
2502ME06	Energy Systems and Management	3	0	0	3	50	50	100	-
2502ME07	Waste to Energy	3	0	0	3	50	50	100	-
2502ME08	Nano Materials for Energy storage Applications	3	0	0	3	50	50	100	-
2502ME09	Energy Simulation lab	0	0	2	2	50	50	100	FSP
2502ME10	Advanced Fluid Dynamics Lab	0	0	2	2	50	50	100	CFD
Total		**26**	**0**	**4**	**27**				

Program Elective Courses (PEC):

Course Code	Course Title	L	T	P	C	CIE	SEE	Total	Pre-requisite
2502ME11	Measurements in Thermal Engineering	3	0	0	3	50	50	100	ERCT
2502ME12	Energy Audit	3	0	0	3	50	50	100	ERCT
2502ME13	Energy Conservation and Waste Heat Recovery	3	0	0	3	50	50	100	ERCT
2502ME14	Heating, Ventilation and Air-Conditioning	3	0	0	3	50	50	100	-
2502ME15	Biomass Gasification and Pyrolysis	3	0	0	3	50	50	100	-
2502ME16	Hydrogen Fuel cell Technology	3	0	0	3	50	50	100	-
2502ME17	Nuclear Energy Technology	3	0	0	3	50	50	100	-
2502ME18	Combustion, Emissions and Environment	3	0	0	3	50	50	100	-
2502ME19	Alternative Fuels	3	0	0	3	50	50	100	-
2502ME20	Energy Storage	3	0	0	3	50	50	100	ERCT
2502ME21	Solar Energy Technologies	3	0	0	3	50	50	100	-
2502ME22	Advanced Fuel Cell Technologies	3	0	0	3	50	50	100	-
2502ME23	Non-Conventional Energy Sources	3	0	0	3	50	50	100	-
2502ME24	Energy Efficient Building Design	3	0	0	3	50	50	100	-
2502ME25	Finite Element Method in Heat Transfer Analysis	3	0	0	3	50	50	100	CFD
	Total	**24**	**02**	**04**	**30**				

University Elective Courses (UEC):

Course Code	Course Title	L	T	P	C	CIE	SEE	Total	Offered to PG Program
2502CE28	Metro Rail Transportation Design and Construction (L&T EduTech)**	3	0	0	3	50	50	100	All, except SE
2502CE29	Building Information Modeling in Architecture, Engineering and Construction (L&T EduTech)**	3	0	0	3	50	50	100	All, except SE
2502CE30	Basic Concrete Technology	3	0	0	3	50	50	100	All, except SE
2502CE31	Repair and Rehabilitation of Structures	3	0	0	3	50	50	100	All, except SE
2502EE28	Neural Networks and Fuzzy Logic	3	0	0	3	50	50	100	All, except PED
2502EE29	Hybrid Electric Vehicles	3	0	0	3	50	50	100	All, except PED
2502EE30	Electrical Power Distribution and Automation (L&T EduTech)**	3	0	0	3	50	50	100	All, except PED
2502EE31	Renewable Energy & Power Evacuation (L&T EduTech)**	3	0	0	3	50	50	100	All, except PED
2502ME26	Design of fire and life safety systems(L&T EduTech)**	3	0	0	3	50	50	100	All, except EST
2502ME27	Green Engineering Systems	3	0	0	3	50	50	100	All, except EST
2502ME28	IC Engines	3	0	0	3	50	50	100	All, except EST
2502EC24	CAD Tools for VLSI Design	3	0	0	3	50	50	100	All, except VLSID
2502EC25	FPGA Design for Embedded Systems	3	0	0	3	50	50	100	All, except VLSID
2502AI30	Artificial Intelligence	3	0	0	3	50	50	100	All, except CSE
2502AI31	Machine Learning Techniques	3	0	0	3	50	50	100	All, except CSE
	Total	**24**	**02**	**04**	**30**				

** The syllabus for the industry partner courses will be released in the department as and when required

Technical Seminar (TS):

Course Code	Course Title	L	T	P	C	CIE	SEE	Total	Pre-requisite
2502ME29	Technical Seminar	0	0	2	2	100	-	100	-

Technical Paper Publication (TPP):

Course Code	Course Title	L	T	P	C	CIE	SEE	Total	Pre-requisite
2502ME30	Technical Paper Publication	0	0	2	2	100	-	100	-

Project (PROJ):

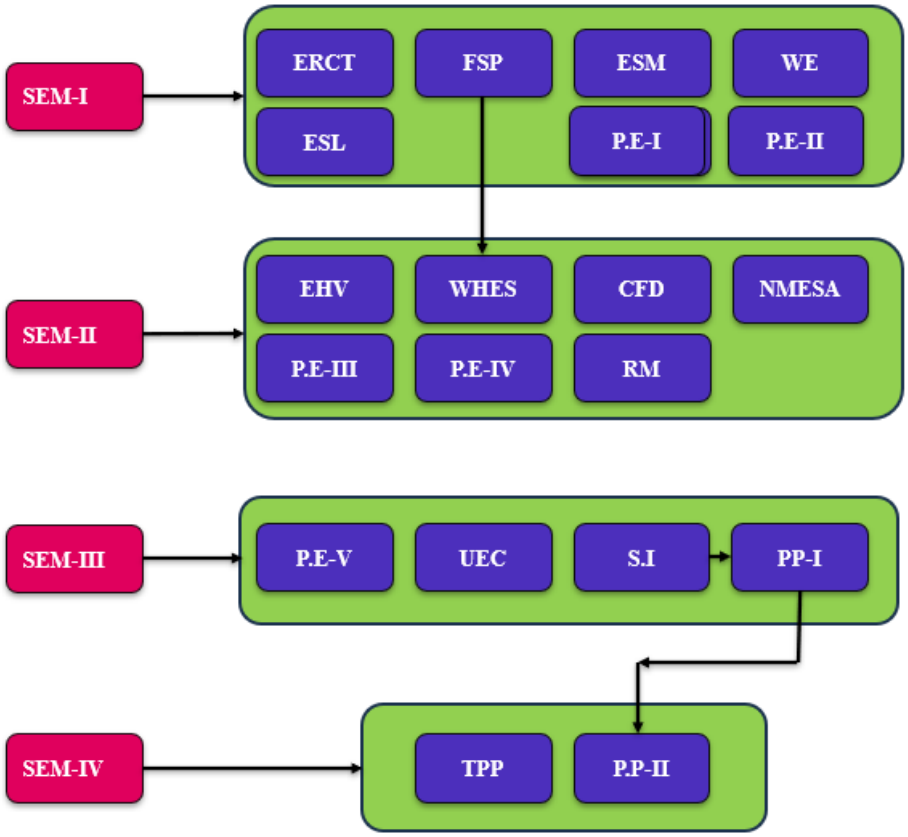
Course Code	Course Title	L	T	P	C	CIE	SEE	Total	Pre-requisite
2502ME31	Project Part-I	0	0	10	10	100	-	100	-
2502ME32	Project Part-II	0	0	18	18	50	50	100	PP-I

Audit Courses (AUC):

Course Code	Course Title	L	T	P	C	CIE	SEE	Total	Pre-requisite
2502CE32	Value Education	2	0	0	0	100	-	100	-
2502CE33	Research Methodology	2	0	0	0	100	-	100	-

2025 M. Tech (EST) CURRICULUM

PRE-REQUISITE FLOW CHART



S. No	Course Name	
1	ERCT	Energy Resources Concepts & Technology
2	FSP	Fundamentals of Solar Photovoltaics
3	ESM	Energy System Management
4	WE	Waste to Energy
5	ESL	Energy Systems Lab
6	EHV	Electric and Hybrid Vehicles
7	CFD	Computational Fluid Dynamics
8	WHES	Wind and Hydro Energy Systems
9	NMESA	Nano Materials for Energy Storage and Applications
10	CFDL	Computational Fluid Dynamics Lab
11	MTE	Measurements in Thermal Engineering
12	HVAC	Heating, Ventilation and Air-Conditioning
13	BGP	Biomass Gasification and Pyrolysis
14	HFCT	Hydrogen Fuel cell Technology
15	NET	Nuclear Energy Technology
16	CEE	Combustion, Emissions and Environment
17	AF	Alternative Fuels
18	ES	Energy Storage
19	SET	Solar Energy Technologies
20	AFCT	Advanced Fuel Cell Technologies
21	NCES	Non-Conventional Energy Sources
22	EEBD	Energy Efficient Building Design
23	FEMHTA	Finite Element Method in Heat Transfer Analysis
24	DFLSS	Design of Fire and Life Safety Systems (L&T)*
25	GES	Green Engineering Systems
26	ICE	IC Engines
27	RM	Research Methodology
28	UEC	University Elective Course
29	TS	Technical Seminar
30	TPP	Technical Paper Publication
31	PP-I	Project Part-I
32	PP-II	Project Part-II with full time Internship
33	PE-I	Program Elective Course -I
34	PE-II	Program Elective Course -II
35	PE-III	Program Elective Course -III
36	PE-IV	Program Elective Course -IV
37	PE-V	Program Elective Course -V

Suggestive Semester wise Curriculum

I Semester

Course Code	Course Title	Course Category	Credits				Total Hours
			L	T	P	C	
2502ME01	Energy Resources Concepts& Technology	PCC	3	0	0	3	3
2502ME03	Fundamentals of Solar Photovoltaics	PCC	3	0	0	3	3
2502ME06	Energy Systems and Management	PCC	3	0	0	3	3
2502ME07	Waste to Energy	PCC	3	0	0	3	3
-	Program Elective Courses-I	PEC	3	0	0	3	3
-	Program Elective Courses-II	PEC	3	0	0	3	3
2502ME09	Energy Simulation lab	PCC	0	0	2	2	2
2502CE32	Value Education	AUC	2	0	0	0	2
Total			**20**	**0**	**2**	**20**	**22**

II Semester

Course Code	Course Title	Course Category	Credits				Total Hours
			L	T	P	C	
2502ME02	Electric and Hybrid Vehicles	PCC	4	0	0	4	4
2502ME04	Computational Fluid Dynamics	PCC	4	0	0	4	4
2502ME05	Wind and Hydro Energy Systems	PCC	3	0	0	3	3
2502ME08	Nano Materials for Energy Storage Applications	PCC	3	0	0	3	3
-	Program Elective Courses-III	PEC	3	0	0	3	3
-	Program Elective Courses-IV	PEC	3	0	0	3	3
2502ME10	Advanced Fluid Dynamics Lab	PCC	0	0	2	2	2
2502CE33	Research Methodology	AUC	2	0	0	0	2
2502ME29	Technical Seminar	TS	0	0	2	2	-
Total			**22**	**0**	**4**	**24**	**24**

III Semester

Course Code	Course Title	Course Category	Credits				Total Hours
			L	T	P	C	
-	Professional Elective – V	PEC	3	0	0	3	3
-	University Elective Course	UEC	3	0	0	3	3
2502ME31	Project Part-I	PROJ	0	0	10	10	20
Total			**6**	**0**	**10**	**16**	**24**

IV Semester

Course Code	Course Title	Course Category	Credits				Total Hours
			L	T	P	C	
2502ME30	Technical Paper Publication	TPP	0	0	2	2	4
2502ME32	Project Part -II	PROJ	0	0	18	18	36
Total					**20**	**20**	**40**

Program Elective Course –I				**Program Elective Course -IV**		
S. No	**Course Code**	**Course Name**		**S. No**	**Course Code**	**Course Name**
1	2502ME11	Measurements in Thermal Engineering		**1**	2502ME15	Bio mass Gasification and Pyrolysis
2	2502ME13	Energy Conservation and Waste Heat Recovery		**2**	2502ME21	Solar Energy Technologies
3	2502ME18	Combustion, Emissions and Environment		**3**	2502ME23	Non Conventional Energy Sources
Program Elective Course -II				**Program Elective Course - V**		
S. No	**Course Code**	**Course Name**		**S. No**	**Course Code**	**Course Name**
1	2502ME16	Hydrogen Fuel Cell Technology		**1**	2502ME22	Advanced Fuel Cell Technologies
2	2502ME19	Alternative Fuels		**2**	2502ME24	Energy Efficient Building Design
3	2502ME20	Energy Storage		**3**	2502ME25	Finite Element Method in Heat Transfer Analysis
Program Elective Course -III						
1	2502ME12	Energy Audit				
2	2502ME14	Heating, Ventilation and Air-Conditioning				
3	2502ME17	Nuclear Energy Technology				

ENERGY RESOURCES; CONCEPTS AND TECHNOLOGIES

Course Code: 2502ME01	L	T	P	C
	3	0	0	3

Course Outcomes: At the end of the Course, Student will be able to:

- **CO1:** To understand the global renewable energy potential through various sources.
- **CO2:** To Evaluate the feasibility and sustainability of biomass-based energy
- **CO3:** To analyse the energy efficiency in thermal utilities
- **CO4:** Evaluate heat recovery and cogeneration systems for energy efficiency.
- **CO5:** Understand suitable hydrogen storage systems for integration with fuel cells

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	2	2	-	-	-	-
CO2	2	2	2	-	-	-
CO3	2	3	-	-	-	-
CO4	2	3	2	-	-	-
CO5	2	2	-	-	-	-

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	3	-
CO2	3	-
CO3	3	-
CO4	3	-
CO5	3	-

UNIT – I

Renewable Energy Conversion Technologies

Renewable Energy potential, Basic concepts and working principals of: Solar Energy, Wind Energy, Bio Energy, Hydro, Tidal energy, Ocean energy, Nuclear Energy, Geothermal Energy, Magneto-hydro-dynamic (MHD) energy conversion, Fuel Cells, Waste to Energy Conversion, Energy Waste Management

UNIT – II

Solar Photovoltaic Systems

Classification of PV systems and components - Central Power Station System, Distributed PV System, Standalone PV system, Grid Interactive PV System.

Solar Thermal Systems

Solar thermal power plants - Solar thermal electric power plants based on parabolic trough, solar central receiver, parabolic dish-Stirling engine.

UNIT – III

Bio- Energy Systems

Thermal Decomposition Mechanisms: Direct Combustion, Technology of Biomass gasification, Pyrolysis, Hydrothermal Liquefaction of Bio-renewable Feedstocks, Direct Liquefaction Chemical Conversion Hydrolysis and hydrogenation. Chemical kinetics and

mathematical modelling of bio-methanation process, Dung, Vegetable Waste and Municipal Waste based Bio -gas plants.

UNIT – IV

Heat recovery Systems Heat recovery systems, Recuperators and regenerators, Heat pipes, Thermoelectric industrial waste heat analysis/characterization, waste heat recovery boilers, Creation of electricity by Waste Heat Recovery, Fluidized bed heat recovery, Shell and tube heat exchangers, Prime mover exhausts, Incineration plants, heat pump systems, thermoelectric devices.

UNIT – V

Fuel Cells

Fuel Cells History, Working principle of fuel cells, Fuel cell thermodynamics, fuel cell electrochemistry - Nernst equation, Electrochemical kinetics, Types of Fuel Cells: AFC, PAFC, SOFC, MCFC, DMFC.

Hydrogen production processes Thermal-Steam reformation, thermochemical water splitting, gasification-pyrolysis, nuclear thermal catalytic and partial oxidation methods. Electrochemical Electrolysis, photo electro chemical method.

Text Books:

1. Principles of Solar Engineering, Edition, Yogi Goswami .D, Frank Kreith, Jan F. Kreider Taylor & Francis, 2003,4th Edition, ISBN: 978-1560329740.
2. Bio-fuels: biotechnology, chemistry, and sustainable development by DM Mousdale, CRC Press, 1st Edition, ISBN-13: 978-1420051247.
3. Energy from Waste - An Evaluation of Conversion Technologies by C Parker and T Roberts (Ed), Elsevier Applied Science, London, 1st Edition, ISBN-13: 978-0853343527.

Reference Books:

1. Fuel cell Systems Explained by James Larminie and Andrew Dicks, John Wiley & Sons, Inc, 3rd Edition, ISBN-13: 978-1118613528.
2. Solar Energy: Principles of Thermal Collection and Storage by SP Sukhatme, Tata McGraw-Hill, 4th Edition, ISBN-13: 978-9352607112.

Web Links:

1. Energy | MIT OpenCourseWare | Free Online Course Materials
2. https://www.nrel.gov/education

FUNDAMENTALS OF SOLAR PHOTOVOLTAICS

Course Code: 2502ME03	L	T	P	C
	3	0	0	3

Course Outcomes: At the end of the Course, Student will be able to:

- **CO1:** Understand principles of solar cells and photovoltaic effect.
- **CO2:** Analyze types, performance, and fabrication of solar cells
- **CO3:** Design standalone and grid-connected PV systems with proper component selection
- **CO4:** Evaluate performance, reliability, and economics of solar PV systems
- **CO5:** Understand solar energy policies for effective project planning and implementation

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	2	-	-	-	-
CO2	3	2	-	-	-	-
CO3	3	2	-	-	-	-
CO4	3	2	-	-	-	-
CO5	3	2	-	-	-	-

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	3	-
CO2	3	-
CO3	3	-
CO4	3	-
CO5	3	-

UNIT – I

Fundamentals of Solar Energy and Photovoltaics

Basics of solar radiation: extraterrestrial and terrestrial spectra, air mass, irradiance Solar geometry and measurements: angles, instruments, and tracking Semiconductor physics: energy bands, doping, p-n junction behavior Photovoltaic effect and types of solar cells

UNIT – II

Solar Cell Technolgies

First-generation solar cells: Crystalline silicon (mono and poly) Second-generation: Thin film (CdTe, CIGS, a-Si) Third-generation: Organic, dye-sensitized, perovskite, quantum dot solar cells Efficiency limits (Shockley-Queisser), I-V characteristics, temperature effects.

UNIT – III

PV Module and System Components

PV module construction, interconnection, and protection Maximum Power Point Tracking (MPPT) algorithms Balance of System (BoS): charge controllers, inverters, batteries

Mounting structures and wiring techniques

UNIT – IV

PV System Design and Grid Integration

Stand-alone vs grid-connected system design Sizing of PV array, battery, and inverter Net metering, grid standards, and safety codes Hybrid PV systems and microgrids

UNIT – V

Performance Evaluation, Policy and Economics

PV performance metrics: PR, CUF, degradation Monitoring and data logging Cost estimation, payback period, LCOE Indian and global solar policies, subsidies, and future trends.

Text Books:

1. "Solar Photovoltaics: Fundamentals, Technologies and Applications" by Chetan Singh Solanki, PHI Learning Pvt. Ltd, 3rd Edition (2021), ISBN: 978-9353066220
2. "Non-Conventional Energy Resources" by B.H. Khan, McGraw Hill Education, 2nd Edition (2017) ISBN: 978-0070648159

Reference Books:

1. "Renewable Energy Engineering and Technology: Principles and Practice" by V. V. N. Kishore, TERI Press (The Energy and Resources Institute), 1st Edition (2009) ISBN: 9788179930939
2. "Solar Energy: Principles of Thermal Collection and Storage" by S. P. Sukhatme and J. K. Nayak, McGraw Hill Education, 3rd Edition (2008), ISBN: 9780070144767

Web Links:

1. https://nptel.ac.in/courses/115/107/115107116
2. https://mnre.gov.in/solar
3. https://www.solarpathshala.com/solar_pathshala/pathshala.php

ENERGY SYSTEMS AND MANAGEMENT

Course Code: 2502ME06	L	T	P	C
	3	0	0	3

Course Outcomes: At the end of the Course, Student will be able to:

- **CO1:** Apply energy management and auditing techniques to optimize energy use
- **CO2:** Apply methods of direct energy conversion and energy storage systems.
- **CO3:** Analysis the energy efficiency in thermal utilities
- **CO4:** Evaluate heat recovery and cogeneration systems for optimizing energy efficiency.
- **CO5:** Apply energy management and financial tools to assess energy projects

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	2	2	-	-	-	-
CO2	2	2	2	-	-	-
CO3	2	3	-	-	-	-
CO4	2	3	2	-	-	-
CO5	2	2	-	-	-	-

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	3	-
CO2	3	-
CO3	3	-
CO4	3	-
CO5	3	-

UNIT – I

Introduction: Energy scenario, various forms of energy, Need for energy storage, Grid balancing: Supply and demand concept for energy management. recent trends in energy conservation. Importance of energy management.

Energy auditing: methodology, analysis of past trends plant data, closing the energy balance, laws of thermodynamics, measurements, portable and online instruments.

UNIT – II

Direct Energy Conversion methods: Magneto-hydrodynamic (MHO) power generation, Thermionic power generation, Thermoelectric power generation, Fuel cells, Hydrogen energy system

Energy storage Methods and systems: Thermal, Electrical and Mechanical energy storage methods and systems, Energy saving in IC engines and Gas turbines.

UNIT – III

Energy Efficiency in Thermal Utilities: Boilers, steam system, furnaces insulation and refractories, FBC boilers, cogeneration, waste heat recovery. Energy Efficiency in electrical Utilities: Electrical systems, electric motors, compressed air system, HVAC and refrigeration systems, fans and blowers, pumps and pumping systems, cooling towers, lighting system, diesel generating system.

UNIT – IV

Heat recovery systems: Incinerators, regenerators and boilers. Waste heat recovery: recuperators, heat wheels, heat pipes, heat pumps. Cogeneration - concept, options (steam/gas turbines/diesel engine based), selection criteria, control strategy.

UNIT – V

Energy Economics: Discount rate, payback period, internal rate of return, life cycle costing.

Energy Management: Principles of Energy Management, Energy demand estimation, Organizing and Managing Energy Management Programs, Energy pricing.

Text Books:

1. Energy Management audit & Conservation, De, B. K., Vrinda Publication, 2nd Edition ISBN: 9788182813434
2. Energy Management, Murphy, W. R., Elsevier, 1st Edition ISBN-13. 978-8131207383

Reference Books:

1. Guide to Energy Management, Capehart, B.L., Turner, W.C., Kennedy, W.J., 7th Edition, Fairmont Press. ISBN 978-1439883488
2. Energy: Management, Supply and Conservation, Clive Beggs, Routledge. ISBN-13: 978-0750686709

Web Links:

1. https://www.iea.org/
2. https://archive.nptel.ac.in/courses/108/106/108106022/

WASTE TO ENERGY

Course Code: 2502ME07

L	T	P	C
3	0	0	3

Course Outcomes: At the end of the Course, Student will be able to:

CO1: Analyze waste types and their energy recovery potential.
CO2: Evaluate thermochemical WTE methods and their environmental impacts
CO3: Design and evaluate biochemical processes for energy from organic waste.
CO4: Design basic WTE plants with suitable technology and pollution control
CO5: Analyze environmental, economic, and policy aspects of WTE projects

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	2	-	-	-	-
CO2	3	2	-	-	-	-
CO3	3	2	-	-	-	-
CO4	3	2	-	-	-	-
CO5	3	2	-	-	-	-

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	3	-
CO2	3	-
CO3	3	-
CO4	3	-
CO5	3	-

UNIT – I

Introduction to Waste-to-Energy (WTE) Systems

Overview of waste generation and characterization. Classification and sources of solid waste: municipal, industrial, agricultural, and biomedical. Fundamentals of energy recovery from waste. Environmental and health impacts of waste disposal.

UNIT – II

Thermochemical Conversion Technologies

Incineration: principles, design, and emissions control. Pyrolysis and gasification processes. Plasma arc gasification. Energy recovery efficiency and environmental considerations.

UNIT – III

Biochemical Conversion Technologies

Anaerobic digestion: process parameters and biogas production. Composting techniques and applications. Fermentation processes for bioethanol and biodiesel production. Landfill gas recovery systems.

UNIT – IV

Waste-to-Energy Plant Design and Operation

Design considerations for WTE facilities. Operational parameters and performance optimization. Emission control technologies and regulatory compliance. Case studies of existing WTE plants.

UNIT – V

Policy, Economics, and Sustainability

National and international policies on waste management and energy recovery. Economic analysis: cost-benefit, life cycle assessment, and funding mechanisms. Sustainability assessment of WTE technologies.
Public perception and community engagement.

Text Books:

1. "Waste to Energy" by Vardhan Goyal, Notion Press (2018), ISBN-13: 978-1646618217
2. "Waste to Energy: Prospects and Applications" by Brijendra Kumar Kashyap, Manoj Kumar Solanki, Dev Vrat Kamboj, Akhilesh Kumar Pandey, Springer(2021), ISBN-13: 978-9813343467

Reference Books:

1. "Waste to Energy" by Amrinder Singh Sethi, LAP LAMBERT Academic Publishing (2018), ISBN-13: 978-3659506161
2. "Waste-to-Energy: Sustainable Approaches for Emerging Economies" by Naresh Kumar Sharma, Elsevier, 1st Edition (Published November 8, 2024), ISBN-13: 978-0-443-22356-3

Web Links:

1. https://archive.nptel.ac.in/noc/courses/noc21/SEM1/noc21-ch09/
2. https://www.che.iitb.ac.in/event/gian-course-energy-waste-sustainable-approaches
3. https://www.coursera.org/learn/solid-waste-management

ENERGY SIMULATION LAB

Course Code: 2502ME09

L	T	P	C
0	0	2	2

Course Outcomes: At the end of the Course, Student will be able to:

CO1: To understand experimental skills for energy related measurements and experiments.

CO2: To understand the effect of reflector material reflectivity on the optical performance of solar devices.

CO3: To develop the skill for using different simulation software for energy system performance analysis

CO4: To understand experiments on solar stills and solar heaters to measure efficiency and output.

CO5: To understand characterize fuels and materials using standard instruments

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	-	-	-	-	-
CO2	3	2	-	-	-	-
CO3	3	2	-	-	-	-
CO4	3	-	-	-	-	-
CO5	3	2	-	-	-	-

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	3	-
CO2	3	-
CO3	3	-
CO4	3	-
CO5	3	-

List of Experiments

1. Design and Simulation of V-trough to study ray behaviour and optical efficiency
2. Design and Simulation of Flat Plate Compounded parabolic concentrator to study ray behaviour and optical efficiency
3. Effect of Reflector Material Reflectivity on Optical efficiency
4. Design and Simulation of Triple fluid heat exchanger using Straight and sinusoidal coil
5. Design and Simulation of mixing of fluids through Elbow
6. Experimental study on double slope symmetrical basin solar still Distilled water yield calculation Vs Time
7. Extraction of biodiesel - chemical and physical methods and its characterization.
8. Determination of flash and fire point of the given sample fuel/oil by using the Pensky Martin apparatus.
9. Characterization of Energy Materials using FT-IR and GCMS
10. To measure the efficiency of flat plate solar water heater.

List of Augmented Experiments: (Any two of the following experiments can be performed)

1. To study the performance and emission characteristics of a diesel engine for biodiesel-diesel blend
2. Performance of PV panel in series and parallel combination
3. Study of vapour absorption refrigeration.
4. Study of Cooling Tower

Reference books:

1. D.P.Kothari and D.K.Sharma, Energy Engineering: Theory and Practice. S. Chand Publisher, New Delhi
2. .P. Sukhatme and J.K. Nayak, Solar Energy: Principles of Thermal Collection and Storage, McGraw Hill Education.

ELECTRIC AND HYBRID VEHICLES

Course Code: 2502ME02	L	T	P	C
	4	0	0	4

Course Outcomes: At the end of the Course, Student will be able to:

CO1: Understand working of different configurations of electric vehicles.

CO2: Analyse hybrid vehicles configuration, components, performance.

CO3: Explore the properties of batteries, including their different types and characteristics.

CO4: Demonstrate how to operate an electric vehicle drive system.

CO5: Understand of hybrid electric vehicles.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	2	-	-	-	-
CO2	3	2	-	-	-	-
CO3	3	2	-	-	-	-
CO4	3	2	-	-	-	-
CO5	3	2	-	-	-	-

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	3	-
CO2	3	-
CO3	3	-
CO4	3	-
CO5	3	-

UNIT – I

Introduction to Electric Vehicles

Sustainable Transportation - EV System - EV Advantages — Vehicle Mechanics - Performance of EVs - Electric Vehicle drive train - EV Transmission Configurations and Components-Tractive Effort in Normal Driving - Energy Consumption - EV Market - Types of Electric Vehicle in Use Today - Electric Vehicles for the Future.

UNIT – II

Electric Vehicle Modeling

Rolling Resistance - Transmission Efficiency -Consideration of Vehicle Mass - Tractive Effort - Modeling Vehicle Acceleration - Modeling Electric Vehicle Range - Aerodynamic Considerations - Ideal Gearbox Steady State Model - EV Motor Sizing - General Issues in Design.

UNIT – III

Batteries

Introduction to electric vehicle batteries - electric vehicle battery efficiency - electric vehicle battery capacity - electric vehicle battery charging - electric vehicle battery fast charging - electric vehicle battery discharging - electric vehicle battery performance testing.

UNIT – IV

Hybrid Electric Vehicles

HEV Fundamentals -Architectures of HEVs- Interdisciplinary Nature of HEVs - State of the Art of HEVs - Advantages and Disadvantages - Challenges and Key Technology of HEVs - Concept of Hybridization of the Automobile-Plug-in Hybrid Electric Vehicles - Design and Control Principles of Plug-In Hybrid Electric Vehicles - Fuel Cell Hybrid Electric Drive Train Design - HEV Applications for Military Vehicles.

UNIT – V

Advanced Topics

Battery Charger Topologies, Charging Power Levels, and Infrastructure for Plug-In Electric and Hybrid Vehicles - The Impact of Plug-in Hybrid Electric Vehicles on Distribution Networks Sizing Ultra capacitors for Hybrid Electric Vehicles.

Text Books:

1. Modern Electric, Hybrid Electric and Fuel Cell Vehicles — Fundamentals, Theory and Design— Mehrdad Ehsani, Uimin Gao and Ali Emadi - Second Edition - CRC Press, 2010.
2. Electric Vehicle Technology Explained - James Larminie, John Lowry - John Wiley & Sons Ltd, - 2003.

Reference Books:

1. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.
2. MehrdadEhsani, YimiGao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.

Web Links:

1. https://archive.nptel.ac.in/courses/108/103/108103009/
2. https://nptel.ac.in/courses/108106170
3. https://online.stanford.edu/courses/xeiet239-hybrid-and-electric-vehicles

COMPUTATIONAL FLUID DYNAMICS

Course Code: 2502ME04	L	T	P	C
	4	0	0	4

Course Outcomes: At the end of the Course, Student will be able to:

CO1: Analyse the basics of computational fluid dynamics (CFD).
CO2: Analyze PDEs, their role in CFD, and basics of discretization
CO3: Understand basic concepts of potential flow and flow around objects
CO4: Understand the numerical methods to solve fluid flow problems
CO5: To solve steady diffusion and fluid flow problems

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	2	2	-	-	-
CO2	3	2	2	-	-	-
CO3	3	2	1	-	-	-
CO4	3	2	1	-	-	-
CO5	3	2	1	-	-	-

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	-	3
CO2	-	3
CO3	-	3
CO4	-	3
CO5	-	3

UNIT – I

Introduction: Role of CFD and its applications, future of CFD. Introduction to heat transfer, Compressible flows, Incompressible flows.

Governing equations (GE's) of Fluid dynamics: Modelling of flow, control volume concept, Continuity equation, momentum equation, energy equation and its conservation form. Energy equation, Navier-Stokes equations for viscous flow, Euler equations for inviscid flow, Physical boundary conditions.

UNIT – II

Mathematical behavior of partial differential equations: Classification of quasi-linear partial differential equations, Methods of determining the classification, General behaviour of Hyperbolic, Parabolic and Elliptic equations.

Finite Difference Method: formulae for first and second order terms, Solution of physical problems with Elliptic, type of Governing Equations for different boundary conditions.

UNIT – III

Potential flow – Mathematical considerations, Stokes' theorem, Circulation in irrotational flows, Velocity potential, Stream function and its relationship with

velocity field, Streamlines, two-dimensional sources and sinks, Simple vortex, Doublet, Superposition of 2D flows – sink plus vortex, flow about a cylinder without circulation, Rotating cylinder.

UNIT – IV

Finite Difference Applications in Fluid Flow Problems: Fundamentals of fluid Flow modelling using Burger's Equation, Upwind Scheme and Artificial Viscosity.

Solutions of Navier Stokes Equations for Incompressible Fluid Flows: Staggered Grid, Marker and Cell (MAC) Formulation, Numerical Stability Considerations, SIMPLE Algorithm

UNIT – V

FVM: 2D steady state diffusion, 3D steady state diffusion.

Standard Variation Methods: Linear fluid flow problems, steady state problems.

Text Books:

1 Introduction to Computational Fluid Dynamics, an: The Finite Volume Method, H. Versteeg, W. Malalasekera, Pearson Education Limited, 2nd Edition ISBN-10. 0131274988

2 Introduction to Computational Fluid Dynamics Development, Application and Analysis, Atul Sharma, Wiley Publication. ISBN-10. 9781119002994

Reference Books:

1 Numerical Heat Transfer and Fluid Flow, Suhas V Patankar, Mc Graw Hill Publication ISBN 0-07-048740-5

2 Computational Fluid Dynamics, John D. Anderson, McGraw-Hill Book Company. ISBN-10. 1259025969

Web Links:

1 https://nptel.ac.in/courses/112105045
https://archive.nptel.ac.in/courses/112/105/112105254/

WIND AND HYDRO ENERGY SYSTEMS

Course Code: 2502ME05	L	T	P	C
	3	0	0	3

Course Outcomes: At the end of the Course, Student will be able to:

CO1: To understand the process of generation of wind energy extraction.
CO2: To understand the aerodynamic principle of turbine blade design
CO3: To understand the recent developments and technologies in the wind.
CO4: To apply the concepts of hydro power systems.
CO5: To understand different hydroelectric equipment.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	2	-	-	-	-
CO2	3	2	-	-	-	-
CO3	3	2	-	-	-	-
CO4	3	2	-	-	-	-
CO5	3	2	-	-	-	-

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	3	-
CO2	3	-
CO3	3	-
CO4	3	-
CO5	3	-

UNIT – I
Wind Energy
Atmospheric circulations, classification, factors influencing wind, wind shear, turbulence, wind speed monitoring, Wind resource assessment, Weibull distribution

UNIT – II
Power in the wind
Bentz limit, Wind energy conversion systems: classification, applications, power, torque and speed, Characteristics Aerodynamic design principles; Aerodynamic theories: Axial momentum, Blade element and Combine theory, Rotor characteristics, Maximum power coefficient, Tip loss correction.

UNIT – III
Wind Turbines
Wind turbine design and materials considerations: methodology, theoretical simulation of wind turbine Characteristics, wind pumps, performance analysis of wind pumps, design concept and testing, Principle of WEG: standalone, grid connected; Hybrid applications of WECS; Economics of Wind energy Utilization.

UNIT – IV

Hydropower plant

Hydrology, Resource assessment, Potential of hydropower in India, Classification of Hydropower Plants, Small Hydropower Systems: Overview of micro, mini and small hydro systems, Status of Hydropower Worldwide and India.

UNIT – V

Hydraulic Turbines

Types and operational aspects of turbines, classification of turbines, elements of turbine, selection and design criteria, geometric similarity operating characteristic curves; Speed and voltage regulation.

Text Books:

1. J. F. Manwell, J. G. McGowan, &, A. L. Rogers, Wind Energy Explained: Theory, Design and Application 2nd Edition Wiley, ISBN: 978-0470015001
2. M. Ragheb & P.A. Elghobashi, Hydroelectric Energy: Challenges and Opportunities. CRC Press. ISBN: 978-1138326828,

Reference Books:

1. B. N. Eldridge, Wind Energy Basics: A Guide to Small and Micro Wind Systems, New Society Publishers,
2. H.J. Delay, Introduction to Hydropower. ASCE Press, ISBN: 978-0784413118,

Web Links:

1. https://archive.nptel.ac.in/courses/112/103/112103016
2. http://www.rmki.kfki.hu/~vpet/AdvThd/adv_thermo_lnp1.pdf
3. https://www.cdeep.iitb.ac.in/slides/A15/ME661/ME661-L1.pdf

NANOMATERIALS FOR ENERGY STORAGE APPLICATION

Course Code: 2502ME08	L	T	P	C
	3	0	0	3

Course Outcomes: At the end of the Course, Student will be able to:

CO1: Explain the basics about energy storage and nanomaterials.
CO2: Explain synthesis and energy conversion techniques of nanomaterials.
CO3: Learn the use of nanomaterials for energy storage.
CO4: Learn the knowledge about the new advance energy storage material.
CO5: Assess the challenges and future research directions for nanomaterials.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	2	-	-	-	-
CO2	3	2	-	-	-	-
CO3	3	2	-	-	-	-
CO4	3	2	-	-	-	-
CO5	3	2	-	-	-	-

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	3	-
CO2	3	-
CO3	-	3
CO4	-	3
CO5	-	3

UNIT – I

Introduction to Energy Storage: Introduction to energy storage devices and its necessity, Key challenges for energy storage, Solution of key challenges, Different types of energy storage, thermal, electrical, electrochemical, mechanical.

Nanomaterials: Overview of various nanomaterials (carbon nanotubes, graphene, metal nanoparticles, etc.), their properties, Nanomaterials vs. conventional materials, Role of nanomaterials in energy storage.

UNIT – II

Synthesis and Characterization of Nanomaterials: Physical and chemical synthesis techniques, Characterization methods: SEM, TEM, XRD. Applications: Designing nanomaterials for specific energy applications.

Energy Conversion and Storage Devices: Lithium-ion batteries, Capacitors and Supercapacitors, Fuel cells, Photovoltaic cells, Hydrogen storage systems, Thermal energy storage and phase change nanomaterials, Solar energy and Nanomaterials used for solar energy.

UNIT – III

Nanomaterials used in Batteries

Issues and Challenges of functional nanostructured materials for electrochemical energy storage, Primary and secondary batteries focusing on lithium ion batteries, Cathode and anode materials, Nanostructured Carbon based materials, Nano-Oxides, Novel hybrid electrode materials, Current status and future trends.

UNIT – IV

Nanomaterials used in Capacitor

Capacitor, Electrochemical supercapacitors, electrical double layer model, Principles and materials design, Nanostructured Carbon based materials, Redox capacitor Nano- Oxides, Conducting polymers based materials, Current status and future trends.

UNIT – V

Advantages and Challenges of Nanomaterials for Energy Storage: Advantages of nanomaterials in terms of energy densities, power densities, cycle life, design considerations, Surface area and diffusivity issues, Mechanical and physical properties including electrical conductivity, Special beneficial aspects of nanostructured materials for performance of Li batteries.

Text Books:

1 Ishani Chakrabartty, Khalid Rehman Hakeem, Green Nanomaterials in Energy Conversion and Storage Applications, Apple Academic Press, 2024.

2 Doughty Liaw, Narayan and Srinivasan, Batteries for Renewable Energy Storage, The Electrochemical Society, New Jersy, 2010.

Reference Books:

1 Leite, Edson Roberto, Nanostructured materials for electrochemical energy production and storage, New York: Springer, 2009.

2 G.A. Nazri and G. Pistoia, Lithium Batteries: Science and Technology, Kulwer Acdemic, Publishers, Dordrecht, Netherlands, 2004.

Web Links:

1 https://archive.nptel.ac.in/courses/112/107/112107283/

2 https://nps.edu/web/nps-video-portal/-/LmQaXhdC7C5c8ZjBInHmdcjfL8SBpe5r.

ADVANCED FLUID DYNAMICS LAB

Course Code: 2502ME10

L	T	P	C
0	0	2	2

Course Outcomes: At the end of the Course, students will be able to:

- **CO1:** Analyse the basics of computational fluid dynamics (CFD).
- **CO2:** Analyse the concepts of PDEs, their application to CFD problems and fundamentals of discretization.
- **CO3:** Analyse the concept of Finite Difference Method.
- **CO4:** Solve the problem related to Finite Different Method.
- **CO5:** Solve the problem related to Finite Volume Method

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	2	2	-	1	-
CO2	3	2	2	-	1	-
CO3	3	2	1	-	1	-
CO4	3	2	1	-	1	-
CO5	3	2	1	-	1	-

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	-	3
CO2	-	3
CO3	-	3
CO4	-	3
CO5	-	3

List of Experiments:

1. Introduction to CFD Drafting: Development of part drawings for various components in the theory of orthographic and isometric. Representation of dimensioning and tolerances.
2. Part Modelling: Generation of various 3D Models through Protrusion, revolve, and sweep. Creation of various features. Study of parent-child relations. Feature-based, Boolean-based, and Assembly modelling.
3. Heat conduction through a slab
4. Lumped heat capacity model.
5. Flow over a flat plate.
6. Flow through pipe.
7. Natural convection in a cavity (steady state)
8. Natural convection in a cavity (Unsteady)
9. Numerical solution of potential flow problem.
10. Heat transfer in porous media

Text Books:

1. Introduction to Computational Fluid Dynamics, an: The Finite Volume Method, H. Versteeg, W. Malalasekera, Pearson Education Limited, 2nd Edition ISBN-10. 0131274988
2. Introduction to Computational Fluid Dynamics Development, Application and Analysis, Atul Sharma, Wiley Publication. ISBN-10. 9781119002994

Reference Books:

1. Numerical Heat Transfer and Fluid Flow, Suhas V Patankar, Mc Graw Hill Publication ISBN 0-07-048740-5
2. Computational Fluid Dynamics, John D. Anderson, McGraw-Hill Book Company. ISBN-10. 1259025969

Web Links:

1. https://nptel.ac.in/courses/112105045
2. https://archive.nptel.ac.in/courses/112/105/112105254/

RESEARCH METHODOLOGY

Course Code: 2502CE33

L	T	P	C
3	0	0	3

Course Outcomes: At the end of the Course, Student will be able to:

CO1: Explain the characteristics and process of research.
CO2: Choose the research problem by applying problem identification techniques.
CO3: Develop and execute research design process.
CO4: Show the results of research process adhering to professional ethics.
CO5: Analyze the results of research using statistical measures of central tendency & coefficient of variation, correlation and regression

Mapping of course outcomes with program outcomes:

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

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	-	-
CO2	-	-
CO3	-	-
CO4	-	-
CO5	-	-

UNIT – I:

Meaning of Research: Function of Research - Characteristics of Research – Steps involved in Research – Research in Pure and Applied Sciences - Inter Disciplinary Research. Factors which hinder Research – Significance of Research - Research and scientific methods – Research Process– Criteria of good Research – Problems encountered by Researchers – Literature review.

UNIT – II:

Identification of Research Problem: Selecting the Research problem – Necessity of defining the problem – Goals and Criteria for identifying problems for research. Perception of Research problem – Techniques involved in defining the problem.

UNIT – III:

Research Design: Formulation of Research design – Need for Research design – Features of a good design – Important concepts related to Research design.

UNIT – IV:

Interpretation and Report Writing: Meaning and Technique of interpretation – Precautions in interpretation, Significance of report writing – Different steps in writing a report – Layout of a Research report.

UNIT – V:

Statistical Techniques and Tools: Introduction of statistics – Functions – Limitations – Measures of central tendency - Arithmetic mean – Median – Mode – Standard deviation – Co-efficient of variation (Discrete serious and continuous serious) – Correlation – Regression.

Text Books:

1. Research Methodology Methods & Techniques, C.R. Kothari – New Age international Publishers ISBN: 9789386649225
2. A Hand Book of Methodology of Research, Rajammall, P. Devadoss and K. Kulandaivel, RMM Vidyalaya press.ISBN: 9780367135720

Reference Books:

1. Thesis and Assignment Writing, J. Anderson, Wiley Eastern Ltd.ISBN: 9780471339274
2. Research Methodology, Mukul Gupta, Deepa Gupta – PHI Learning Private Ltd., New Delhi.
ISBN: 9788120343818
3. Fundamentals of Mathematical statistics, S.C. Gupta and V.K. Kapoor, Sultan Chand & Sons, New Delhi.ISBN: 9788180545283

Web Links:

1. https://nptel.ac.in/courses/127106227
2. https://www.coursera.org/learn/research-methodologies

MEASUREMENTS IN THERMAL ENGINEERING

Course Code: 2502ME11	L	T	P	C
	3	0	0	3

Course Outcomes: At the end of the Course, Student will be able to:

- **CO1:** Apply concepts of measurement systems, including errors, calibration, and transducer types and models
- **CO2:** Apply principles and methods to measure and analyze various types of pressure.
- **CO3:** Apply flow measurement and visualization methods to analyze fluid flow.
- **CO4:** Evaluate temperature measurement techniques and analyze errors and uncertainties.
- **CO5:** Apply different types of controllers to model and analyze control systems

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	2	3	1	-	-	-
CO2	2	3	1	-	-	-
CO3	2	3	1	-	-	-
CO4	2	3	1	-	-	-
CO5	2	3	1	-	-	-

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	3	-
CO2	3	-
CO3	3	-
CO4	3	-
CO5	3	-

UNIT – I

Concept of Generalized Measurement System: System configurations - Errors Problem analyses - Basic characteristics of measuring devices – Calibration. The transducer and its environment; an overview; sensing process and physical laws. Types of measurement problems. Transducer classification and their modeling; information, energy and incremental models

UNIT – II

Measurement of Pressure: principles of pressure measurement, static and dynamic pressure, vacuum and high-pressure measurement – Measurement of low pressure, Manometers, Calibration methods, Dynamic characteristics, design principles. pressure Variable reluctance & LVDT Type pressure sensors – Knudsen gauge Thermal conductivity ionization gauge High pressure measurement – Piezo-electric and vibrating elements pressure sensors

UNIT – III

Flow measurement and Flow Visualization methods: Positive displacement methods, Flow-obstruction methods, sonic nozzle, Flow measurement by drag effect, Hot-wire and

hot-film anemometers, Magnetic flow meters, Flow-visualization methods, The shadowgraph. The schlieren, The interferometer, The Laser Doppler Anemometer (LDA), Smoke method, Pressure probes and impact pressure in supersonic flow

UNIT – IV

Measurement of Temperature: Thermo-electric sensors – Thermocouple & electrical resistance- Radiation & optical thermometers – Quartz crystal Thermometers – High speed Temperature probe, Digital Control Systems

Errors in Measurement and its Analysis: Causes and types of experimental errors; systematic and random errors. Uncertainty analysis; Tion of overall uncertainty; estimation for design and selection for alternative test methods.

UNIT – V

Process Control: Types of controllers - on/off, P, PI, PID controllers. Modeling of mechanical translation, rotary and simple hydraulic and pneumatic systems. Block diagrams, transfer functions and steady state behavior of systems. Dynamic behavior, stability criterion. Analog computer simulation of control systems. Discrete state process control. Introduction to digital control.

Text Books:

1. Experimental methods for engineers, J. P. Holman, McGraw Hill Education, 7th Edition, **ISBN 978-0070647763**
2. Experimentation, validation, and uncertainty analysis for engineers, H.W. Coleman and W.G. Steele Jr, Wiley, 3d Edition ISBN-10, 0470168889

Reference Books:

1. Modern Control Engineering, M. Ogata, 4th Edition, Prentice-Hall, ISBN-13. 978-8178085791
2. Control Systems - Principles & Design, M. Gopal, TMH, 2nd Edition. ISBN-13. 978-0071333269

Web Links:

1. https://nptel.ac.in/courses/112103261
2. https://nptel.ac.in/courses/103105064

ENERGY CONSERVATION AND WASTE HEAT RECOVERY

Course Code: 2502ME13	L	T	P	C
	3	0	0	3

Course Outcomes: At the end of the Course, Student will be able to:

CO1: Analyze waste heat recovery and power plant cycles using thermodynamics.
CO2: Apply thermodynamics to improve energy system efficiency.
CO3: Analyze cogeneration, trigeneration, and boiler performance.
CO4: Evaluate the performance of heat recovery system for industrial applications
CO5: Evaluate energy storage methods and their economic impact.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	2	1	1	1	-	-
CO2	2	2	1	1	-	-
CO3	2	2	2	1	-	-
CO4	2	1	-	1	-	-
CO5	2	1	-	1	-	-

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	3	-
CO2	3	-
CO3	3	-
CO4	3	-
CO5	3	-

UNIT – I

Introduction to Waste Heat: Importance of Waste Heat Recovery, Review of Thermodynamics – Introduction to First and Second Laws – Entropy, Entropy Generation, First and Second Law efficiency Power Plant Cycles - Energy Cascading, Rankine Cycle, modification of Rankine cycle, examples.

UNIT – II

Energy Conservation: Introduction: Principles of thermodynamics: Rankine and Brayton cycles; enhancement of efficiency by reheat, regenerative, intercooling; topping, bottoming and combined cycles;

UNIT – III

Co-generation, Tri-generation & Boilers: Definition, concept of tri generation; Cogenerations, Boilers: Types, Performance evaluation of boilers, Boiler Water Treatment and blow down, Introduction to FBC Boilers, Mechanism and Operational Features of FBC, Retrofitting FBC system to conventional boilers.

UNIT – IV

Waste Heat Recovery: Classification, Advantages and applications, Selection criteria for waste heat recovery technologies, waste heat recovery devices: recuperators, regenerators, economizers, plate heat exchangers, thermic fluid heaters, Waste heat boilers-design aspects.

UNIT – V

Energy Storage Techniques – Pumped hydro, Compressed Air, Flywheel, Superconducting Magnetic storage Thermal storage (Sensible & Latent), Battery, Chemical Energy Storage, Fuel cells, Energy Economics.

Text Books:

1. Energy Storage, J Jensen, Elsevier ISBN: 9780408012256.
2. Advance Energy Systems, Nikolai V. Khartchenko, Taylor and Francis Publishing, 2nd Edition ISBN-13: 978-1439886588

Reference Books:

1. Powerplant Technology, M.M.El-Wakil, Tata McGraw Hill, Indian Edition. ISBN-10. 9780070702448
2. Waste Heat Utilization and Management, Lee SS EDS, Seagate Subrata, Hemisphere, Washington, ISBN-13. 978-0891161189

Web Links:

1. https://archive.nptel.ac.in/courses/112/105/112105221/
2. https://beeindia.gov.in/sites/default/files/2Ch8.pdf
3. https://www.slideshare.net/slideshow/waste-heat-recovery-and-sustainable-energy-785c/266274018

COMBUSTION, EMISSIONS AND ENVIRONMENT

Course Code: 2502ME18	L	T	P	C
	3	0	0	3

Course Outcomes: At the end of the Course, Student will be able to:

- **CO1:** Analyse combustion principles, including chemical composition, stoichiometry, and reaction kinetics.
- **CO2:** Calculate and analyse the thermodynamic properties of combustion, including enthalpy, heating value, and adiabatic flame temperature.
- **CO3:** Analyse flame propagation and structure, including burning velocity, and evaluate combustion in various fuel and furnace systems.
- **CO4:** Analyse pollution formation, measurement, and control methods, including emission standards.
- **CO5:** Evaluate the Environmental Considerations

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	2	1	1	1	-	-
CO2	2	2	1	1	-	-
CO3	2	2	2	1	-	-
CO4	2	1	-	1	-	-
CO5	2	1	-	1	-	-

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	-	3
CO2	-	3
CO3	-	3
CO4	-	3
CO5	-	3

UNIT – I

Principles of Combustion: Chemical composition, Flue gas analysis, dew point of products, Combustion stoichiometry, Chemical kinetics, Rate of reaction, Reaction order, Molecularity, Zeroth, first, second and third order reactions, complex reactions, chain reactions, Theories of reaction Kinetics, General oxidation behavior of HCs.

UNIT – II

Thermodynamics of Combustion: Enthalpy of formation, Heating value of fuel, Adiabatic flame Temperature, Equilibrium composition of gaseous mixtures.

UNIT – III

Laminar and Turbulent Flames Propagation and Structure: Flame stability, burning velocity of fuels, Measurement of burning velocity, factors affecting the Burning velocity. Combustion of fuel droplets and sprays, Combustion systems, Pulverized fuel furnaces-fixed, entrained and fluidized bed systems.

UNIT – IV

Pollution Formation Measurement and Control: Causes for Formation of NOx, SOx, COx, Smoke and UBHC. Different methods of measurement of pollutants. methods of controlling the formation of pollutants, BHARAT and EURO standards of emissions**.**

UNIT – V

Environmental Considerations: Air pollution, effects on environment, human health etc. Principal pollutants, Legislative measures, methods of emission control..

Text Books:

1. Fuels and combustion, Sharma and Chandra Mohan, Tata McGraw Hill ISBN-13. 978-0070966277
2. Combustion Engineering and Fuel Technology, Shaha A.K., Oxford and IBH

Reference Books:

1. Principles of Combustion, Kanneth K.Kuo, Wiley and Sons. ISBN-978-0471046899
2. An Introduction to Combustion, Stephen R. Turns, Mc. Graw Hill International 4th Edition, 2020. ISBN-13, 1260575521-978

Web Links:

1. http://nptel.ac.in/courses/107106080/
2. http://www.engineering108.com/Data/Engineering/Automobile/advance-vehicle echnology.pdf
3. http://nptel.ac.in/112999903

HYDROGEN FUEL CELL TECHNOLOGY

Course Code: 2502ME16	L	T	P	C
	3	0	0	3

Course Outcomes (COs):

At the end of the course, the student will be able to:

CO1: Understand the basics of hydrogen economy, including production, storage, and safety

CO2: Understand the chemical and physical processes involved in fuel cell function

CO3: Differentiate various types of fuel cells based on structure, efficiency, and losses.

CO4: Analyze fuel cell design and performance, including flow, losses, and water management.

CO5: Evaluate fuel cell uses across sectors and their economic and environmental effect.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	–	–	–	–
CO2	3	2	–	–	–	–
CO3	3	2	–	–	–	–
CO4	3	2	–	–	–	–
CO5	3	2	–	–	–	–

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2	PSO3
CO1	3	–	–
CO2	3	–	–
CO3	3	–	–
CO4	3	–	–
CO5	3	–	–

UNIT - I

INTRODUCTION

Introduction to hydrogen economy, production, storage and transportation systems, hydrogen from fossil fuels, electrolysis of water, thermo chemical cycles, transmission and infrastructure requirements, safety and environmental impacts, economics of transition to hydrogen systems.

UNIT - II

Fuel Cells

Concept, key components, physical and chemical phenomena in fuel cells, advantages and disadvantages, different types of fuel cells and applications, characteristics, Nernst equation, relation of the fuel consumption versus current output.

UNIT - III

Type of Fuel Cells

Proton-exchange membrane, alkaline, anion exchange membrane, solid oxide, microbial, storage.

UNIT - IV

Fuel Cell Design and Performance

Stoichiometric coefficients and utilization percentages of fuels and oxygen, mass flow rate calculation for fuel and oxygen in single cell and fuel cell stack, total voltage and current for fuel cells in parallel and serial connection, over-potential and polarizations, DMFC operation scheme, general issues-water flooding and water management, polarization in PEMFC.

UNIT - V

Fuel Cells Application and Economics

Fuel cell usage for domestic power systems, large scale power generation, automobile, space applications, economic and environmental analysis on usage of fuel cell, future trends of fuel cells.

Text Books:

1. Modern Electric, Hybrid Electric and Fuel Cell Vehicles Fundamentals, Theory and Design, CRC Press, 2nd Edition, ISBN 9781420053982.
2. Electric Vehicle Technology Explained, John Wiley & Sons Ltd, ISBN 111994273X**.**

Reference Books:

1. Fuel Cells: From Fundamentals to Applications, Springer, 2nd Edition, ISBN 9781441937728.
2. Hydrogen Production and Fuel Cells: Emerging Technologies and Applications, Elsevier, ISBN 0081007086

Web Links:

1. https://archive.nptel.ac.in/courses/103/102/103102015/
2. https://archive.nptel.ac.in/courses/103/101/103101215/

ALTERNATIVE FUELS

Course Code: 2502ME19	L	T	P	C
	3	0	0	3

Course Outcomes: At the end of the Course, Student will be able to:

- **CO1:** Demonstrate various liquid alternative fuels for IC engines and their significance.
- **CO2:** Evaluate the performance and of SI & CI engines using gaseous alternative fuels.
- **CO3:** Explain the formation of emissions from SI engine and its control strategies.
- **CO4:** Analyse emission formation and control strategies in CI engines, including the effects of operating variables and various control technologies
- **CO5:** Apply different techniques and test procedures to measure emissions.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	2	1	1	1	-	-
CO2	2	2	1	1	-	-
CO3	2	2	2	1	-	-
CO4	2	1	-	1	-	-
CO5	2	1	-	1	-	-

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	-	2
CO2	-	2
CO3	-	2
CO4	-	2
CO5	-	2

UNIT – I

Liquid Fuels, Alcohols: Properties, production, advantages and disadvantages of Methanol and Ethanol and their blends as fuel for SI and CI engine.

Biodiesels: Background of Diesel/Biodiesel fuels-Oil feed stocks-Transesterification-Biodiesel production from Vegetable oils. Properties of biodiesel and their importance in the context of performance and emissions of IC Engines.

Recycled Fuels: Pyrolysis- plastic, tyre and cooking oils.

UNIT – II

Gaseous Fuels, Hydrogen: Introduction, properties and production of hydrogen. Storage, Advantages and disadvantages of hydrogen as fuel for SI and CI engines. Hazards and safety systems for hydrogen, hydrogen combustion. Performance and emission of from hydrogen.

Other Gaseous Fuels: Properties, production, advantages and disadvantages of LPG, CNG, Bio gas as fuel for SI and CI engines.

UNIT – III

SI Engine Emissions and its Control: Emission formation in SI Engines- Carbon monoxide & Carbon dioxide - Unburned hydrocarbon, NOx, Smoke-Effects of design and operating variables on emission formation- controlling of pollutants - Catalytic converters, Charcoal Canister, Positive Crank case ventilation system, Secondary air injection.

UNIT – IV

CI Engine Emission and its Control

Emission formation in CI Engines- Carbon monoxide & Carbon dioxide - Unburned hydrocarbon, NOx, soot, particulate matter and Intermediate Compounds - Physical and Chemical delay- Significance Effect of operating variables on Emission formation- Fumigation, Split injection, Catalytic Coating, EGR, HCCI, Particulate Traps, SCR.

UNIT – V

Test Procedures and Emission Measurements

Emission test cycles, constant volume sampling method, non-dispersive infrared (NDIR) analyzer, flame ionization detectors (FID), chemiluminescence analyzer, smoke meters, gas chromatograph.

Text Books:

1. Alternate Fuels, S. S. Thipse, Jaico Publications ISBN 13 978-8184950786
2. IC Engine Combustion & Emissions by B.P. Pundir, 4th Edition, Narosa Publications, 2020. ISBN-13. 978-1842656457

Reference Books:

1. Alternative Fuels Guidebook, Richard L.Bechtold, Society of Automotive Engineers (SAE), ISBN 978-0-7680-0052-8
2. Internal Combustion Engines Fundamentals, John B. Heywood, , Mc Graw Hill Publications, 2nd Edition, 2018. ISBN 9781260116106

Web Links:

1. https://archive.nptel.ac.in/content/storage2/courses/112104033/lecture39
2. https://nptel.ac.in/courses/112104033
3. https://www.udemy.com/course/automotive-engineering-automobile-fundamentals-and-advanced/?couponCode=LEADERSALE24A

ENERGY STORAGE

Course Code: 2502ME20	L	T	P	C
	3	0	0	3

Course Outcomes: At the end of the Course, Student will be able to:

CO1: Design suitable hydrogen storage systems for integration with fuel cells.

CO2: Analyze and compare performance, efficiency, and costs of various energy storage systems.

CO3: To design and simulate energy storage for grid, renewable, and transport applications

CO4: Understand the different energy storage technologies and their uses.

CO5: Design and optimize energy storage systems for smart grids and electric vehicles

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	2	-	-	-	-
CO2	3	2	-	-	-	-
CO3	3	2	-	-	-	-
CO4	3	2	-	-	-	-
CO5	3	2	-	-	-	-

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	3	-
CO2	3	-
CO3	3	-
CO4	3	-
CO5	3	-

UNIT - I

Introduction & Classification: Energy demand trends; role of storage in stability and resilience, Classification: Mechanical (pumped hydro, flywheels, CAES), thermal (sensible, latent), chemical (batteries, hydrogen), electrostatic (super-capacitors), electromagnetic (SMES), Comparative metrics: energy–power density, round-trip efficiency, response time, lifespan, cost, environmental impact.

UNIT - II

Thermal Energy Storage: Sensible vs. latent heat storage; Phase Change Materials (PCMs), Energy & exergy analysis; integration with solar thermal systems, Case studies: industrial process heat, building HVAC, concentrated solar power.

UNIT - III

Mechanical & Electrostatic Storage: Pumped hydro and compressed air: thermodynamic cycles, isothermal/adiabatic processes, Flywheel storage: rotor dynamics, bearing and vacuum technologies, Super-capacitors: EDLC principles, Ragone plot interpretation.

UNIT - IV

Electrochemical Storage (Batteries & Fuel Cells): Battery fundamentals: electrochemistry, electrode/electrolyte materials, Technologies: lead-acid, NiMH, Li-ion, sodium-ion, high-temperature (NaS), flow batteries, Fuel cells overview (PEMFC, SOFC): thermodynamics, polarization curves, system components.

UNIT - V

System Integration & Applications: Hybrid Energy Storage Systems (HESS): configuration, control strategies, Battery Management Systems (BMS): SOC/SOH estimation, balancing, safety protocols, Applications: grid leveling, renewable smoothing, UPS, EV traction, microgrid/Smart-Home integration, Regulations and safety standards for high-voltage storage

Text Books:

1. Huggins R. (2010); Energy Storage, Springer
2. Ter-Gazarian A. (2011); Energy Storage for Power System, Second Edition, The Institution of Engineering and Technology

Reference Books:

1. O'Hayre R. Cha S. Colella W. and Prinz F.B. (2009); Fuel Cell Fundamentals, Second Edition, Wiley
2. Narayan R. and Viswanathan B. (1998); Chemical and Electrochemical Energy System, Universities Press
3. Dincer I. and Rosen M.A. (2010), Thermal Energy Storage: System and Applications, Second Edition, Wiley
4. Rahn C.D. and Wang C. (2013); Battery Systems Engineering, First Edition, Wiley

Weblinks:

1. https://archive.nptel.ac.in/courses/113/105/113105102/
2. https://archive.nptel.ac.in/courses/103/101/103101215/

ENERGY AUDIT

Course Code: 2502ME12	L	T	P	C
	3	0	0	3

Course Outcomes: At the end of the Course, Student will be able to:

- **CO1:** Identify different types of energy and explain the importance of energy conservation.
- **CO2:** Analyze energy management strategies, audit types, audit instruments, and methods to enhance system efficiency.
- **CO3:** Assess energy-saving opportunities and performance assessment in electrical systems.
- **CO4:** Analyze the performance of mechanical systems to improve energy efficiency.
- **CO5:** Apply cost analysis and financial methods to evaluate project investments.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	2	3	-	-	-	-
CO2	3	2	-	-	-	-
CO3	2	3	-	-	-	-
CO4	3	2	-	-	-	-
CO5	3	2	-	-	-	-

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	3	-
CO2	3	-
CO3	3	-
CO4	3	-
CO5	3	-

UNIT – I

Energy Scenario:

Classification of Energy-Primary and Secondary Energy, Commercial and Non-commercial Energy, Renewable and Non-renewable Energy. Various Forms of Energy-Potential Energy (Stored Energy) & Kinetic Energy (Working Energy). Basics of Electrical Energy and Thermal Energy and Environment; Energy Conservation and Its Importance; Energy Conservation Act-2001 and its features.

UNIT – II

Energy Management & Audit:

Definition and objectives of Energy Management, Energy Audit – types and methodology; need for energy audit; energy auditing methodology; Benchmarking energy performance; Maximizing system efficiency; Energy Audit Instruments.

UNIT – III

Energy Efficiency in Electrical Systems:

Electricity billing, electrical load management and maximum demand control: Power factor improvement benefits, selection and location of capacitors, performance assessment of Power Factor capacitors, distribution and transformer losses.

Electric motors: Motor efficiency, factors affecting motor performance, rewinding and motor replacement issues, energy saving opportunities with energy efficient motors.

UNIT – IV

Energy Efficiency in Mechanical Systems:

Purpose and parameters of performance of (a) Boilers, (b) Furnaces, (c) Turbines, (d) Fans and Blowers, (e) Pumps, (f) Compressors and (g) Lighting.

Detailed performance analysis of boilers and pumps.

UNIT – V

Financial Analysis:

Introduction, fixed and variable costs, interest charges, simple payback period, discounted cash flow methods - Net Present Value method and Internal rate of return method; Factors affecting analysis

Text Books:

1. Energy Audit: Thermal Power, Combined Cycle, and Cogeneration Plants, Y. P. Abbi, The Energy and Resources Institute, TERI
2. Energy Management Handbook, Stephen A. Roosa, Steve Doty & Wayne C. Turner, River Publishers, 9th edition, 2018

Reference Books:

1. Energy Management, W.R. Murphy & G. Mckey Butterworths, New Age International Publishers, 2007
2. Energy conversion systems, Rakosh Das Begamudre, New Age International Publishers 10th Edition, 2000

Web Links:

1. https://www.ergoelearning.com/courses/energy-audit-course
2. Success stories of Energy Conservation by BEE, New Delhi (www.bee-india.org)

Heating Ventilation and Air Conditioning

Course Code: 2502ME14	L	T	P	C
	3	0	0	3

Course Outcomes: At the end of the Course, Student will be able to:

- **CO1:** Demonstrate air distribution system for HVAC.
- **CO2:** Explain about requirement and types of ventilation.
- **CO3:** Explain psychrometry of air conditioning processes.
- **CO4:** Apply air conditioning systems for different areas.
- **CO5:** Calculate heating and cooling loads and evaluate air conditioning systems for different climate zones.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	2	1	1	1	-	-
CO2	2	2	1	1	-	-
CO3	2	2	2	1	-	-
CO4	2	1	-	1	-	-
CO5	2	1	-	1	-	-

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	-	2
CO2	-	2
CO3	-	2
CO4	-	2
CO5	-	2

UNIT – I

Introduction: Brief history of air conditioning and its impact, HVAC systems and classifications, Heat pumps, Devices used in supply systems: Air inlet system, Filters heating & cooling equipment, Fans, Duct, Grills, Diffusers, Exhaust Systems: General exhaust systems, Local exhaust system, Removal of pollutants and contaminated air, Air cleaning devices.

UNIT – II

Ventilation system: Indoor air quality, Need for ventilation, Effects of R.H. in building ventilation, Types of ventilation system-Exhaust Ventilation Systems, Supply Ventilation Systems, Balanced Ventilation Systems, and Energy Recovery Systems. Ventilation in Kitchen, Ventilation of Commercial Buildings: Design of commercial, Residential ventilation system.

UNIT – III

Psychrometry of Air Conditioning Processes: Thermodynamic properties of moist air, Important Psychrometry properties, Psychometric chart; Psychrometric process in air conditioning equipment, applied Psychrometry, Psychrometric processes in air conditioning equipment, Bypass factor, air washers, Mixing, Heating and dehumidifying coils, Cooling

by dry and wet coils, Use of hygroscopic solution in air washers, Adiabatic dehumidifiers. Humidifiers, Water injection, Steam injection.

UNIT – IV

Air Conditioning Systems: Commercial, Residential and Industrial Air-Conditioning; Summer, Winter and Year round Air-Conditioning system, Comfort Air Conditioning: Thermodynamics of human body, metabolic rate, energy balance and models, thermoregulatory mechanism, Comfort & Comfort chart, Effective temperature, Factors governing optimum effective temperature, Design consideration, Selection of outside and inside design conditions.

UNIT – V

Heating and Cooling load calculations: Sensible and latent heat loads, Sensible heat factor. Relationship between ESHF, ADP and BF, Recirculated air, Bypassed air and high latent heat load systems on Psychrometric chart, Cooling and heating load calculations, Selection of suitable air conditioning/ventilation system for different climate zones.

Text Books:

1. Refrigeration & Air Conditioning, Arora & Domkundwar, Dhanpat Rai & Co, 2018. ISBN: 9788177000009
2. HVAC Simplified, S. P., Kavanaugh, American Society of Heating, Refrigerating and Air-Conditioning Engineers; Pap/Cdr edition. ISBN-13. 978-1931862974

Reference Books:

1. Refrigeration & Air Conditioning, C.P. Arora, TMH, 3rd Edition, ISBN-13. 978-9351340164
2. Refrigeration and Air Conditioning, Er. V. K. Jain, Laxmi Publications Pvt. Ltd, 1st edition, 2019. ISBN: 9789352745081
3. Ventilation Systems: Design and Performance, Hazim B. Awbi., Routledge, 1st edition. ISBN-13, 0419217008-978

Web Links:

1. https://archive.nptel.ac.in/courses/112/107/112107208/
2. https://archive.nptel.ac.in/courses/112/105/112105129/

NUCLEAR ENERGY TECHNOLOGY

Course Code: 2502ME17

L	T	P	C
3	0	0	3

Course Outcomes (COs):

CO1: Understand the principles of nuclear reactions and sources of nuclear energy.
CO2: Identify and differentiate various nuclear reactor types and their working principles.
CO3: Explain the nuclear fuel cycle and associated waste management practices.
CO4: Assess nuclear safety systems, environmental impacts, and regulatory aspects.
CO5: Explore the applications, economics, and future trends in nuclear energy technologies.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	-	-	-	2
CO2	3	3	2	2	-	1
CO3	3	2	2	-	-	2
CO4	2	2	2	2	-	3
CO5	2	2	2	-	2	2

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	3	-
CO2	3	2
CO3	3	3
CO4	3	3
CO5	3	2

UNIT - I
INTRODUCTION TO NUCLEAR ENERGY

Atomic structure and nuclear reactions, Binding energy and mass defect, Nuclear fission and fusion, nuclear fuels (uranium, thorium, plutonium), History of nuclear energy development, Comparison of nuclear, conventional, and renewable energy sources.

UNIT - II
NUCLEAR REACTORS AND TYPES

Principle of nuclear reactor operation, Components of nuclear reactors (fuel, moderator, control rods, coolant, shielding), Types of reactors – PWR, BWR, PHWR, FBR, reactor design, operation, and efficiency.

UNIT - III
NUCLEAR FUEL CYCLE AND WASTE MANAGEMENT

Nuclear fuel cycle – mining, enrichment, fuel fabrication, reactor operation, reprocessing, Closed and open fuel cycles, Classification of nuclear waste, Waste disposal methods, Regulatory and environmental aspects.

UNIT - IV
SAFETY, SECURITY, AND ENVIRONMENTAL IMPACT

Nuclear reactor safety systems, Emergency cooling systems, Nuclear accidents (Chernobyl, Fukushima, Three Mile Island), Nuclear security and radiation protection, Environmental impact and radioactive pollution, Safety regulations and agencies.

UNIT - V
APPLICATIONS AND FUTURE OF NUCLEAR ENERGY
Applications of nuclear energy (medicine, industry, space), Small Modular Reactors (SMRs), Generation IV reactors, Nuclear fusion research, Economics of nuclear energy, Nuclear energy for sustainable development and climate change mitigation.

Text Books:

1. Introduction to Nuclear Engineering, Pearson Education – John R. Lamarsh, Anthony J. Baratta – 4th Edition, ISBN 0134570057.
2. Fundamentals of Nuclear Science and Engineering, CRC Press, 3rd Edition, ISBN 1498769292.

Reference Books:

1. The Physics of Nuclear Reactors, Serge Marguet, Springer, ISBN 3030096440.
2. Nuclear Energy: An Introduction to the Concepts, Systems, and Applications, Butterworth-Heinemann 7th Edition ISBN 0124166547.

Web Links:

1. https://nptel.ac.in/courses/112105051
2. https://nptel.ac.in/courses/115104114

BIOMASS GASIFICATION AND PYROLISIS

Course Code: 2502ME15	L	T	P	C
	3	0	0	3

Course Outcomes: At the end of the Course, Student will be able to:

CO1: Analyze biomass types, properties, and thermochemical conversion methods.
CO2: Analyze different gasification processes, reactor designs, and syngas applications
CO3: Explain the pyrolysis process and factors affecting the yield of its products.
CO4: Evaluate the characteristics and applications of bio-oil, syngas, and biochar
CO5: Understand case studies and new trends in biomass conversion

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	2	-	-	-	-
CO2	3	3	2	-	-	-
CO3	3	2	-	-	-	-
CO4	2	2	-	-	-	-
CO5		2	-	-	-	-

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	3	-
CO2	3	-
CO3	3	-
CO4	3	-
CO5	3	-

UNIT – I

Fundamentals of Biomass and Gasification

Biomass Resources and Classification, Biomass properties, Thermochemical Conversion of Biomass: Combustion, gasification, pyrolysis, Comparison of gasification vs. pyrolysis, Biomass Gasification Principles: Gasification process and reactions, Stages of gasification, Gasification agents, Types of Biomass Gasifiers: Fixed Bed Gasifiers, Fluidized Bed Gasifiers, Entrained Flow Gasifiers, Environmental and economic aspects.

UNIT – II

Gasification Reactor Design and Applications

Biomass Gasifier Design: Design principles for fixed bed, fluidized bed, and entrained flow gasifiers, Parameters influencing gasifier performance, Gasifier size, material selection, and reactor optimization. Gasification Efficiency and Optimization: Gasifier operation and control: Tar formation, fuel-flexibility.

UNIT – III

Biomass Pyrolysis

Reaction mechanisms and stages: drying, devolatilization, cracking, Pyrolysis types: slow, fast, flash, Pyrolysis products: Bio-oil, syngas, and biochar.

Pyrolysis Chemistry and Reactions: Thermal decomposition reactions, Influence of temperature and heating rate on product distribution, Reaction mechanisms and kinetics of biomass pyrolysis.

UNIT – IV

Pyrolysis Product Characterization and Applications

Pyrolysis Product Analysis, Bio-oil characterization, Composition, chemical properties, Syngas and biochar properties.

Pyrolysis Process Optimization: Factors affecting pyrolysis efficiency: Feedstock type, temperature, and heating rate.

Applications of Pyrolysis Products: Bio-oil for energy and chemicals, Syngas utilization: Power generation and chemical synthesis.

UNIT – V

Industrial Applications and Emerging Trends in Biomass Conversion

Industrial Scale Gasification and Pyrolysis: Large-scale biomass gasification and pyrolysis plants, Cost analysis of biomass conversion systems.

Future Trends in Biomass Gasification and Pyrolysis: Emerging technologies and innovations in biomass conversion, Role of biomass in sustainable energy systems and climate change mitigation.

Text Books:

1 Biomass Gasification and Pyrolysis: Practical Design and Theory, Prabir Basu, Academic Press (Elsevier), ISBN: 9780123749888.

2 Biomass to Renewable Energy Processes Cheng, Jay, CRC Press, ISBN: 978-1420095173

Reference Books:

1 Renewable Energy: Power for a Sustainable Future, Godfrey Boyle, Oxford University Press, ISBN: 9780199545339.

2 Advanced Biomass Gasification: New Concepts for Efficiency Increase and Product Flexibility, by Michael Muller, Pier Ugo Foscolo, Steffen Heidenreich, Academic Press Inc, ISBN: 978-0128042960

Web Links:

1 https://archive.nptel.ac.in/courses/103/103/103103207/

2 https://nptel.ac.in/courses/112105221

SOLAR ENERGY TECHNOLOGIES

Course Code: 2502ME21	L	T	P	C
	3	0	0	3

Course Outcomes: At the end of the Course, Student will be able to:

- **CO1:** Explain the concept of solar radiation and its measurement
- **CO2:** Describe the working principle of solar water heating system
- **CO3:** Explain the various solar thermal energy technologies and their applications
- **CO4:** Analyse the various solar PV cell materials and conversion techniques.
- **CO5:** Apply economic analysis principles to evaluate life cycle costs and optimize solar and water heating systems.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	2	1	1	1	-	-
CO2	2	2	1	1	-	-
CO3	2	2	2	1	-	-
CO4	2	1	-	1	-	-
CO5	2	1	-	1	-	-

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	-	1
CO2	-	1
CO3	-	1
CO4	-	1
CO5	-	1

UNIT – I

Introduction: Solar energy option, specialty, and potential, Solar radiation, beam and diffuse – measurement, estimation of average solar radiation on horizontal and tilted surfaces, problems, applications.

Capturing solar radiation – physical principles of collection, types – liquid flat plate collectors – construction details performance analysis – concentrating collection, flat plate collectors with plane reflectors, cylindrical parabolic collectors, Orientation and tracking Performance Analysis

UNIT – II

Design of Solar Water Heating System and Layout: Power generation –solar central receiver system – Heliostats and Receiver – Heat transport system – solar distributed receiver system – Power cycles, working fluids and prime movers, concentration ratio.

UNIT – III

Thermal Energy Storage: Introduction – Need for – Methods of sensible heat storage using solids and liquids – Packed bed storage – Latent heat storage – working principle –

construction – application and limitations. Other solar devices – stills, air heaters, dryers, Solar Ponds & Solar Refrigeration, active and passive heating systems.

UNIT – IV

Direct Energy Conversion: Solid state principles, semiconductors, solar cells performance, modular construction – applications. conversion efficiencies calculations

UNIT – V

Economics: Principles of Economic Analysis – Discounted cash flow – Solar system, life cycle costs – cost benefit analysis and optimization – cost-based analysis of water heating and photo voltaic applications.

Text Books:

1. Solar Energy-Principles of Thermal Collection and Storage, S P Sukhatme & J K Nayak, McGraw Hill Education, 3rd Edition ISBN-13: 978-0070142961
2. Principles of Solar Engineering, D.Yogi Goswami, Frank Krieth and Jan F. Kreider Taylor and Francis, USA. 2nd Edition, ISBN-13. 978-1560327141

Reference Books:

1. Solar Energy- Fundamentals, Design, Modelling and Applications, G.N.Tiwari, Narosa publishing house. 6— edition ISBN: 0849324092
2. Solar Energy and Non-conventional Energy Sources, Domkundwar, Dhanpat Rai & Co, (P) Ltd., Revised 2nd edition

Web Links:

1. https://archive.nptel.ac.in/courses/115/103/115103123/
2. https://www.nrel.gov/research/re-solar.html

NON-CONVENTIONAL ENERGY SOURCES

Course Code: 2502ME23	L	T	P	C
	3	0	0	3

Course Outcomes: At the end of the Course, Student will be able to:

CO1: Explain the fundamental for non-conventional Energy Sources
CO2: Analyse and optimize solar energy-based technologies and their applications
CO3: Explain the biogas and biomass based power generation systems
CO4: Illustrate the scientific principles of wind and hydropower systems and assess their associated challenges
CO5: Explain the working principles of tidal, geothermal, and nuclear energy systems and discuss their applications.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	-	-	-	-	3
CO2	3	2	2	-	-	3
CO3	3	2	2	-	-	3
CO4	3	2	-	-	-	3
CO5	3	2	-	-	-	3

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	3	-
CO2	3	-
CO3	3	-
CO4	3	-
CO5	3	-

UNIT – I

Conventional Energy Sources, Non-Conventional Energy Sources, Renewable Energy Potential, World Energy Scenario, Indian Energy Scenario, Renewable Energy Polices of India, Indian Solar Energy Mission.

UNIT – II

Solar Energy, Solar radiation Availability, Instruments for measurement of Solar Radiation, Solar angles, Atmospheric phenomena, Solar Collectors (FPC, ETC and PTC), Solar thermal and PV applications: water heating application, Solar Dryer, Solar distillation, Solar refrigeration and Fundamental of Photovoltaic

UNIT – III

Hydropower Energy, Present status of Hydro Power, Magneto-hydro-dynamic (MHD) system, Ocean thermal energy conversion (OTEC), Tidal energy conversion, Spring and neap tides, Single and double basin system, Geothermal Energy, Types of geothermal energy sites, Geothermal power plants.,

UNIT – IV

Biomass availability, Bio-Energy Scenario, Technologies for Bioenergy conversion, Global and Indian Bio Energy Potential, Nuclear Energy

UNIT – V

Wind Energy: Fundamental of Wind Energy, Indian Wind Energy Potential, Types of wind turbine, Characteristics of the wind, Wind speed monitoring instruments and applications, Offshore Wind energy systems concepts and design.

Text Books:

1. N. K. Bansal, M. Kleeman& M. Mielee, Renewable Conversion Technology, Tata McGraw Hill, New Delhi.
2. T. John and W. Tony, Renewable Energy Resources, Taylor & Francis

Reference Books:

1. Renewable energy resources, Twidell, J.W. and Weir, A., BSP Books Pvt.Ltd, UK, 2nd edition.
2. Non-Conventional Energy, Ashok V.Desai, New Age International Publications, Tokyo, 1st edition.

Web Links:

1. https://nptel.ac.in/courses/121/106/121106014/
2. https://nptel.ac.in/courses/108/108/108108078/
3. https://nptel.ac.in/courses/103/103/103103206/

ADVANCED FUEL CELL TECHNOLOGIES

Course Code: 2502ME22	L	T	P	C
	3	0	0	3

Course Outcomes: At the end of the Course, Student will be able to:

CO1: Describe hydrogen properties and production methods.
CO2: Explain hydrogen storage methods and safety.
CO3: Describe the operation, types, applications, and history of fuel cells.
CO4: Explain the different types of fuel cells and their functions
CO5: Evaluate fuel cell applications and future trends.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	2	1	1	1	-	-
CO2	2	2	1	1	-	-
CO3	2	2	2	1	-	-
CO4	2	1	-	1	-	-
CO5	2	1	-	1	-	-

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	-	2
CO2	-	2
CO3	-	2
CO4	-	2
CO5	-	2

UNIT – I

Hydrogen – physical and chemical properties, salient characteristics. Production of hydrogen – steam reforming – water electrolysis – biological hydrogen production –direct thermal or catalytic splitting of water.

UNIT – II

Hydrogen storage options – Compressed gas – Liquid hydrogen – Chemical Storage – comparisons. Safety and Management of Hydrogen. Applications of Hydrogen.

UNIT – III

Fuel Cells as Electrochemical Engines, Generic Fuel Cell and Stack, Classification of Fuel Cells, Potential Applications, History of Fuel Cell Development.

UNIT – IV

Alkaline Fuel Cells, Molten Carbonate Fuel Cells, PEM Fuel Cells, Solid Oxide Fuel Cells, Phosphoric acid Fuel Cells, Microbial Fuel Cells, Regenerative Fuel Cells.

UNIT – V

Fuel cell usage for domestic power systems, large scale power generation, Automobile, Space. Economic and environmental analysis on usage of Hydrogen and Fuel cell. Future trends in fuel cells.

Text Books:

1 Hydrogen and Fuel Cells: A Comprehensive Guide, Rebecca L. and Busby, Penn Well Corporation, Oklahoma, ISBN-13: 978-1593700430
2 Engines and Hydrogen, Barclay F.J., Fuel Cells, Wiley ISBN-13. 978-0470019047

Reference Books:

1 Fuel Cells – Principles and Applications, Viswanathan B. and Aulice Scibioh.M, Universities Press, ISBN-13. 978-8173715570
2 Hydrogen and Fuel Cells: A Comprehensive Guide, Rebecca L. and Busby, Penn Well Corporation, Oklahoma, ISBN-13: 978-1593700430

Web Links:

1 https://archive.nptel.ac.in/courses/103/102/103102015/
2 https://archive.nptel.ac.in/content/storage2/courses/112104033/lecture40/40_5.htm

ENERGY EFFICIENT BUILDING DESIGN

Course Code: 2502ME24

L	T	P	C
3	0	0	3

Course Outcomes: At the end of the Course, Student will be able to:

CO1: Demonstrate the ability to manually calculate building energy balance.
CO2: Understand the impact of energy-saving measures on indoor climate
CO3: Analyze and interpret energy and indoor climate data from calculations and measurements-
CO4: Understand energy and indoor climate issues and present findings effectively
CO5: Evaluate sustainability, safety, and rules in battery use and recycling.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	2	-	-	-	-
CO2	3	2	-	-	-	-
CO3	3	2	-	-	-	-
CO4	3	2	-	-	-	-
CO5	3	2	-	-	-	-

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	3	-
CO2	3	-
CO3	3	-
CO4	3	-
CO5	3	-

UNIT - I

Introduction to energy efficiency in buildings-Architecture- Building Science and its significance- Indoor Environment. Components of Indoor Environment - Classification of building materials based on energy intensity-Energy Management of Buildings and Energy Audit of Buildings

UNIT - II

Quality of Indoor Environment. Human Comfort-Thermal, Visual, Acoustical and Olfactory comfort. Concept of Sol- air temperature and its significance. Building technology and building services engineering (HVAC) Contribution to lower energy consumption, with different conditions for new and existing buildings

UNIT - III

Ventilation and is significance. Cooling and heating concepts, Passive solar heating, active solar heating and solar electricity - Passive concepts appropriate for the various climatic zones in India- Electric efficiency for fans, pumps, lighting etc. Building related problems and health issues. Indoor climate issues regarding air quality, thermal indoor climate and acoustics.

UNIT - IV

Energy management matrix monitoring and targeting. Energy Efficient Landscape Design - Modification of microclimate through landscape elements for energy conservation.

UNIT - V

Case studies: Calculations of the energy balance of buildings without available energy calculation programs, primarily monthly calculations for residential buildings. Energy efficiency and conservation requirements for existing buildings – contradictions and opportunities. Energy efficiency and healthy buildings – contradictions and opportunities – Softwares.

Text Books:

1. "Solar Passive Buildings" by Sodha M.,Bansal N.K., Bansal,P.K Kumar, A. and Malik, M.A.S., Pergamon Press
2. "Manual of Tropical Housing and Building part 1: Climatic Design" Koenigsberger, O.H., Ingersoll, T.G., Mayhew Alan and Szokolay, S. V., OLBN 0 002120011, Orient Longman Limited,

Reference Books:

1. "Understanding Engineering Thermo Upper Saddle River" by Levenspiel, Octave. NJ: Prentice Hall, ISBN: 9780135312032
2. "Solar Passive Buildings" by Sodha M.,Bansal N.K., Bansal,P.K Kumar, A. and Malik, M.A.S., Pergamon Press

Web Links:

1. http://www.wbdg.org/resources/daylighting.php
2. https://nptel.ac.in/courses/108/108/108108078/

FINITE ELEMENT METHOD IN HEAT TRANSFER ANALYSIS

Course Code: 2502ME25	L	T	P	C
	3	0	0	3

Course Outcomes: At the end of the Course, Student will be able to:

- **CO1:** Analyse finite element models for trusses and beams, including shape functions, stiffness matrices, and boundary conditions.
- **CO2:** Analyse higher-order and isoparametric elements for heat transfer problems.
- **CO3:** Apply finite element analysis to 1-D problems for various engineering applications.
- **CO4:** Apply 2-D finite element models to problems in heat transfer and fluid mechanics.
- **CO5:** Apply finite element analysis to 2-D plane stress, plane strain problems, and bending of plates.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	2	1	1	1	-	-
CO2	2	2	1	1	-	-
CO3	2	2	2	1	-	-
CO4	2	1	-	1	-	-
CO5	2	1	-	1	-	-

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PO	PSO1	PSO2
CO1	2	-
CO2	2	-
CO3	2	-
CO4	2	-
CO5	2	-

UNIT – I

Finite element modelling coordinates and shape functions. Assembly of Global stiffness matrix and load vector. Finite element equations, Treatment of boundary conditions, Quadratic shape functions.

Analysis of Trusses: Introduction, analysis of plane trusses, local and global stiffness matrix, treatment of boundary conditions, solutions, temperature effects.

Analysis of Beams: Formulation, load vector, boundary conditions, shear force and bending moment, solutions.

UNIT – II

Higher order and Isoparametric elements: One dimensional quadratic and cubic elements in natural coordinates, two dimensional four noded isoparametric elements and numerical integration.

Steady State Heat Transfer Analysis: One dimensional analysis of conduction, convection problems.

UNIT – III

Finite element analysis of 1-D problems: formulation by different approaches (direct, potential energy and Galerkin), Derivation of elemental equations and their assembly. Applications in heat transfer, fluid mechanics and solid mechanics. Bending of beams, analysis of truss and frame.

UNIT – IV

Finite element analysis of 2-D problems: finite element modelling of single variable problems, triangular and rectangular elements, Applications in heat transfer, fluid mechanics.

UNIT – V

2D problem for Plane stress and plane strain problems; Bending of plates; Eigen value and time dependent problems; Discussion about pre-processors, postprocessors and finite element package ANSYS.

Text Books:

1. Introduction to Finite Elements in Engineering, T.R. Chandrupatla and A.D. Belegundu, PHI publications, 4th Edition, ISBN-13. 978-9332551824
2. A First Course in the Finite Element Method, Daryl L. Logan, Cengage Learning India Private Limited, 6th edition, ISBN-13: 978-1305635111

Reference Books:

1. An Introduction to the Finite Element Method, J.N. Reddy, McGraw Hill Education, 4th Edition, 2020. ISBN-13. 978-9390385270
2. Concepts and Applications of Finite Element Analysis, Cook et al, Wiley Publications, 4th edition, ISBN-13. 978-0471356059

Web Links:

1. https://nptel.ac.in/courses/112/104/112104193/
2. https://nptel.ac.in/courses/112/104/112104205/

BASIC CONCRETE TECHNOLOGY

Course Code: 2502CE30	L	T	P	C
	3	0	0	3

Course Outcomes: At the end of the Course, Student will be able to:

CO1: Understand the chemical composition, hydration, and physical properties of Portland cement.

CO2: Evaluate the effects of mineral and chemical admixtures on concrete performance.

CO3: Classify and assess aggregates based on mechanical properties, grading, and thermal behavior.

CO4: Analyze workability and setting characteristics of fresh concrete, including relevant testing methods.

CO5: Design and proportion concrete mixes using BIS and ACI methods, ensuring quality control.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	2	3	1	-	-	-
CO2	2	1	3	-	-	-
CO3	2	1	3	-	-	-
CO4	2	1	3	-	-	-
CO5	2	2	3	-	-	-

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	-	-
CO2	-	-
CO3	-	-
CO4	-	-
CO5	-	-

UNIT – I

Cement: Portland cement – chemical composition – Hydration, Setting of cement – Structure of hydrate cement – Test on physical properties – Different grades of cement. Admixtures: Types of admixtures – mineral and chemical admixtures.

UNIT – II

Aggregates: Classification of aggregate – Particle shape & texture –, strength & other mechanical properties of aggregate – Specific gravity, Bulk density, porosity, adsorption &moisture content of aggregate – Bulking of sand – Deleterious substance in aggregate – Soundness of aggregate – Alkali aggregate reaction – Thermal properties – Sieve analysis – Fineness modulus – Grading curves – Grading of fine & coarse Aggregates – Gap graded aggregate – Maximum aggregate size.

UNIT – III

Fresh Concrete: Workability – Factors affecting workability – Measurement of workability by different tests – Setting times of concrete – Effect of time and temperature on workability – Segregation & bleeding – Mixing and vibration of concrete – Steps in manufacture of concrete – Quality of mixing water.

UNIT – IV

Hardened Concrete : Water / Cement ratio – Abram's Law – Gelspaoe ratio – Nature of strength of concrete – Maturity concept – Strength in tension & compression – Factors affecting strength – Relation between compressive & tensile strength - Curing. Testing Of Hardened Concrete: Compression tests – Tension tests– Flexure tests – Splitting tests – Pull-out test, Non-destructive testing methods – codal provisions for NDT. Elasticity, Creep & Shrinkage – Modulus of elasticity – Dynamic modulus of elasticity – Poisson's ratio – Creep of concrete – Factors influencing creep.

UNIT – V

Mix Design: Factors in the choice of mix proportions – Durability of concrete – Quality Control of concrete – Statistical methods – Acceptance criteria – Proportioning of concrete mixes by IS codes mix design. Special Concretes: Introduction to light weight concrete – Cellular concrete

Text Books:

1. Properties of Concrete by A. M. Neville Pearson 5th edition Education ltd. (ISBN: 9780273755807)
2. Concrete Technology by M. S. Shetty. – S. Chand & Co. (ISBN: 9788121900034)
3. Concrete Technology by Job Thomas -Cengage learning India Pvt Ltd.(ISBN: 9788131521099)

Reference Books:

1. Concrete Technology by M.L. Gambhir. – Tata Mc. Graw Hill Publishers, New Delhi. (ISBN: 9780070141100)
2. Concrete: Microstructure, Properties and Materials – P. K. Mehta and J. M. Monteiro, McGraw Hill Publishers. (ISBN: 9780071797870)

Web Links:

1. http://nptel.ac.in/courses/105102012/
2. www.archive.nptel.ac.in/noc/courses/noc15/SEM1/noc15-ce01
3. https://archive.nptel.ac.in/courses/105/102/105102012/

REPAIR AND REHABILITATION OF STRUCTURES

Course Code: 2502CE31	L	T	P	C
	3	0	0	3

Course Outcomes: At the end of the Course, Student will be able to:

CO1: Identify the causes of deterioration of concrete structures.
CO2: Illustrate the various materials for repair and rehabilitation techniques
CO3: Construct the various strengthening and stabilization techniques.
CO4: Determine various repair techniques of damaged structures.
CO5: Evaluate the usage of different types of concretes and durability aspects
CO6: Classify the usage of high-performance concretes for repairing works

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	2	2	2	2	-
CO2	3	2	2	2	2	-
CO3	3	2	2	2	2	-
CO4	3	2	2	2	2	-
CO5	2	2	1	2	1	-
CO6	2	2	1	2	1	-

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	-	-
CO2	-	-
CO3	-	-
CO4	-	-
CO5	-	-
CO6	-	-

UNIT – I

Materials for Repair and Rehabilitation: Admixtures- types of admixtures- purposes of using admixtures- chemical composition- Natural admixtures- Fibers- wraps- Glass and Carbon fiber wraps- Steel Plates-Nondestructive evaluation: Importance- Concrete behavior under corrosion, disintegrated mechanisms- moisture effects and thermal effects – Visual investigation- Acoustical emission methods-Corrosion activity measurement-chloride content– Depth of carbonation- Impact echo methods- Ultrasound pulse velocity methods- Pull out tests.

UNIT – II

Strengthening and Stabilization: Techniques- design considerations-Beam shear capacity strengthening- Shear Transfer strengthening-stress reduction techniques- Column strengthening-flexural strengthening Connection stabilization and strengthening, Crack stabilization.

UNIT – III

Bonded Installation Techniques: Externally bonded FRP- Wet layup sheet, bolted plate, near surface mounted FRP, fundamental debonding mechanisms-intermediate crack debonding- CDC debonding- plate end debonding- strengthening of floor of structures.

UNIT – IV

Fiber Reinforced Concrete: Properties of constituent materials- Mix proportions, mixing and casting methods-Mechanical properties of fiber reinforced concrete- applications of fibre reinforced concretes-Lightweight concrete- properties of light weightconcrete-Nofinesconcrete-designoflightweightconcreteFlyashconcrete- Introduction- classification of fly ash- properties and reaction mechanism of fly ash- Properties of fly ash concrete in fresh state and hardened state- Durability of fly ash concretes.

UNIT – V

High Performance Concrete: Introduction- Development of high performance concretes-Materials of high performance concretes-Properties of high performance concretes - Self Consolidating concrete-properties qualifications.

Text Books:

1. Concrete repair and maintenance illustrated-Peter Emmons, published by Brandon W. Emmons.(ISBN: 9780876291916)
2. Experimental Techniques and Instrumentation, Dr.M.Sreenivasa Reddy, Dr.S.Govindarajan and Dr.S.Pachaiappan, Charulatha Publications, 2022.

Reference Books:

1. Rehabilitation of Concrete Structures, Dr. B. Vidivelli, Standard Publishers Distributors. (ISBN: 978-8180140276)
2. Concrete technology, M S Shetty, S. Chand Publications.(ISBN: 9788121900034)
3. Concrete technology, Neville & Brooks, pearson education ltd.(ISBN: 9788131708384)

Web Links:

1. http://nptel.ac.in/courses/112101095/38
2. http://www.nptel.ac.in/courses/105105041/module%206.pdf
3. https://www.youtube.com/watch?v=N4KrZ_DczrE

NEURAL NETWORKS AND FUZZY LOGIC

Course Code: 2502EE28	L	T	P	C
	3	0	0	3

Course Outcomes: At the end of the Course, Student will be able to:

CO1: Explain artificial neuron models.
CO2: Explain various learning methods of ANN
CO3: Apply different algorithms of ANN..
CO4: Distinguish between Classical and Fuzzy Sets.
CO5: Apply application of fuzzy logic control to real time systems.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	-	1	1	-	-
CO2	3	-	1	1	-	-
CO3	3	-	1	1	-	-
CO4	3	-	1	1	-	-
CO5	3	-	1	1	-	-

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	-	-
CO2	-	-
CO3	-	-
CO4	-	-
CO5	-	-

UNIT – I

Introduction to Neural Networks Introduction, Humans and Computers, Organization of the Brain, Biological Neuron, Biological and Artificial Neuron Models, Hodgkin-Huxley Neuron Model, Integrate-and Fire Neuron Model, Spiking Neuron Model, Characteristics of ANN, McCulloch-Pitts Model, Applications of ANN.

UNIT – II

Essentials of Artificial Neural Networks Artificial Neuron Model, Operations of Artificial Neuron, Types of Neuron Activation Function, ANN Architectures, Classification Taxonomy of ANN, Connectivity, Neural Dynamics (Activation and Synaptic), Learning Strategy (Supervised, Unsupervised, Reinforcement), Learning Rules, Types of Application

UNIT – III

Multilayer feed forward Neural Networks Credit Assignment Problem, Generalized Delta Rule, Derivation of Back propagation (BP) Training, Summary of Backpropagation Algorithm, Kolmogorov Theorem, Learning Difficulties and Improvements, Radial Basis Function (RBF) Neural Network – Kohonen Self Organizing feature Map (KSOM).

UNIT – IV

Classical & Fuzzy Sets Introduction to classical sets - properties, Operations and relations; Fuzzy sets, Membership, Uncertainty, Operations, properties, fuzzy relations, cardinalities, membership functions**.**

UNIT – V

Fuzzy Logic Modules Fuzzification, Membership value assignment, development of rule base and decision making system, Defuzzification to crisp sets, Defuzzification methods**.**

Text Books:

1. Neural Networks, Fuzzy logic, Genetic algorithms: synthesis and applications by Rajasekharan and Rai – PHI Publication. (ISBN: 9788120353343)
2. Introduction to Neural Networks using MATLAB 6.0 - S.N.Sivanandam, S.Sumathi, S.N.Deepa, TMH. (ISBN: 9780070591127)

Reference Books:

1. Neural Networks, James A Freeman and Davis Skapura, Pearson Education. (ISBN: 9780201513769)
2. Fuzzy sets University and information, J.Klin and T.A.Folger, Prentice Hall. (ISBN: 9789353065782)
3. Introduction to artificial neural systems, J.M.Zurada, Jaico Publication house.(ISBN: 9780314933911)

Web Links:

1. http://nptel.ac.in/courses/108104049/16
2. www.archive.nptel.ac.in/courses/127/105/127105006/
3. www.geeksforgeeks.org/fuzzy-logic-introduction/

HYBRID ELECTRIC VEHICLES

Course Code: 2502EE29	L	T	P	C
	3	0	0	3

Course Outcomes: At the end of the Course, Student will be able to:

- **CO1:** Analyze the architectures of HEVs with various components
- **CO2:** Illustrate the concept of Electric Vehicle and Hybrid Electric Vehicles
- **CO3:** Explain the Plan concept of Plug-in Electrical Vehicles
- **CO4:** Analyze the power electronics converters for HEVs
- **CO5:** Apply various energy storage technologies in Hybrid Vehicles.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	1	-	3	2	-	-
CO2	1	-	3	2	-	-
CO3	1	-	3	2	-	-
CO4	1	-	3	2	-	-
CO5	1	-	3	2	-	-

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	-	-
CO2	-	-
CO3	-	-
CO4	-	-
CO5	-	-

UNIT – I

Introduction to Electric Vehicles: History of electric vehicles, social and environmental importance of electric vehicles, impact of modern drive-trains on energy supplies, Challenges and Key Technologies of EVs – Challenges for EV Industry in India

UNIT – II

Hybridization of Automobile: Fundamentals of vehicle, components of conventional vehicle and propulsion load, Drive cycles and drive terrain, Concept of electric vehicle and hybrid electric vehicle, Plug-in hybrid vehicle, constituents of PHEV, comparison of HEV and PHEV; Fuel Cell vehicles and its constituents.

UNIT – III

Plug-in Hybrid Electric Vehicle PHEVs and EREVs, PHEV Architectures, equivalent electric range of blended PHEVs, Fuel economy and power management of PHEVs, end-of-life battery for electric power grid support, vehicle to grid technology, battery charging.

UNIT – IV

Power Electronics in HEVs Rectifiers and Buck converter used in HEVs, isolated and non-isolated bidirectional DC-DC converter, regenerative braking, voltage source inverter, current source inverter, PWM rectifier in HEVs, EV and PHEV battery chargers.

UNIT – V

Battery and Storage Systems: Energy Storage Parameters; Lead–Acid Batteries; Ultra capacitors; Flywheels - Superconducting Magnetic Storage System; Pumped Hydroelectric Energy Storage; Compressed Air Energy Storage - Storage Heat; Energy Storage as an Economic Resource.

Text Books:

1. Advanced Electric Drive Vehicles, Ali Emadi, CRC Press.(ISBN: 9781138072855)
2. Electric and Hybrid Vehicles: Design Fundamentals, Iqbal Hussein, CRC Press. (ISBN: 9780367693930)

Reference Books:

1. Introduction to Hybrid Vehicle System Modeling and Control, Wei Liu, Wiley.(ISBN: 9788126556205)
2. Electric and Hybrid Vehicles Technologies, Modelling and Control: A Mechatronic Approach", Amir Khajepour, Saber Fallahand Avesta Goodarzi, John Wiley & Sons Ltd. (ISBN: 9781118341513)

Web Links:

1. https://archive.nptel.ac.in/courses/108/103/108103009/
2. https://ndl.iitkgp.ac.in/he_document/nptel/nptel/IN__N__1_E_E__12391_I_t_H_a_E_V__1402 4_D_o_H_E_v__14030_14031

GREEN ENGINEERING SYSTEMS
(Except EST)

Course Code: 2502ME27	**L**	**T**	**P**	**C**
	3	**0**	**0**	**3**

Course Outcomes: At the end of the Course, Student will be able to:

- **CO1:** Distinguish the various solar energy collection methods and measuring instruments.
- **CO2:** Explain the different methods of solar energy storage and their applications.
- **CO3:** Illustrate the various types of wind mills and performance characteristics.
- **CO4:** Explain the principle of Biomass production, Geothermal energy sources and Ocean thermal energy conversion
- **CO5:** Illustrate the various types of electrical systems and mechanical systems.
- **CO6:** Compare the various energy efficient process.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	2	1	1	1	-	-
CO2	2	2	1	1	-	-
CO3	2	2	2	1	-	-
CO4	2	1	-	1	-	-
CO5	2	1	-	1	-	-
CO6	2	1	-	1	-	-

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	-	-
CO2	-	-
CO3	-	-
CO4	-	-
CO5	-	-
CO6	-	-

UNIT – I

Introduction: Solar Radiation: Role and potential of new and renewable sources, the solar energy option, Environmental impact of solar power, structure of the sun, the solar constant, sun-earth relationships, coordinate systems of the sun, extraterrestrial and terrestrial solar radiation, solar radiation on titled surface, instruments for measuring solar radiation and sun shine, solar radiation data, numerical problems. Photo voltaic energy conversion – types of PV cells, I-V characteristics

Solar Energy Collection: Flat plate and concentrating collectors, classification of concentrating collectors, orientation and thermal analysis, advanced collectors.

UNIT – II

Solar Energy Storage and Applications: Different methods, sensible, latent heat and stratified storage, solar ponds, solar applications- solar heating/cooling technique, solar distillation and drying, solar cookers, central power tower concept and solar chimney.

Wind Energy: Sources and potentials, horizontal and vertical axis windmills, performance characteristics, betz criteria, types of winds, wind data measurement.

UNIT – III

Bio-Mass: Principles of bio-conversion, anaerobic/aerobic digestion, types of bio-gas digesters, gas yield, combustion characteristics of bio-gas, utilization for cooking, bio fuels, I.C. engine operation and economic aspects.

Geothermal Energy: Resources, types of wells, methods of harnessing the energy, potential in India.

Ocean Energy: OTEC, Principles of utilization, setting of OTEC plants, thermodynamic cycles. Tidal and wave energy: Potential and conversion techniques, mini-hydel power plants, and their economics.

UNIT – IV

Electrical Systems: Energy efficient motors, energy efficient lighting and control, selection of luminaire, variable voltage variable frequency drives (adjustable speed drives), controls for HVAC (heating, ventilation and air conditioning), demand site management.

Mechanical Systems: Fuel cells- principle, thermodynamic aspects, selection of fuels & working of various types of fuel cells, Environmentally friendly and Energy efficient compressors and pumps.

UNIT – V

Energy Efficient Processes: Environmental impact of the current manufacturing practices and systems, benefits of green manufacturing systems, selection of recyclable and environment friendly materials in manufacturing, design and implementation of efficient and sustainable green production systems with examples like environmentally friendly machining, vegetable based cutting fluids, alternate casting and joining techniques, zero waste manufacturing.

Green Buildings: Definition, features and benefits. Sustainable site selection and planning of building for maximum comfort. Environmentally friendly building materials like bamboo, timber, rammed earth, hollow blocks, lime & lime pozzolana cement, agro materials and industrial waste.

Text Books:

1. Solar Energy – Principles of Thermal Collection and Storage/Sukhatme S.P. and J.K. Nayak/ TMH.
2. Non-Conventional Energy Resources/ Khan B.H/ Tata McGraw Hill, New Delhi,

Reference Books:

1. Renewable Energy Technologies /Ramesh & Kumar /Narosa.
2. Renewable Energy Resources-2 Edition/ J. Twidell and T. Weir/ BSP Books Pvt. Ltd.

Web Links:

1. https://onlinecourses.nptel.ac.in/noc17_me33
2. https://nptel.ac.in/courses/105107176/20

I.C. ENGINES
(Except EST)

Course Code: 2502ME28	**L**	**T**	**P**	**C**
	3	**0**	**0**	**3**

Course Outcomes: At the end of the Course, Student will be able to:

CO1: Summarize the finite element methods
CO2: Analyse one-dimensional problems in trusses and beams
CO3: Solve structural problems using CST and axis - symmetric formulation
CO4: Apply finite elements to higher order, Iso-parametric elements, and one-dimensional heat transfer analysis.
CO5: Apply finite element methods to dynamic analysis.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	2	1	1	1	-	-
CO2	2	2	1	1	-	-
CO3	2	2	2	1	-	-
CO4	2	1	-	1	-	-
CO5	2	1	-	1	-	-

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	-	-
CO2	-	-
CO3	-	-
CO4	-	-
CO5	-	-

UNIT – I

Gas Exchange Processes: Inlet and exhaust processes in the four-stroke cycle volumetric efficiency quasi static effects combined quasi static and dynamic effects variation with speed and valve area and timing-flow through valves poppet valve geometry and timing flow rate and discharge efficient, residual gas fraction exhaust gas flow rate and temperature variation, scavenging in wnike eyelid engines, scavenging parameters and mdeluctual scavenging processes. Flow through parts supercharging and turbo changing methods of power buying abusive relationships compressors, turbines wave compression devices.

UNIT – II

Charge Motion Within the Cylinder: Intake Jet Flow, Mean velocity and turbulence characteristics definitions application to engine velocity data swirl swirl measurement, swirl generation during induction swit modification within the cylinder squish pre chamber engine flow crevice flows and blowby News nerated by piston-cylinder wall interaction

UNIT – III

Combustion In S.I and C.I Engines: Review of normal and abnormal combustion in SI and Ci engine cyclic variation in combustion of St engine analysis of cylindrical pressure data in SI and CI engine. EMP Flix SI engines common rail fuel injection system in Ci engines fuel spray behavior in CI engine

UNIT – IV

Electric Vehicles: Introduction Limitations of IC Engines as prime mover. History of EV, components of EV and AC electric machines: Introduction and basic structure, Electric vehicle drive train, advantages and limitations Permanent magnet and switched reluctance motors.

UNIT – V

Hybrid Vehicles: Configurations of hybrid, Series and parallel, advantages and limitations, Hybrid drive trains, sizing of components Initial acceleration, rated vehicle velocity, Maximum velocity and maximum gradeability, Hydrogen: Production, Hydrogen storage systems, reforms.

Fuel Cell Vehicles: Introduction, Fuel cell characteristics, Thermodynamics of Fuel cells, Fuell cell types; emphasis on PEM fuel cell.

Text Books:

1. Internal Combustion Engine Fundamentals, J.B. Heywood, Mc Graw Hill Co,, ISBN-13. 978-1259002076
2. Build your own electric vehicle, Seth Leitman and Bob Brant. McGraw Hill, Co, 3 rd edition, ISBN-13. 978-0071770569

Reference Books:

1. Engineering Fundamentals of IC Engine, H.N. Gupta, 2nd edition PHI Pvt. Ltd. ISBN-13: 978-8120346802
2. PEM Fuel Cells-Theory and Practice, F. Barbir Elsevier Academic Press, ISBN: 9780128102398

Web Links:

1. http://nptel.ac.in/courses/112101097/
2. www.thermopedia.com/content/786

CAD TOOLS FOR VLSI DESIGN

Course Code: 2502EC24	L	T	P	C
	3	0	0	3

Course Outcomes: At the end of the Course, Student will be able to:

- **CO1:** Comprehend the insight of CAD Tools in modern design
- **CO2:** Develop combinational logic circuits by using CAD tools
- **CO3:** Build sequential logic circuits using Verilog HDL operators
- **CO4:** Analyze the performance of logic schematics using CAD simulation tools.
- **CO5:** Infer the performance of logic circuits in terms of DRC, LVS and PEX.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	1	3	1	2	2	1
CO2	2	3	1	2	1	2
CO3	2	2	3	2	2	1
CO4	2	3	1	2	2	1
CO5	2	3	2	2	2	1

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	-	-
CO2	-	-
CO3	-	-
CO4	-	-
CO5	-	-

UNIT – I

Understanding the working platform with Xilinx Vivado and its device, family and package Selection. Design and Implementation of Combinational Circuits Priority Encoder and Comparator using data flow & structural style

UNIT – II

Design and Implementation of Sequential Circuits to detect a given sequence using with and without overlapping (mealy & Moore machines). Design and Implementation of a traffic light controller in three road & four road junctions.

UNIT – III

Exercise on Concatenation, Replication operators, Reduction and Conditional operators in Verilog HDL. Performance characteristics of an n-channel and p-channel MOSFET.

UNIT – IV

Working with Schematic for Ring Oscillator with variable amounts of Pull up to pull down ratios. Design a full adder by instantiating the logic gates. Make a comment on design style on its performance.

UNIT – V

Design a NAND gate by using NMOS, PMOS and CMOS technologies and make a comment on its performance. Design a Schematic, stick and layout for given logic.

Text Books:

1. S. M. Kang and Y. Leblebici, CMOS Digital Integrated Circuits : Analysis and Design, Third Edition, MH, (ISBN Number-0072460539)
2. Plummer, Deal , Griffin “Silicon VLSI Technology: Fundamentals, Practice &Modeling”PH, (ISBN Number-0130850373)

Reference Books:

1. P. VanZant , “Microchip Fabrication”, 5th Edition, MH, (ISBN Number-6053901308)
2. R. J. Baker, H. W. Li and D. E. Boyce, CMOS Circuit Design, Layout and Simulation, PH, (ISBN Number-1119481511)

Web Links:

1. https://themosisservice.com/university-support
2. https://youtu.be/OF3Zwfu6Ngc
3. https://newsroom.ibm.com/2021-05-06-IBM-Unveils-Worlds-First-2-

FPGA DESIGN FOR EMBEDDED SYSTEMS

Course Code: 2502EC25	L	T	P	C
	3	0	0	3

Course Outcomes: At the end of the Course, Student will be able to:

- **CO1:** Outline the concepts of Embedded System and Hardware Description Languages
- **CO2:** Develop an embedded system using FPGA
- **CO3:** Explain FPGA platforms and cross development tools.
- **CO4:** Illustrate Parallelism and scheduling concepts
- **CO5:** Interpret the parallelism with in FPGA hardware core.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	1	1	3	1	-	-
CO2	3	-	2	-	-	-
CO3	1	-	2	-	-	-
CO4	1	-	2	-	-	-
CO5	1	-	2	-	-	-

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	-	-
CO2	-	-
CO3	-	-
CO4	-	-
CO5	-	-

UNIT – I

Embedded System Overview & Hardware Description Languages

H/W-FPGA-Embedded SoC and use of VLSI circuit technology-platform FPGA's-Altera, Cyclone, Hardware Description Languages - VHDL , Verilog , Other High-Level HDLs, From HDL to Configuration Bit-stream

UNIT – II

System Design using FPGA:

Principles of system design-Design quality, Modules and interfaces, Abstraction and state, Cohesion and coupling, Designing and Reuse, Control flow graph, Design-Origins of platform FPGA designs.

UNIT – III

FPGA Platform

Components, adding to platform FPGA systems, assembling custom compute cores. Software Design-System Software Options, Root File system, Cross-Development Tools, Monitors and Boot-loader.

UNIT – IV

Partitioning, Scheduling & Communication

Overview of Partitioning Problem, Analytical Solution to Partitioning-Basic definitions, expected performance gain, resource considerations, Analytical Approach, Communication-Invocation/Coordination, Transfer of State, Practical Issues- Profiling Issues, Data Structures Manipulate Feature Size.

UNIT – V

Spatial Design

Principles of Parallelism-Identifying Parallelism - Spatial Parallelism with Platform FPGAs Parallelism within FPGA Hardware Cores, Parallelism within FPGA Designs

Text Books:

1. Embedded Systems Design with Platform FPGAs, Ron Sass, Andrew G Schmidt Principles and Practices, First Edition, Tata McGraw Hill, India, ISBN Number-0123743338
2. Digital Systems design using VHDL, Charles H Roth. Jr, Re-Print, PWS publishing company (Thomson Books), USA, ISBN Number-9788131518304

Reference Books:

1. Design with VHDL,V A. Padroni Circuit First Edition, MIT Press Cambridge, England, ISBN Number-0262162245
2. FPGA Based System Design, Wayne Wolf, First Edition, Prentices Hall Modern Semiconductor Design Series, USA, ISBN Number-0131424610

Web Links:

1. https://www.coursera.org/learn/intro-fpga-design-embedded-systems
2. https://www.colorado.edu/ali/fpga-design-embedded-systems-specialization

ARTIFICIAL INTELLIGENCE

Course Code: 2502AI30	L	T	P	C
	3	0	0	3

Course Outcomes: At the end of the Course, Student will be able to:

CO1: Describe fundamentals of Artificial Intelligence and its applications
CO2: Solve basic AI based problems and construct logical building blocks for problem Formulation
CO3: Apply various logical systems inferencing different logical problems.
CO4: Illustrate knowledge representation using predicate logic and predicate rules.
CO5: Design expert systems that leverage domain knowledge effectively

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	2	1	-	-	1	-
CO2	2	1	2	-	1	-
CO3	2	1	2	2	1	2
CO4	2	1	2	-	1	-
CO5	2	1	-	-	1	-

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	-	-
CO2	-	-
CO3	-	-
CO4	-	-
CO5	-	-

UNIT – I

Introduction to Artificial Intelligence: Introduction, History, Intelligent Systems, Foundations of AI, Applications, Tic-Tac-Toe Game playing, Development of AI Languages, Current trends in AI

UNIT – II

Problem Solving: State-Space Search and Control Strategies: Introduction, General Problem Solving, Characteristics of problem, Exhaustive Searches, Heuristic Search Techniques, Iterative- Deepening A*, Constraint Satisfaction

Problem Reduction and Game Playing: Problem Reduction, Game Playing, Minimax algorithm, Alpha- Beta Pruning, Two-player perfect information games

UNIT – III

Logic Concepts Introduction, Propositional calculus, Proportional logic, Representing facts in logic, functions and predicates, Axiomatic System, Semantic Tableau System in Proportional logic, Resolution Refutation in proportional logic, predicate logic.

UNIT – IV

Knowledge Representation Knowledge Representation Using Predicate logic, Knowledge Representation using Semantic Network, Knowledge Representation using

Frames. **Representing Knowledge Using Rules:** Procedural Versus Declarative knowledge, Logic Programming, Forward versus Backward Reasoning

UNIT – V

Expert System Representing and using Domain Knowledge, Reasoning with knowledge, Expert System Shells, Support for explanation examples, Knowledge acquisition-examples.

Text Books:

1. Artificial Intelligence- Saroj Kaushik, 1st edition CENGAGE Learning, (ISBN: 9789355730428).
2. Artificial intelligence, A modern Approach, Stuart Russel, Peter Norvig, Pearson Education Ltd, 2 nd ed, (ISBN: 97881203238)
3. Artificial Intelligence- Elaine Rich, Kevin Knight, Shivashankar B Nair, 3rd ed, McGraw Hill Education, (ISBN-13. 9780070087705)

Reference Books:

1. Artificial intelligence structures and strategies for complex problem solving, George F Lugar, 5th Edition, Addison Wesley. ISBN-13: 978-0321263186

Web Links:

1. https://www.tutorialspoint.com/artificial_intelligence/index.htm/
2. https://www.slideshare.net/slideshow/logic-in-ai/5005940//
3. https://www.slideshare.net/slideshow/artificial-intelligence-3638681/3638681/

MACHINE LEARNING TECHNIQUES

Course Code: 2502AI31	L	T	P	C
	3	0	0	3

Course Outcomes: At the end of the Course, Student will be able to:

CO1: Describe the need for AI and ML, and the types of ML algorithms..
CO2: Apply regression techniques and dimensionality reduction methods.
CO3: Implement and evaluate various classification techniques.
CO4: Describe and implement Artificial Neural Networks.
CO5: Utilize unsupervised learning methods for clustering and dimensionality reduction

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	2	1	-	-	-	-
CO2	2	1	2	-	-	-
CO3	2	1	2	2	-	2
CO4	2	1	2	-	-	-
CO5	2	1	-	-	-	-

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	-	-
CO2	-	-
CO3	-	-
CO4	-	-
CO5	-	-

UNIT – I

Introduction: Understanding the need for AI and Machine Learning (ML), AI & Data, Types of ML Algorithms: Supervised, Unsupervised Learning and semi supervised learning, reinforcement learning, evolutionary computation ML Model development life cycle Deep Learning for Human Like Learning

UNIT – II

Regression Techniques: Regression for prediction, Gradient Descent and Ascent, Learning with Momentum, Loss Functions, Over fitting and under fitting, Model evaluation techniques Types of Regression: Linear Regression,

UNIT – III

Classification Techniques: Naïve Bayes Classification: Bayesian Learning, Naïve Bayes Classification, MAP, Bayesian Belief Networks, Decision Tree, K-Nearest Neighbors Support Vector Machines: Hard Margin and Soft Margin, Kernels and Kernel Trick, Evaluation Measures for Classification Techniques

UNIT – IV

Classification Techniques: Naïve Bayes Classification: Bayesian Learning, Naïve Bayes Classification, MAP, Bayesian Belief Networks Decision Tree K-Nearest Neighbors

Support Vector Machines: Hard Margin and Soft Margin, Kernels and Kernel Trick, Evaluation Measures for Classification Techniques

UNIT – V

Unsupervised Learning: Uses in Clustering, associations and dimensionality reduction Clustering, Hierarchical Agglomerative Clustering, k-means Algorithm.

Text Books:

1. Machine Learning, Tom Mitchell, McGraw-Hill international editions, TMH, (ISBN: 0071154671)
2. Pattern Recognition and Machine Learning C. Bishop, Springer, (ISBN: 9781493938438)
3. Elements of Artificial Neural Networks , Kishan Mehrotra, Chilukuri Mohan and Sanjay Ranka, Penram International, (ISBN: 9780262133289).

Reference Books:

1. Pattern Recognition, Techniques and Applications , Rajjan Shinghal, OXFORD Higher Education , (ISBN:9780195676853)
2. Andrew Kelleher, Adam Kelleher, Applied Machine Learning for Data Scientist and Software engineers, Addison-Wesley Professional, (ISBN:9780134116549)

Web Links:

1. https://onlinecourses.nptel.ac.in/noc21_cs24/preview/
2. https://www.udemy.com/course/machinelearning/