



GOVERNMENT COLLEGE OF ENGINEERING, SALEM

(NAAC Accredited with A⁺, An Autonomous Institution, Affiliated to Anna University, Chennai)

POSTGRADUATE CURRICULUM

(Applicable to the students admitted in M.E. Programme, from the Academic Year 2026-2027)

Programme: M.E. Thermal Engineering

Regulations: 2026

Overview of Credits

Sem	BS	ES(PC)	ES(PE)	SD	MC	AC	Total
I	4	12		1	3	0	20
II		16	6			0	22
III			6	8			14
IV				14			14
Total	4	28	12	23	3	0	70
% of Category	5.71	40.00	17.14	32.86	4.29	0	100

Abbreviations:

Course Type:

T - Theory
L - Laboratory
PW - Project Work

Category :

BS - Basic Science
ES - Engineering Science [Programme Core (**PC**)
Programme Elective (**PE**)]
SD - Skill Development
MC - Mandatory Course
AC - Audit Course

Others :

TCP - Total Contact Periods
L - Lecture
T - Tutorial
P - Practical

Semester I											
Sl. No.	Course Code	Course Name	Course Type	Hours per Semester				Credits	Category	Weightage	
				L	T	P	TCP			CA %	ES %
1.	26MPC01	Advanced Mathematical Methods in Engineering	T	45	15	0	60	4	BS	40	60
2.	26TH101	Advanced Thermodynamics	T	45	15	0	60	4	ES(PC)	40	60
3.	26TH102	Advanced Fluid Dynamics	T	45	0	0	45	3	ES(PC)	40	60
4.	26TH103	Advanced Heat Transfer	T	45	0	0	45	3	ES(PC)	40	60
5.	26MLC01	Research Methodology and IPR	T	45	0	0	45	3	MC	40	60
6.	26TH104	Thermal Engineering Laboratory	L	0	0	60	60	2	ES(PC)	60	40
7.	26TH105	Technical Seminar	-	0	0	30	30	1	SD	100	0
8.	26AC00X	Audit Course – I	T	30	0	0	30	0	AC	100	0
Total							375	20			

Semester II											
Sl. No.	Course Code	Course Name	Course Type	Hours per Semester				Credits	Category	Weightage	
				L	T	P	TCP			CA %	ES %
1.	26TH201	Hydrogen and Fuel cell Technologies	T	45	0	0	45	3	ES(PC)	40	60
2.	26TH202	Computational Fluid Dynamics for Thermal Systems	T	45	0	0	45	3	ES(PC)	40	60
3.	26TH203	Instrumentation for Thermal Systems	T	45	0	0	45	3	ES(PC)	40	60
4.	26TH204	Design of Heat Exchangers	T	45	0	0	45	3	ES(PC)	40	60
5.	26THEXX	Programme Elective – I	T	45	0	0	45	3	ES(PE)	40	60
6.	26THEXX	Programme Elective – II	T	45	0	0	45	3	ES(PE)	40	60
7.	26TH205	Analysis & Simulation Laboratory	L	0	0	60	60	2	ES(PC)	60	40
8.	26TH206	Applied Thermal Engineering Laboratory	L	0	0	60	60	2	ES(PC)	60	40
9.	26AC00X	Audit Course – II	T	30	0	0	30	0	AC	100	0
Total							420	22			

Semester III											
Sl. No.	Course Code	Course Name	Course Type	Hours per Semester				Credits	Category	Weightage	
				L	T	P	TCP			CA %	ES %
1	26THEXX	Programme Elective – III	T	45	0	0	45	3	ES(PE)	40	60
2	26THEXX	Programme Elective – IV	T	45	0	0	45	3	ES(PE)	40	60
3	26TH301	Dissertation Phase – I	PW	0	0	240	240	8	SD	60	40
Total							330	14			

Semester IV											
Sl. No.	Course Code	Course Name	Course Type	Hours per Semester				Credits	Category	Weightage	
				L	T	P	TCP			CA %	ES %
1	26TH401	Dissertation Phase – II	PW	0	0	420	420	14	SD	60	40
Total							420	14			
Total Credits for the Programme = 20+22+14 +14								70			

Programme Electives

Sl. No.	Course Code	Course Name	Course Type	Hours per Semester				Credits	Category	Weightage	
				L	T	P	TCP			CA %	ES %
Programme Elective - I (Semester II)											
1.	26THE01	Thermal management of Electric Vehicle Battery Systems	T	45	0	0	45	3	ES(PE)	40	60
2.	26THE02	Optimization Techniques in Engineering	T	45	0	0	45	3	ES(PE)	40	60
3.	26THE03	Electric and Hybrid Vehicle Technology	T	45	0	0	45	3	ES(PE)	40	60
4.	26THE04	Electronic Engine Management Systems	T	45	0	0	45	3	ES(PE)	40	60
5.	26THE05	Advanced Energy Storage Technologies	T	45	0	0	45	3	ES(PE)	40	60
Programme Elective - II (Semester II)											
6.	26THE06	Design of Solar and Wind Systems	T	45	0	0	45	3	ES(PE)	40	60
7.	26THE07	Design and Analysis of Turbo machines	T	45	0	0	45	3	ES(PE)	40	60
8.	26THE08	Combustion in IC Engines	T	45	0	0	45	3	ES(PE)	40	60
9.	26THE09	Waste to Energy	T	45	0	0	45	3	ES(PE)	40	60
10.	26THE10	Advanced Refrigeration Systems	T	45	0	0	45	3	ES(PE)	40	60
Programme Elective - III (Semester III)											
11.	26THE11	Environmental and Pollution control	T	45	0	0	45	3	ES(PE)	40	60
12.	26THE12	Nanotechnology	T	45	0	0	45	3	ES(PE)	40	60
13.	26THE13	Solar Energy for Industrial Process Heating	T	45	0	0	45	3	ES(PE)	40	60
14.	26THE14	Energy Efficient Buildings Design	T	45	0	0	45	3	ES(PE)	40	60
15.	26THE15	Analysis of Thermal Power Cycles	T	45	0	0	45	3	ES(PE)	40	60

Programme Elective - IV (Semester III)

16.	26THE16	Advanced Internal Combustion Engines	T	45	0	0	45	3	ES(PE)	40	60
17.	26THE17	Energy Management and Environmental Benefits	T	45	0	0	45	3	ES(PE)	40	60
18.	26THE18	Solar Energy Appliances	T	45	0	0	45	3	ES(PE)	40	60
19.	26THE19	Cost Management of Engineering Projects	T	45	0	0	45	3	ES(PE)	40	60
20.	26THE20	Advanced Composite materials	T	45	0	0	45	3	ES(PE)	40	60

Audit Courses

Sl. No.	Course Code	Course Name	Course Type	Hours per Semester				Credits	Category	Weightage	
				L	T	P	TCP			CA %	ES %
1.	26AC001	English for Research paper writing	T	30	0	0	30	0	AC	100	0
2.	26AC002	Disaster Management	T	30	0	0	30	0	AC	100	0
3.	26AC003	Sanskrit for Technical Knowledge	T	30	0	0	30	0	AC	100	0
4.	26AC004	Value Education	T	30	0	0	30	0	AC	100	0
5.	26AC005	Constitution of India	T	30	0	0	30	0	AC	100	0
6.	26AC006	Pedagogy Studies	T	30	0	0	30	0	AC	100	0
7.	26AC007	Stress Management by Yoga	T	30	0	0	30	0	AC	100	0
8.	26AC008	Personality Development through Life Enlightenment Skills	T	30	0	0	30	0	AC	100	0
9.	26AC009	Sustainable Development Goals	T	30	0	0	30	0	AC	100	0

26MPC01	ADVANCED MATHEMATICAL METHODS IN ENGINEERING			SEMESTER		I		
Prerequisites				Category	BS	Credits	4	
Basic knowledge of matrices, vector calculus, differential equations and probability concepts is required.				Hours/ Semester	L	T	P	TH
					45	15	0	60
COURSE OBJECTIVES								
1.	To understand vector spaces, linear transformations and the rank–nullity theorem.							
2.	To formulate and solve second order partial differential equations using standard methods.							
3.	To apply Fourier transform techniques for solving diffusion, wave and Laplace equations.							
4.	To perform hypothesis testing using normal, t, chi-square and F distributions.							
5.	To analyze experimental data using ANOVA and standard design of experiments.							
UNIT - I	LINEAR ALGEBRA							9+3
Vector Spaces – Linear Dependence and Independence of Vectors – Basis and Dimension – Linear Transformations (Maps) – Range and Kernel of Linear Transformations – Rank and Nullity – Inverse of Linear Transformations – Rank–Nullity Theorem – Composition of Linear Maps – Matrix Associated with a Linear Map.								
UNIT - II	PARTIAL DIFFERENTIAL EQUATIONS							9+3
Classification of second order PDE – Solution of PDE by separation of variables – Solution of Parabolic, Elliptic and Hyperbolic equations in cylindrical and spherical coordinates – Initial and Boundary value problems for Two-dimensional wave equation by the Eigenfunction Method – D'Alembert's Solution for the wave equation.								
UNIT - III	FOURIER TRANSFORM TECHNIQUES FOR PARTIAL DIFFERENTIAL EQUATIONS							9+3
Fourier Transform: Definition – Properties – Fourier Transforms of Elementary Functions – Solution of Diffusion, Wave and Laplace Equations Using Fourier Transform Techniques.								
UNIT - IV	TESTING OF HYPOTHESIS							9+3
Sampling distributions – Small and large samples – Tests based on Normal, t, Chi square, and F distributions for testing of means, variance and proportions – Analysis of $r \times c$ Contingency Tables – Goodness-of-Fit Tests – Tests for Independence of Attributes.								
UNIT - V	ANALYSIS OF VARIANCE AND DESIGN OF EXPERIMENTS							9+3
Analysis of variance – One way and Two-way classifications – Principles of Design of Experiments – Standard Experimental Designs (Completely Randomized Design, Randomized Block design and Latin square design).								
Total:60 Hours								
Weightage:								
Continuous Assessment 40%								
End Semester Examinations 60%								

REFERENCE BOOKS:

1.	Gilbert Strang, "Linear Algebra and its applications", Cengage Learning, New Delhi, 4th edition, 2006.
2.	K.Sankara Rao, "Introduction to Partial Differential Equations", Prentice Hall of India Pvt. Ltd., New Delhi, 2003.
3.	Veerarajan.T, "Probability, Statistics and Random process", Tata McGraw- Hill publications, second edition, New Delhi, 2002.
4.	Gupta, S.C. and Kapur, V.K., "Fundamentals of Mathematical Statistics", S.Chand and Sons, New Delhi, 11th Edition 2014
5.	Grewal, B.S., "Higher Engineering Mathematics", 43rd edition, Khanna Publishers, New Delhi 2014.

E-RESOURCES:

1.	NPTEL Linear Algebra https://nptel.ac.in/courses/111/106/111106051
2.	NPTEL Partial Differential Equations https://nptel.ac.in/courses/111/106/111106100
3.	NPTEL – Fourier Transforms & Their Applications https://nptel.ac.in/courses/111/102/111102114
4.	NPTEL – Probability & Statistics https://nptel.ac.in/courses/111/105/111105041
5.	Khan Academy – Hypothesis Testing and Distributions https://www.khanacademy.org/math/statistics-probability

COURSE OUTCOMES (COs) /**At the end of the course, the students will have the ability to****Mapping
POs****Mapping
PSOs**

CO1	Explain vector spaces, linear transformations, classification of PDEs, Fourier transforms, hypothesis testing, ANOVA and design of experiments.	PO3	PSO1
CO2	Apply linear algebra concepts, separation of variables, eigenfunction methods, Fourier transforms, and hypothesis testing tools for solving engineering problems.	PO1, PO3	PSO1
CO3	Analyze engineering systems and data using linear transformations, PDEs, Fourier transforms, statistical distributions, hypothesis tests, and $r \times c$ table analysis for decision making.	PO1, PO3	PSO1, PSO2
CO4	Evaluate ANOVA results and assess suitable experimental designs such as CRD, RBD and Latin square design for engineering studies.	PO1, PO3	PSO2
CO5	Develop mathematical models using linear algebra, PDE solution techniques, Fourier transforms and statistical tools, and present conclusions through reports.	PO1, PO2, PO3	PSO1, PSO2

The Course Articulation Matrix (CAM) for defined COs

COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	-	-	3	2	1
CO2	3	-	3	3	2
CO3	3	-	3	3	2
CO4	3	-	3	2	3
CO5	3	3	3	3	3
AVERAGE	2.4	0.6	3	2.6	2.2

Activities:

1.	Verify vector space properties, determine basis and dimension, compute rank and nullity, and analyze linear transformations and their matrix representations.
2.	Solve second order PDE by classification and separation of variables and apply eigen function method and D'Alembert's solution for wave equation.
3.	Compute Fourier transform of elementary functions and solve diffusion, wave and Laplace equations using Fourier transform technique.
4.	Perform hypothesis testing using normal, t, chi-square and F distributions, including $r \times c$ tables, goodness-of-fit tests and tests for independence of attributes.
5.	Perform one-way and two-way ANOVA and apply CRD, RBD and Latin square design for experimental data analysis.

Rubrics for evaluation: CO4

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Understanding of Statistical Methods and Experimental Designs	10	Demonstrates strong understanding of statistical methods and experimental designs and their applicability	Shows adequate understanding with minor gaps	Demonstrates limited understanding
2.	Selection and Justification of Statistical Test/Experimental Design	10	Appropriate statistical test or experimental design is selected with clear justification	Suitable test/design selected with minor issues	Incorrect or unclear test/design selection
3.	Application of Statistical Procedures	10	Statistical procedures are correctly applied using appropriate methods and assumptions	Minor errors in applying statistical procedures	Major errors in applying statistical procedures
4.	Accuracy, Validity and Interpretation of Statistical Analysis	10	Statistical analysis is accurate, valid, and appropriately interpreted	Minor computational or statistical analysis errors	Major computational, analytical, or interpretation errors

5.	Technical Presentation and Communication of Results	10	Results are critically analyzed and clearly presented in a systematic, organized, and professional manner	Interpretation and presentation are acceptable with minor issues	Poor analysis, interpretation, and presentation
Total		50			

Rubrics for evaluation: C05

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Problem Formulation and Mathematical Modelling	10	Engineering problem is clearly formulated with an appropriate mathematical model	Minor issues in formulation or modelling	Problem formulation and modelling are unclear
2.	Selection of Mathematical Method	10	Appropriate mathematical method is selected with clear justification	Suitable method selected with minor issues	Inappropriate or unclear method selection
3.	Development of Solution Procedure	10	Mathematical method and solution procedure are correctly developed and systematically presented	Methodology is adequate with minor errors	Incorrect or incomplete methodology
4.	Solution Accuracy and Validation	10	Solutions are accurate and properly verified or validated	Validation is adequate with minor issues	Poor or incomplete validation of solutions
5.	Analysis, Engineering Interpretation and Technical Presentation	10	Results are effectively analyzed, related to engineering applications, and communicated through clear, organized, and technically sound reports and presentations	Interpretation and presentation are acceptable with minor issues	Poor interpretation of results and inadequate presentation/documentation
Total		50			

The Internal Assessment Matrix (IAM) for the defined COs:

	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
C01	16	16	—	—	10	2
C02	28	28	—	—	20	2
C03	16	16	—	—	20	3
C04	—	—	40	—	25	3
C05	—	—	—	40	25	3
Total	60	60	40	40	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);

Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26TH101	ADVANCED THERMODYNAMICS		SEMESTER		I	
Prerequisites		Category	ES(PC)	Credits		4
Engineering Thermodynamics		Hours/ Semester	L	T	P	TH
			45	15	0	60
COURSE OBJECTIVES						
1.	To develop the ability to use the thermodynamics concepts for various applications like availability analysis and thermodynamic relations.					
2.	To impart the knowledge to analyze the real gas behaviour and chemical thermodynamics.					
3.	To impart the knowledge about chemistry behind the thermodynamics.					
4.	To design and develop simulation-based thermodynamic system profiles using modern engineering computational tools.					
5.	To investigate complex thermodynamic phenomena, state-of-the-art equations, and irreversible thermodynamic developments through independent technical research papers.					
UNIT - I		AVAILABILITY ANALYSIS AND THERMODYNAMIC PROPERTY RELATIONS				9+3
Reversible work - availability - irreversibility and second – law efficiency for a closed system and steady – state control volume. Availability analysis of simple cycles. Thermodynamic potentials. Maxwell relations. Generalized relations for changes in entropy - internal energy and enthalpy - generalized relations for Cp and CV. Clausius Clayperon equation, Joule–Thomson coefficient. Bridgeman tables for thermodynamic relations.						
UNIT - II		REAL GAS BEHAVIOUR AND MULTI-COMPONENT SYSTEM				9+3
Different equations of state – fugacity – compressibility - principle of corresponding states – Use of generalized charts for enthalpy and entropy departure - fugacity coefficient. Fundamental property relations for systems of variable composition. Partial molar properties. Real gas mixtures - Ideal solution of real gases and liquid – activity – equilibrium in multi– phase systems – Gibbs phase rule for non – reactive components.						
UNIT - III		CHEMICAL THERMODYNAMICS				9+3
Thermochemistry - First law analysis of reacting systems – Adiabatic flame temperature - entropy change of reacting systems – Second law analysis of reacting systems – Criterion for reaction equilibrium. Equilibrium constant for gaseous mixtures – evaluation of equilibrium composition.						
UNIT - IV		STATISTICAL THERMODYNAMICS				9+3
Micro states and Macro states - thermodynamic probability – degeneracy of energy levels - Maxwell – Boltzman, Fermi – Diarc and Bose – Einstein statistics – microscopic interpretation of heat and work, evaluation of entropy, Partion function, calculation of the Macroscopic properties from partition functions.						
UNIT - V		IRREVERSIBLE THERMODYNAMICS				9+3
Conjugate fluxes and forces – entropy production Onsager’s reciprocity relations – thermos-electric phenomena, formulations.						
Total:60 Hours						
Weightage:						
Continuous Assessment 40%						
End Semester Examinations 60%						

REFERENCE BOOKS:

1.	Bejan, A., Advanced Engineering Thermodynamics, John Wiley and Sons, 1988.
2.	DeHoff, R.T., Thermodynamics in Materials Science, McGraw-Hill Inc., 1993.
3.	Holman, J.P., Thermodynamics, Fourth Edition, McGraw-Hill Inc., 1988.
4.	Kenneth Wark Jr., Advanced Thermodynamics for Engineers, McGraw-Hill Inc., 1995.
5.	Rao, Y.V.C., Postulational and Statistical Thermodynamics, Allied Publisher Limited, New Delhi, 1996.
6.	Sears, F.W. and Salinger, G.I., Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Third Edition, Narosa Publishing House, New Delhi, 1993.

E-RESOURCES:

1.	NPTEL – Advanced Engineering Thermodynamics
2.	NPTEL – Statistical Thermodynamics
3.	MIT Open Courseware – Chemical Thermodynamics / Thermal Systems
4.	NIST Chemistry Webbook (Thermophysical Properties Databases)
5.	CODATA Key Values for Thermodynamics Reports

COURSE OUTCOMES (COs) /**At the end of the course, the students will have the ability to****Mapping
POs****Mapping
PSOs**

CO1	Apply availability analyses and second law efficiencies to evaluate closed systems and control volume property transformations.	PO1, PO3	PSO1
CO2	Analyze multi-component real gas mixtures by utilizing departure charts, fugacity principles, and equations of state.	PO1, PO3	PSO1
CO3	Analyze reacting thermal systems to determine chemical equilibrium metrics, equilibrium constants, and adiabatic flame temperatures.	PO1, PO3	PSO1
CO4	Apply specialized thermodynamic simulation tools, scripting codes, or engineering equation solvers to model real gas behavior and predict macroscopic thermal properties.	PO1, PO2, PO3	PSO1, PSO2
CO5	Evaluate complex real-world thermal power systems, non-equilibrium architectures, or reacting flows through an independent case study or technical seminar research report.	PO1, PO2, PO3	PSO1, PSO2

The Course Articulation Matrix (CAM) for defined COs

COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	2	—	2	2	—
CO2	2	—	2	2	—
CO3	2	—	2	2	—
CO4	3	3	3	3	3
CO5	3	3	3	2	3
AVERAGE	2.4	3.0	2.4	2.2	3.0

Activities:

1.	Model and analyze real gas behaviour using thermodynamic simulation software, scripting tools.
2.	Conduct an independent case study or technical seminar research project to evaluate complex thermal power systems.

Rubrics for evaluation: CO4

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Technical Understanding	20	Comprehensive and accurate analysis of multi-parameter equations of state and real gas behavior models.	Good understanding with minor errors in property relation formula applications.	Basic understanding of real gas simulation parameters.
2.	Industrial Data Analysis	20	Excellent interpretation using real thermodynamic chart data and steam tables.	Adequate analysis of compressibility indices or departure functions.	Limited interpretation of thermodynamic simulation outputs.
3.	Sustainability & Economic Evaluation	20	Strong techno-economic assessment mapping energy degradation and exergy values.	Moderate evaluation of thermal losses and cycle boundaries.	Limited discussion tracking thermodynamic optimization paths.
4.	Presentation & Communication	20	Highly professional and engaging delivery using formatted property curves and charts.	Clear communication with minor layout inconsistencies.	Moderate delivery with weak control of core thermodynamic terminology.
5.	Report Quality & References	20	Well-organized with quality references extracted from premier thermal science journals.	Adequate documentation with minor style formatting variations.	Basic report structure lacking essential code block scripts.
	Total	100			

Rubrics for evaluation: C05

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Innovation & Design	20	Highly innovative and optimized design architectures for advanced thermal power cycles.	Good design methodology tracking system constraints and irreversibility fields.	Conventional approach utilizing basic textbook system schematics.
2.	Functionality of Prototype / Model	20	Fully functional and reliable computational cycle routine execution with zero matrix errors.	Functional layout displaying minor convergence tracking delays.	Partially functional framework experiencing solver limits or loop faults.
3.	Engineering Analysis	20	Strong theoretical and experimental validation checking calculated efficiencies against benchmarks.	Adequate validation tracking primary mass and energy fields correctly.	Limited analysis missing continuous verification indices.
4.	Use of Modern Tools	20	Effective use of modern thermodynamic solver engines and script toolboxes.	Moderate use of open-source configuration layouts and software templates.	Minimal usage of advanced simulation platforms.
5.	Documentation & Demonstration	20	Excellent report and demonstration of modeled cycle states and exergy losses.	Good documentation with tiny chart plotting errors.	Basic presentation format missing essential block systems.
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
C01	12	14	—	—	10	2
C02	12	34	—	—	20	2
C03	36	12	—	—	20	2
C04	—	—	40	—	25	3
C05	—	—	—	40	25	3
Total	60	60	40	40	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26TH102	ADVANCED FLUID DYNAMICS			SEMESTER		I	
Prerequisites			Category	ES(PC)	Credits	3	
Fluid Mechanics			Hours/ Semester	L	T	P	TH
				45	0	0	45
COURSE OBJECTIVES							
1.	To develop computational modelling configurations for analysing distinct compressible and viscous flow regimes.						
2.	To formulate the exact mathematical derivations for mass conservation and differential momentum criteria using integral limits.						
3.	To apply kinematic transformation rules via Reynolds Transport theorem expressions, stream fields, and irrotational systems.						
4.	To evaluate boundary layer separation parameters and integral momentum equations over configurations using simulation software tools.						
5.	To execute rigorous validation of transition models, universal velocity profiles, and Reynolds stress closures using modern fluid science journals.						
UNIT - I	TYPES OF FLOW						9
Compressible flow - Fully developed flows, parallel flow in straight channel, Couette flow, creeping flow							
UNIT - II	GOVERNING EQUATION IN FLUID DYNAMICS						9
Derivation of continuity and momentum equations using integral and differential approach – Dimensionless form of governing equations - Special forms of governing equations – Integral quantities							
UNIT - III	POTENTIAL FLOW						9
Reynolds - Transport theorem - Kelvin's theorem - Irrotational flow - Stream function- Velocity potential function							
UNIT - IV	BOUNDARY LAYERS						9
Boundary layer equations, flow over flat plate, momentum - Integral equations for boundary layer - Approximate solution methodology for boundary layer equations.							
UNIT - V	TURBULENT FLOW CHARACTERISTICS						9
Characteristics of turbulent flow, Laminar - Turbulent transition - Mean motion and fluctuations - Derivation of governing equations for turbulent flow - Shear stress models - Universal velocity distribution.							
Total:45 Hours							
Weightage: Continuous Assessment 40% End Semester Examinations 60%							

REFERENCE BOOKS:

1. Muralidhar and Biswas, Advanced Engineering Fluid Mechanics, Alpha Science International, 2005
2. Irwin Shames, Mechanics of Fluids, McGraw Hill, 2003
3. Fox R.W., McDonald A.T, Introduction to Fluid Mechanics, John Wiley and Sons Inc,1985
4. Pijush K. Kundu, Ira M Kohen and David R. Dawaling, Fluid Mechanics, Fifth Edition,2005

E-RESOURCES:

1. NPTEL – Advanced Fluid Mechanics / Fluid Dynamics
2. MIT Open Course Ware – Advanced Fluid Mechanics Series
3. ANSYS Fluent Fluid Flow Validation Research Literature Databases
4. ERCOFTAC (European Research Community on Flow, Turbulence and Combustion) Learning Resources

COURSE OUTCOMES (COs) /**At the end of the course, the students will have the ability to****Mapping
POs****Mapping
PSOs**

CO1	Apply viscous flow parameters, channel definitions, and creeping approximations to determine fluid state profiles.	PO1, PO3	PSO1
CO2	Analyze differential continuity loops and integral momentum formulations across complex boundaries.	PO1, PO3	PSO1
CO3	Analyze potential fields, irrotational flow paths, transport transformations, and velocity stream parameters.	PO1, PO3	PSO1
CO4	Apply specialized computational fluid software, scripting tools, or differential solvers to construct simulation models for boundary layer profiles.	PO1, PO2, PO3	PSO1, PSO2
CO5	Evaluate turbulent velocity fields, transition structures, and non-linear shear stress formulations via an independent case study seminar.	PO1, PO2, PO3	PSO1, PSO2

The Course Articulation Matrix (CAM) for defined COs

COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	2	—	2	2	—
CO2	2	—	2	2	—
CO3	2	—	2	2	—
CO4	3	3	3	2	2
CO5	3	3	3	2	2
AVERAGE	2.4	3.0	2.4	2.0	2.0

Activities:

1. Computational simulation modelling of boundary layer behaviour and flow characteristics.
2. Structured analytical seminar documenting turbulent shear stress model validations.

Rubrics for evaluation: CO4

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Technical Understanding	20	Comprehensive and accurate analysis of boundary layer equations and Navier-Stokes grids.	Good understanding with minor syntax errors in coding differential solvers.	Basic understanding of boundary layer flow variables.
2.	Industrial Data Analysis	20	Excellent interpretation using real empirical flat plate metrics and velocity contours.	Adequate analysis of streamline tracks or node residuals.	Limited interpretation of velocity vector data fields.
3.	Sustainability & Economic Evaluation	20	Strong techno-economic assessment mapping drag profiles and separation losses.	Moderate evaluation of pressure penalties and drag reductions.	Limited discussion tracking aerodynamic efficiency improvements.
4.	Presentation & Communication	20	Highly professional and engaging delivery using professional vector field plots.	Clear communication with minor graph scaling or plotting deficits.	Moderate delivery with weak control of fluid dynamics terminology.
5.	Report Quality & References	20	Well-organized with quality references compiled from high-impact fluid science archives.	Adequate documentation with minor template formatting gaps.	Basic report structure omitting essential code loop steps.
	Total	100			

Rubrics for evaluation: CO5

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Innovation & Design	20	Highly innovative and optimized turbulent model configurations or mesh schemes.	Good design methodology tracking eddy metrics or kinetic dissipation scales.	Conventional approach utilizing basic standard unrefined flow meshes.
2.	Functionality of Prototype	20	Fully functional and reliable execution loop tracking target velocity distributions flawlessly.	Functional simulation layout displaying minor residual fluctuations.	Partially functional structure experiencing grid skewness or solver failure.
3.	Engineering Analysis	20	Strong theoretical and experimental validation checking shear stresses against exact records.	Adequate validation tracking mean flow motions and transition lines correctly.	Limited analysis missing instrumentation bounds or verification data.

4.	Use of Modern Tools	20	Effective use of modern computational fluid tools and software grid utilities.	Moderate use of open-source fluid solvers and interface models.	Minimal usage of advanced simulation platforms.
5.	Documentation & Demonstration	20	Excellent report and demonstration of simulated flow separation regions.	Good documentation with sparse contour axis labeling oversights.	Basic presentation format lacking essential block flow drawings.
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

CO	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
CO1	14	12	—	—	10	2
CO2	10	36	—	—	20	2
CO3	36	12	—	—	20	2
CO4	—	—	40	—	25	3
CO5	—	—	—	40	25	3
Total	60	60	40	40	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26TH103	ADVANCED HEAT TRANSFER		SEMESTER		I	
Prerequisites		Category	ES(PC)	Credits	3	
Heat Transfer		Hours/ Semester	L	T	P	TH
			45	0	0	45
COURSE OBJECTIVES						
1.	To implement steady state solutions for multi-dimensional conduction expressions and absorbing gas radiation enclaves.					
2.	To build rigorous convective transport balances inside turbulent layers using mixing lengths and analogy theories.					
3.	To design high-performance compact heat exchangers and phase-change configurations utilizing terminal rating schemes.					
4.	To solve non-linear multi-dimensional thermal fields numerically via iterative formulations and algorithmic code arrays.					
5.	To execute targeted engineering design studies tracking coupled mass vapor droplet states in turbine and combustion environments.					
UNIT - I	CONDUCTION AND RADIATION HEAT TRANSFER					9
One dimensional energy equations and boundary condition – three-dimensional heat conduction equations - extended surface heat transfer - conduction with moving boundaries - radiation in gases and vapor. Gas radiation and radiation heat transfer in enclosures containing absorbing and emitting media.						
UNIT - II	TURBULENT FORCED CONVECTIVE HEAT TRANSFER					9
Momentum and energy equations - turbulent boundary layer heat transfer - mixing length concept - turbulence model – k ϵ model - analogy between heat and momentum transfer – Reynolds, Colburn, Prandtl turbulent flow in a tube - high speed flows.						
UNIT - III	PHASE CHANGE HEAT TRANSFER AND HEAT EXCHANGER					9
Condensation with shears edge on bank of tubes - boiling – pool and flow boiling - heat exchanger - ϵ – NTU approach and design procedure - compact heat exchangers.						
UNIT - IV	NUMERICAL METHODS IN HEAT TRANSFER					9
Finite difference formulation of steady and transient heat conduction problems – discretization schemes – explicit - Crank Nicolson and fully implicit schemes - control volume formulation - steady one-dimensional convection and diffusion problems - calculation of the flow field – SIMPLER Algorithm						
UNIT - V	MASS TRANSFER AND ENGINE HEAT TRANSFER CORRELATION					9
Mass transfer - vaporization of droplets - combined heat and mass transfers - heat transfer correlations in various applications like I.C. engines, compressors and turbines.						
Total:45 Hours						
Weightage:						
Continuous Assessment 40%						
End Semester Examinations 60%						

REFERENCE BOOKS:

1.	Ghoshdastidar. P.S., Heat Transfer, Oxford University Press, 2004.
2.	Holman.J.P., Heat Transfer, Tata Mc Graw Hill, 2002.
3.	Incropera F.P. and DeWitt. D.P., Fundamentals of Heat & Mass Transfer, John Wiley & Sons, 2002.
4.	Nag.P.K., Heat Transfer, Tata McGraw-Hill, 2002.
5.	Ozisik. M.N., Heat Transfer – A Basic Approach, McGraw-Hill Co.
6.	Yadav, R., Heat and Mass Transfer, Central Publishing House, 1995.
7.	Yunus A.Cengal., Heat and Mass Transfer – A practical Approach, 3rd edition, Tata- McGraw-Hill, 2007.

E-RESOURCES:

1.	NPTEL – Advanced Heat and Mass Transfer
2.	MIT OpenCourseWare – Thermal-Fluids Engineering II / Heat Transfer
3.	Begell House – International Journal of Heat and Mass Transfer Databases
4.	HTRI (Heat Transfer Research, Inc.) System Learning Platforms

COURSE OUTCOMES (COs) /**At the end of the course, the students will have the ability to****Mapping
POs****Mapping
PSOs**

CO1	Apply three-dimensional conduction formulations and gas-radiation emissive enclosure frameworks under explicit constraints.	PO1, PO3	PSO1
CO2	Analyze turbulent convective layers, boundary mixing distributions, and thermal-momentum transport analogies.	PO1, PO3	PSO1
CO3	Analyze multi-tube phase change condensation modes, boiling flows, and compact heat exchanger design paths.	PO1, PO3	PSO1
CO4	Apply thermal software tool engines, scripting algorithms to map explicit and implicit conduction arrays.	PO1, PO2, PO3	PSO1, PSO2
CO5	Evaluate combined heat-mass transfer balances, droplet vaporization tracks, and internal engine correlations via a specialized seminar report.	PO1, PO2, PO3	PSO1, PSO2

The Course Articulation Matrix (CAM) for defined COs

COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	2	—	2	2	—
CO2	2	—	2	2	—
CO3	2	—	2	2	—
CO4	3	3	3	2	2
CO5	3	3	3	2	2
AVERAGE	2.4	3.0	2.4	2.0	2.0

Activities:					
1.	Explicit and implicit heat conduction modeling using thermal software and scripting algorithms.				
2.	Seminar report evaluating combined heat-mass transfer and droplet vaporization processes.				
Rubrics for evaluation: CO4					
Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Technical Understanding	20	Comprehensive and accurate analysis of multidimensional discretization arrays.	Good understanding with minor errors in configuring spatial boundary nodes.	Basic understanding of numerical transient stability constraints.
2.	Industrial Data Analysis	20	Excellent interpretation using real convective fluxes and operational thermal datasets.	Adequate analysis of control volumes or SIMPLER field tracks.	Limited interpretation of temperature grid values.
3.	Sustainability & Economic Evaluation	20	Strong techno-economic assessment profiling heat exchanger effectiveness limits and cost gains.	Moderate evaluation of material properties and compact scale effects.	Limited discussion tracking entropy creation or thermal losses.
4.	Presentation & Communication	20	Highly professional and engaging delivery using crisp contour layouts and vectors.	Clear communication with minor presentation format inconsistencies.	Moderate delivery with shallow control of heat-mass vocabulary.
5.	Report Quality & References	20	Well-organized with quality references extracted from premier thermal transfer databases.	Adequate documentation with tiny layout formatting differences.	Basic report structure omitting essential grid calculation loops.
	Total	100			
Rubrics for evaluation: CO5					
Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Innovation & Design	20	Highly innovative and optimized configurations for multi-tube phase change or droplet fields.	Good design methodology tracking boundary fluxes and species limits.	Conventional approach relying on basic static unenhanced thermal maps.
2.	Functionality of Prototype	20	Fully functional and reliable execution loop tracking transient thermal gradients flawlessly.	Functional layout displaying minor solver delay or tracking lag.	Partially functional module experiencing matrix convergence failure.

3.	Engineering Analysis	20	Strong theoretical and experimental validation checking calculated fluxes against records.	Adequate validation tracking basic vaporization profiles correctly.	Limited analysis missing continuous verification metrics.
4.	Use of Modern Tools	20	Effective use of modern thermal software tool engines and calculation macro packages.	Moderate use of scripting models and standard software interface screens.	Minimal usage of advanced computational systems.
5.	Documentation & Demonstration	20	Excellent report and demonstration of transient droplet mass boundaries.	Good documentation with minor label or scaling gaps.	Basic presentation structure lacking critical block diagrams.
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
C01	14	12	—	—	10	2
C02	10	36	—	—	20	2
C03	36	12	—	—	20	2
C04	—	—	40	—	25	3
C05	—	—	—	40	25	3
Total	60	60	40	40	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26MLC01	RESEARCH METHODOLOGY AND IPR		SEMESTER			I
Prerequisites		Category	MC	Credits		3
- Problem Solving skill - Professional writing skill		Hours/ Semester	L	T	P	TH
			45	0	0	45
COURSE OBJECTIVES						
1.	To develop essential knowledge for formulating engineering research problems, structuring investigative solutions, and compiling technical reports.					
2.	To apply structured statistical paradigms, parametric checks, and rigorous evaluation rules to authenticate experimental literature findings.					
3.	To execute professional technical writing methodologies suitable for review committee research proposal appraisals.					
4.	To evaluate international patenting regulations, procedural grant timelines, using dedicated global property tools.					
5.	To analyze patent information databases, technology licensing procedures.					
UNIT - I		INTRODUCTION TO RESEARCH				9
Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of the research problem, Approaches to investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations.						
UNIT - II		EFFECTIVE LITERATURE STUDIES, APPROACHES AND ANALYSIS				9
Developing the theoretical framework of research - Developing operational statements of the problem - Criteria for evaluating research approach - Hypotheses: Parametric and non-parametric testing- Establishing the reliability and validity of findings with literature review and experiments – documentation, Plagiarism, Research ethics.						
UNIT - III		EFFECTIVE TECHNICAL WRITING				9
Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee						
UNIT - IV		NATURE OF INTELLECTUAL PROPERTY				9
Patents, Designs, Trade and Copyright, process of Patenting and Development: technological research, innovation, patenting, and development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.						
UNIT - V		PATENT RIGHTS AND IPR				9
Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical indications. Administration of Patents System. New developments in IPR; IPR of Biological Systems, Computer Software etc., Traditional knowledge Case Studies, IPR and IITs.						
Total:45 Hours						
Weightage:						
Continuous Assessment 40%						
End Semester Examinations 60%						

REFERENCE BOOKS:

1.	Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
2.	Ranjit Kumar, 2 nd Edition, "Research Methodology: A Step by Step Guide for beginners"
3.	Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd, 2007
4.	Mayall, "Industrial Design", McGraw Hill, 1992
5.	Niebel, "Product Design", McGraw Hill, 1974
6.	Asimov, "Introduction to Design", Prentice Hall, 1962
7.	Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New Technological Age", 2016.
8.	T. Ramappa, "Intellectual Property Rights Under TO", S. Chand, 2008.

E-RESOURCES:

1.	NPTEL – Research Methodology
2.	WIPO (World Intellectual Property Organization) eLearning Center Protocols
3.	IP India Digital Patent Database Gateways
4.	IEEE Author Center Technical Publication Guidelines

COURSE OUTCOMES (COs) /**At the end of the course, the students will have the ability to****Mapping
POs****Mapping
PSOs**

CO1	Apply research problem identification parameters, data validation rules, and structural scopes to build design approaches.	PO1, PO3	PSO1
CO2	Analyze parametric literature data frameworks, hypothesis thresholds, and ethical compliance to verify field findings.	PO1, PO3	PSO1, PSO2
CO3	Analyze research proposals, document compilation constraints, and evaluation formats required by review bodies.	PO1, PO3	PSO1, PSO2
CO4	Apply specialized global patent databases, search engine tools, indexing portals to map innovations and check novelty.	PO1, PO2, PO3	PSO1, PSO2
CO5	Evaluate global IPR legal scenarios, technology transfer models, and modern software-biological patent rules via an independent seminar study.	PO1, PO2, PO3	PSO1, PSO2

The Course Articulation Matrix (CAM) for defined COs

COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	2	—	2	2	—
CO2	2	—	2	2	2
CO3	2	—	2	2	2
CO4	3	3	3	3	3
CO5	3	3	3	2	3
AVERAGE	2.4	3.0	2.4	2.2	2.5

Activities:

1.	Navigating digital patent databases to execute a complete prior art landscape modeling script.
2.	Compiling an independent research seminar documenting a real-world technological legal infringement case.

Rubrics for evaluation: CO4

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Technical Understanding	20	Comprehensive and accurate analysis of intellectual property rights, criteria, and legal terminology.	Good understanding with minor errors in compiling search queries or data frames.	Basic understanding of global patent classification parameters.
2.	Industrial Data Analysis	20	Excellent interpretation using real multiregional prior-art search indexes and analytics.	Adequate analysis of patent citation trends or claims boundaries.	Limited interpretation of active legal database outputs.
3.	Sustainability & Economic Evaluation	20	Strong techno-economic assessment profiling innovation incentives and market licensing costs.	Moderate evaluation of technology transfer avenues and R&D capital paths.	Limited discussion tracking technological novelty growth bounds.
4.	Presentation & Communication	20	Highly professional and engaging delivery mapping structural infringement timelines.	Clear communication with minor presentation format inconsistencies.	Moderate delivery with weak control of core intellectual property vocabulary.
5.	Report Quality & References	20	Well-organized with quality references extracted from premier legal-tech registries and court records.	Adequate documentation with minor formatting or style index errors.	Basic report structure relying on unverified internet search metrics.
	Total	100			

Rubrics for evaluation: C05					
Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Innovation & Design	20	Highly innovative and optimized strategic enforcement or defense framing configurations.	Good design methodology tracking technology transfer and infringement vectors.	Conventional approach repeating basic unoptimized litigation summaries.
2.	Functionality of Prototype / Model	20	Fully functional and reliable case modeling framework mapping core claims to solutions.	Functional layout displaying minor procedural tracking anomalies.	Partially functional structure experiencing structural definition faults.
3.	Engineering Analysis	20	Strong theoretical validation checking legal arguments against certified trade or patent provisions.	Adequate validation tracking direct validation checks and data lines.	Limited analysis missing core strategic checks or infringement metrics.
4.	Use of Modern Tools	20	Effective use of modern legal informatics tools and international patent databases.	Moderate use of open-source search portals and documentation formats.	Minimal usage of advanced search systems.
5.	Documentation & Demonstration	20	Excellent report and demonstration of prior art landscape models and trend matrices.	Good documentation with tiny chart axis or index labeling gaps.	Basic presentation format missing essential legal-tech structural charts.
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
C01	14	12	—	—	10	2
C02	10	36	—	—	20	2
C03	36	12	—	—	20	2
C04	—	—	40	—	25	3
C05	—	—	—	40	25	3
Total	60	60	40	40	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26TH104	THERMAL ENGINEERING LABORATORY		SEMESTER			I
Prerequisites		Category	ES(PC)	Credits		2
- Engineering Thermodynamics - Fluid Mechanics - Heat Transfer		Hours/ Semester	L	T	P	TH
			0	0	60	60
COURSE OBJECTIVES						
1.	To implement diagnostic procedures to compute performance variables and emission footprints for IC engines utilizing alternative fuels.					
2.	To apply thermodynamic energy balances on cooling towers, flat-plate solar collectors, and heat pump loops.					
3.	To evaluate the fundamental properties of fuels, biomass components, and biogas blends utilizing calorimetric and viscometric instruments.					
4.	To evaluate operational indices of boiler plants and multi-pass heat exchangers under varied fluid loads.					
5.	To execute rigorous testing of aerodynamic fan assemblies and advanced fuel cell stacks to chart performance characteristics.					
LIST OF EXPERIMENTS:						
1.	Performance test on Spark Ignition engine and Compression Ignition using the alternate fuels					
2.	Emission measurement in Spark Ignition and Compression Ignition Engines					
3.	Performance test on variable compression ratio petrol and diesel engines					
4.	Performance test in a refrigeration and heat pump systems					
5.	Performance test in a solar water heater					
6.	Property measurements of fuels and oils					
7.	Direct and diffused solar radiation measurements					
8.	Performance study on Boiler					
9.	Performance test on parallel and counter flow Heat Exchangers					
10.	Performance test on fan					
11.	Performance test on Fuel Cell Systems					
Total:60 Hours						
LIST OF EQUIPMENT						
1.	Single cylinder / multi cylinder Automotive Engine with data acquisition system					
2.	Flue gas analyzer					
3.	Smoke meter					
4.	Single cylinder variable Compression ratio petrol engine					
5.	Single cylinder variable Compression ratio Diesel engine					
6.	Refrigeration cum Heat Pump test rig					

7.	100 LPD Solar flat plate water heater test rig
8.	Pyranometer
9.	Redwood / Saybolt viscometer
10.	Bomb calorimeter apparatus
11.	Gas colorimeter
12.	Cloud & Pour point apparatus
13.	Non-IBR Boiler test rig
14.	Parallel flow / Counter flow Heat exchanger test rig
15.	Fan test rig

Weightage:

Observation & Record 60%

Activities/Internal Test 40%

COURSE OUTCOMES (COs) / At the end of the course, the students will have the ability to		Mapping POs	Mapping PSOs
CO1	Apply engine diagnostic parameters and emission analyzer data to determine alternate fuel performance.	PO1, PO3	PSO1
CO2	Analyze convective variables, psychrometric fields, and refrigeration heat coefficients across steady system loops.	PO1, PO3	PSO1
CO3	Analyze biomass calorific criteria, fluid viscosity bounds, and solar radiation profiles.	PO1, PO3	PSO1
CO4	Apply specialized thermal analysis tool engines to model heat exchanger performance arrays.	PO1, PO2, PO3	PSO1, PSO2
CO5	Evaluate aerodynamic fan curve distributions and electro-chemical fuel cell conversion characteristics via an independent lab project study.	PO1, PO2, PO3	PSO1, PSO2

The Course Articulation Matrix (CAM) for defined COs

COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	2	—	2	2	—
CO2	2	—	2	2	—
CO3	2	—	2	2	—
CO4	2	2	2	2	2
CO5	2	2	2	2	2
AVERAGE	2.0	2.0	2.0	2.0	2.0

Activities:

1. Model and analyze heat exchanger performance characteristics using thermal software.
2. Independent laboratory project study evaluating aerodynamic fan curves and fuel cell stacks.

The Internal Assessment Matrix (IAM) for the defined COs:

CO	Laboratory component		Percentage allocation	Mapping Strength
	Evaluation of Student Work, Observation of Record and Model Test	Activities		
CO1	20	20	20	2
CO2	20	20	20	2
CO3	20	20	20	2
CO4	20	20	20	2
CO5	20	20	20	2
Total	100	100	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26TH105		TECHNICAL SEMINAR		SEMESTER			I
Prerequisites			Category	SD	Credits		1
- Technical writing skill - Presentation skill			Hours/ Semester	L	T	P	TH
				0	0	30	30
COURSE OBJECTIVES							
1.	To develop student autonomy for identifying and researching contemporary thermal engineering breakthroughs and engineering issues.						
2.	To build literature synthesis techniques by interrogating high-impact research archives and peer-reviewed journal indices.						
3.	To compile formal technical seminar documents in exact accordance with designated departmental writing criteria.						
4.	To apply modern visual presentation utilities, animation tools, layout software to map complex thermal processes clearly.						
5.	To execute professional presentation deliveries while managing intense technical review panels confidently.						
GUIDELINES							
1	The student is expected to present a seminar in one of the current topics in the field of Thermal Engineering related issues / technology.						
2	The seminar shall be of 30 minutes duration and give presentation to the Seminar Assessment Committee (SAC).						
3	A faculty guide is to be allotted and he / she will guide and monitor the progress of the student and maintain attendance also.						
4	In a session of two periods per week, 4 students are expected to present the seminar.						
5	Students are encouraged to use various teaching aids such as power point presentation and demonstrative models.						
6	Students are required to prepare a seminar report in the prescribed format given by the Department.						
Total:30 Hours							
Weightage: Continuous Assessment 100%							
COURSE OUTCOMES (COs) / At the end of the course, the students will have the ability to				Mapping POs		Mapping PSOs	
CO1	Apply engineering literature searches to identify and select contemporary topics relevant to thermal systems.			PO1, PO3		PSO1	
CO2	Analyze peer-reviewed research papers to synthesize data maps and summarize technical arguments.			PO1, PO3		PSO1, PSO2	
CO3	Analyze structural writing formats and citation rules to generate professional research reports.			PO1, PO3		PSO1, PSO2	
CO4	Apply modern presentation software, digital vector tools, and animation layout suites to structure technical seminar visuals.			PO1, PO2, PO3		PSO1, PSO2	
CO5	Evaluate thermal performance data, research limitations, and system designs before a review panel.			PO1, PO2, PO3		PSO1, PSO2	

The Course Articulation Matrix (CAM) for defined COs

COs / POs	PO1	PO2	PO3	PS01	PS02
CO1	2	—	2	2	—
CO2	2	—	2	2	2
CO3	2	—	2	2	2
CO4	3	3	3	3	3
CO5	3	3	3	2	3
AVERAGE	2.4	3.0	2.4	2.2	2.5

Activities:

1. Create and organize effective technical seminar visuals and presentation materials using modern software.
2. Present thermal performance data, research findings, and study limitations before the Seminar Assessment Committee.

Rubrics for evaluation: CO4

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Technical Understanding	20	Comprehensive and accurate analysis of presentation flow and slide structures.	Good understanding with minor slide spacing errors.	Basic understanding of presentation layout formatting.
2.	Industrial Data Analysis	20	Excellent interpretation of experimental data graphs and trend visualization charts.	Adequate data analysis with minor visual caption flaws.	Limited interpretation of extracted engineering ranges.
3.	Sustainability & Economic Evaluation	20	Strong techno-economic assessment of life-cycle attributes and modern technical impacts.	Moderate evaluation of environmental and sustainability factors.	Limited discussion on ecological footprints or target limits.
4.	Presentation & Communication	20	Highly professional and engaging delivery utilizing original block sketches and systems.	Clear communication with minor slide transition formatting issues.	Moderate delivery showing weak text and visual template control.
5.	Report Quality & References	20	Well-organized with quality references explicitly aligned to presentation slides.	Adequate documentation with minor reference formatting gaps.	Basic report structure lacking critical reference items.
	Total	100			

Rubrics for evaluation: C05

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Innovation & Design	20	Highly innovative and optimized visual infographics and template layouts.	Good design methodology with minor structural chart errors.	Conventional approach using copied low-resolution graphic captures.
2.	Functionality of Prototype	20	Fully functional and reliable presentation progression tracking complex system physics.	Functional slide setup experiencing minor visual timeline indexing gaps.	Partially functional structure displaying cluttered frames.
3.	Engineering Analysis	20	Strong theoretical and analytical validation using premier high-impact peer journals.	Adequate validation tracking basic empirical field data trends correctly.	Limited analysis missing core technical checks or verification indicators.
4.	Use of Modern Tools	20	Effective use of modern presentation tools, animation layout suites, and formula blocks.	Moderate use of digital design packages and standard vector toolkits.	Minimal usage of modern visual design applications.
5.	Documentation & Demonstration	20	Excellent report compilation and flawless oral slide defense before the panel.	Good record description handling direct panel questions correctly.	Fragmented data presentation with poor technical vocabulary control.
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

CO	SAC Review I	SAC Review II	Activity I	Activity II	Percentage allocation	Mapping Strength
CO1	12	14	—	—	10	2
CO2	12	36	—	—	20	2
CO3	36	10	—	—	20	2
CO4	—	—	40	—	25	3
CO5	—	—	—	40	25	3
Total	60	60	40	40	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26TH201	HYDROGEN AND FUEL CELL TECHNOLOGIES		SEMESTER			II
Prerequisites		Category	ES(PC)	Credits		3
- Engineering Thermodynamics - Heat Transfer - Basic Chemistry		Hours/ Semester	L	T	P	TH
			45	0	0	45
COURSE OBJECTIVES						
1.	To familiarize the hydrogen production techniques.					
2.	To impart knowledge on hydrogen storage techniques and applications.					
3.	To understand the fundamentals, operation and thermodynamics of fuel cells.					
4.	To familiarize various types of fuel cells along with their merits and demerits.					
5.	To create awareness on economic and environmental aspects of hydrogen and fuel cell technologies.					
UNIT - I	HYDROGEN BASICS AND PRODUCTION TECHNIQUES					9
Hydrogen physical and chemical properties, salient characteristics. Production of hydrogen through steam reforming, water electrolysis, gasification and woody biomass conversion, biological hydrogen production, photo dissociation and direct thermal or catalytic splitting of water.						
UNIT - II	HYDROGEN STORAGE AND APPLICATIONS					9
Hydrogen storage options – compressed gas, liquid hydrogen, hydride and chemical storage - comparisons. Safety and management of hydrogen. Applications of hydrogen.						
UNIT - III	FUEL CELLS					9
History, principle, working, thermodynamics and kinetics of fuel cell process, performance evaluation of fuel cell and comparison on battery V's fuel cell.						
UNIT - IV	FUEL CELL TYPES					9
Types of fuel cells – AFC, PAFC, SOFC, MCFC, DMFC and PEMFC. Relative merits and demerits.						
UNIT - V	APPLICATION OF FUEL CELL AND ECONOMICS					9
Fuel cell usage for domestic power systems, large scale power generation, automobile and space applications. Economic and environmental analysis on usage of hydrogen and fuel cell. Future trends in fuel cells.						
Total: 45 Hours						
Weightage:						
Continuous Assessment 40%						
End Semester Examinations 60%						

REFERENCE BOOKS:

1.	Viswanathan B. and Aulice Scibioh M., Fuel Cells – Principles and Applications, Universities Press, 2006.
2.	Rebecca L. and Busby, Hydrogen and Fuel Cells: A Comprehensive Guide, Penn Well Corporation, Oklahoma, 2005.
3.	Bent Sorensen, Hydrogen and Fuel Cells: Emerging Technologies and Applications, Elsevier, UK, 2005.
4.	Kordesch K. and G. Simader, Fuel Cell and Their Applications, Wiley-VCH, Germany, 1996.
5.	Hart A.B. and G.J. Womack, Fuel Cells: Theory and Application, Prentice Hall, London, 1989.

E-RESOURCES:

1.	NPTEL – Hydrogen Energy Systems
2.	US Department of Energy – Fuel Cell Technologies Office
3.	IEA Hydrogen Technology Reports
4.	ScienceDirect – Fuel Cell Engineering Resources
5.	Hydrogen Energy Research Databases

COURSE OUTCOMES (COs) /**At the end of the course, the students will have the ability to****Mapping
POs****Mapping
PSOs**

CO1	Apply hydrogen production principles and analyze hydrogen properties.	PO1, PO3	PSO1
CO2	Analyze hydrogen storage systems and safety mechanisms.	PO1, PO3	PSO1
CO3	Evaluate thermodynamics and kinetics of fuel cell systems.	PO1, PO3	PSO1
CO4	Compare various fuel cell technologies for engineering applications.	PO1, PO2, PO3	PSO1, PSO2
CO5	Investigate techno-economic and environmental aspects of hydrogen energy systems through case studies and technical reports.	PO1, PO2, PO3	PSO1, PSO2

The Course Articulation Matrix (CAM) for defined COs

COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	2	—	3	3	—
CO2	3	—	3	3	—
CO3	3	—	3	3	—
CO4	3	2	3	2	3
CO5	3	3	3	2	3
AVERAGE	2.8	2.5	3.0	2.6	3.0

Activities:					
1.	Comparative analysis of hydrogen production methods.				
2.	Simulation study on hydrogen storage and transportation systems.				
Rubrics for evaluation: CO4					
Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Understanding of Fuel Cell Technologies	20	Excellent understanding of different fuel cell systems and their applications.	Good conceptual understanding.	Weak understanding of fuel cell technologies.
2.	Thermodynamic and Performance Analysis	25	Comprehensive analysis with accurate calculations and performance evaluation.	Minor analytical errors.	Weak analytical approach.
3.	Technical Comparison & Evaluation	25	Strong comparison of fuel cell systems with justified engineering reasoning.	Adequate comparison performed.	Poor comparative analysis.
4.	Industrial Relevance & Sustainability	15	Strong discussion on energy efficiency and environmental impact.	Moderate sustainability discussion.	Very limited sustainability analysis.
5.	Technical Documentation & Presentation	15	Excellent report structure with graphs, charts and technical clarity.	Moderately organized report.	Poorly documented work.
	Total	100			
Rubrics for evaluation: CO5					
Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Hydrogen Economy & Sustainability Concepts	20	Excellent understanding of hydrogen economy and sustainable energy systems.	Good conceptual clarity.	Weak understanding of sustainability concepts.
2.	Literature Review & Technical References	25	Uses high-quality journals and hydrogen energy resources.	Adequate references used.	Limited technical references.
3.	Techno-Economic Analysis	20	Comprehensive economic and environmental evaluation.	Moderate evaluation.	Weak techno-economic analysis.

4.	Industrial Applications & Future Scope	15	Strong industrial relevance and future technology discussion.	Moderate industrial discussion.	Poor industrial linkage.
5.	Technical Communication & Defense	20	Excellent presentation and technical defense.	Adequate communication skills.	Weak technical communication.
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

COs	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
CO1	12	14	–	–	10	2
CO2	12	36	–	–	20	2
CO3	36	10	–	–	20	2
CO4	–	–	40	–	25	3
CO5	–	–	–	40	25	3
Total	60	60	40	40	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26TH202	COMPUTATIONAL FLUID DYNAMICS FOR THERMAL SYSTEMS			SEMESTER		II
Prerequisites			Category	ES(PC)	Credits	3
- Fluid Mechanics - Heat Transfer - Numerical Methods			Hours/ Semester	L	T	P
				45	0	0
TH						
45						
COURSE OBJECTIVES						
1.	To introduce numerical analysis for heat transfer, fluid flow and combustion problems.					
2.	To understand finite volume methods for solving steady and unsteady diffusion problems.					
3.	To solve one-dimensional convection-diffusion problems using numerical techniques.					
4.	To discretize and solve incompressible flow problems using SIMPLE and related algorithms.					
5.	To model and analyze turbulent flow problems.					
UNIT - I						
GOVERNING DIFFERENTIAL EQUATIONS AND DISCRETISATION TECHNIQUES			9			
Basics of heat transfer and fluid flow. Mathematical description of fluid flow and heat transfer. Conservation of mass, momentum, energy and chemical species. Classification of partial differential equations. Initial and boundary conditions. Discretization techniques using finite difference methods, Taylor's series, uniform and non-uniform grids, numerical errors and grid independence test.						
UNIT - II			9			
DIFFUSION PROCESSES: FINITE VOLUME METHOD			9			
Steady one-dimensional diffusion, two- and three-dimensional steady state diffusion problems. Discretization of unsteady diffusion problems using Explicit, Implicit and Crank-Nicolson's schemes. Stability of schemes.						
UNIT - III			9			
CONVECTION-DIFFUSION PROCESSES: FINITE VOLUME METHOD			9			
One-dimensional convection-diffusion problem, central difference scheme, upwind scheme, hybrid and power law discretization techniques and QUICK scheme.						
UNIT - IV			9			
FLOW PROCESSES: FINITE VOLUME METHOD			9			
Discretization of incompressible flow equations. Pressure based algorithms including SIMPLE, SIMPLER and PISO algorithms.						
UNIT - V			9			
TURBULENCE AND ITS MODELING			9			
Description of turbulent flow, free turbulent flows, flat plate boundary layer and pipe flow. Algebraic models, one equation model, k-ε and k-ω models. Standard and high and low Reynolds number models.						
Total:45 Hours						
Weightage:						
Continuous Assessment 40%						
End Semester Examinations 60%						

REFERENCE BOOKS:

1.	Anderson D.A., Tannehill J.C. and Pletcher R.H., Computational Fluid Mechanics and Heat Transfer, Hemisphere Publishing Corporation, New York, USA, 2012.
2.	Bose T.K., Numerical Fluid Dynamics, Narosa Publishing House, 1997.
3.	Fletcher C.A.J., Computational Techniques for Fluid Dynamics 1: Fundamental and General Techniques, Springer-Verlag, 1991.
4.	Fletcher C.A.J., Computational Techniques for Fluid Dynamics 2: Specific Techniques for Different Flow Categories, Springer-Verlag, 1988.
5.	Muralidhar K. and Sundararajan T., Computational Fluid Flow and Heat Transfer, Narosa Publishing House, New Delhi, 2003.

E-RESOURCES:

1.	NPTEL – Computational Fluid Dynamics
2.	NPTEL – Numerical Methods for Engineers
3.	MIT OpenCourseWare – CFD and Fluid Mechanics
4.	ANSYS Fluent Learning Resources
5.	NASA CFD Verification and Validation Resources

COURSE OUTCOMES (COs) /**At the end of the course, the students will have the ability to****Mapping
POs****Mapping
PSOs**

CO1	Apply governing equations and discretization techniques in CFD simulations.	PO1, PO3	PSO1
CO2	Analyze diffusion problems using finite volume numerical methods.	PO1, PO3	PSO1
CO3	Evaluate convection-diffusion problems using suitable numerical schemes.	PO1, PO3	PSO1
CO4	Develop CFD simulation models for incompressible flow problems.	PO1, PO2, PO3	PSO1, PSO2
CO5	Investigate turbulence models and industrial CFD applications through simulation studies and technical reports.	PO1, PO2, PO3	PSO1, PSO2

The Course Articulation Matrix (CAM) for defined COs

COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	2	—	3	3	—
CO2	3	—	3	3	—
CO3	3	—	3	3	—
CO4	3	2	3	2	3
CO5	3	3	3	2	3
AVERAGE	2.8	2.5	3.0	2.6	3.0

Activities:	
1.	Comparative analysis of hydrogen production methods.
2.	Simulation study on hydrogen storage and transportation systems.

Rubrics for evaluation: CO4

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Problem Definition & Boundary Conditions	20	Clearly defines geometry, flow assumptions and boundary conditions.	Defines problem with minor missing assumptions.	Problem definition incomplete or unclear.
2.	Numerical Formulation & Discretization	25	Correct implementation of FDM/FVM schemes with proper discretization.	Minor numerical formulation errors.	Incorrect discretization or governing equations.
3.	Mesh Generation & Solver Implementation	25	Appropriate mesh, convergence achieved and solver setup validated.	Minor meshing or convergence issues.	Poor mesh quality or unstable solution.
4.	Result Interpretation & Validation	15	Results validated with theory/literature and interpreted correctly.	Basic interpretation with limited validation.	Weak interpretation and no validation.
5.	Technical Documentation & Presentation	15	Professional report with CFD contours, graphs and discussions.	Moderately organized report.	Poorly documented work.
	Total	100			

Rubrics for evaluation: CO5

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Understanding of Turbulence Models	20	Excellent understanding of turbulence physics and models.	Good conceptual understanding.	Weak understanding of turbulence modelling.
2.	Literature Review & Technical References	25	Uses high-quality journals and CFD resources.	Adequate reference support.	Limited or weak references.
3.	Industrial CFD Analysis	20	Comprehensive industrial CFD evaluation and analysis.	Moderate analysis.	Very limited industrial relevance.

4.	Sustainability & Optimization	15	Discusses energy efficiency and optimization effectively.	Basic sustainability discussion.	No meaningful optimization discussion.
5.	Technical Communication & Defense	20	Excellent presentation and technical defense.	Adequate communication skills.	Poor technical communication.
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

COs	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
C01	14	12	—	—	10	2
C02	12	36	—	—	20	2
C03	36	12	—	—	20	2
C04	—	—	40	—	25	3
C05	—	—	—	40	25	3
Total	60	60	40	40	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

E-RESOURCES:

1. NPTEL – Industrial Instrumentation
2. NPTEL – Sensors and Transducers
3. MIT OpenCourseWare – Measurement Systems
4. National Instruments Learning Resources
5. OMEGA Engineering Technical Resources

COURSE OUTCOMES (COs) /**At the end of the course, the students will have the ability to****Mapping
POs****Mapping
PSOs****CO1**

Apply concepts of measurement systems and analyze measurement errors.

PO1,
PO3

PSO1

CO2

Analyze sensor interfacing and data acquisition systems for thermal engineering applications.

PO1,
PO3

PSO1

CO3

Evaluate instruments used for thermo-physical measurements.

PO1,
PO3

PSO1

CO4

Develop advanced thermal measurement and instrumentation techniques for engineering applications.

PO1,
PO2,
PO3PSO1,
PSO2**CO5**

Investigate gas analysis systems and industrial instrumentation through technical case studies and reports.

PO1,
PO2,
PO3PSO1,
PSO2**The Course Articulation Matrix (CAM) for defined COs**

COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	2	—	3	3	—
CO2	3	—	3	3	—
CO3	3	—	3	3	—
CO4	3	2	3	2	3
CO5	3	3	3	2	3
AVERAGE	2.8	2.5	3.0	2.6	3.0

Activities:

1. Calibration and uncertainty analysis of thermal measurement systems.
2. Sensor interfacing and data acquisition experiments.

Rubrics for evaluation: CO4

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Instrumentation Problem Definition	20	Clearly defines instrumentation objectives, variables and measurement constraints.	Adequate instrumentation definition.	Weak problem definition.

2.	Sensor Selection & Measurement Techniques	25	Appropriate sensor selection with accurate measurement methodology.	Minor issues in sensor or method selection.	Incorrect measurement approach.
3.	Data Acquisition & Experimental Setup	25	Excellent setup with proper calibration and signal acquisition.	Minor setup/calibration issues.	Weak experimental arrangement.
4.	Result Interpretation & Validation	15	Results validated and interpreted correctly.	Moderate analysis performed.	Poor interpretation and validation.
5.	Technical Documentation & Presentation	15	Professional report with graphs, calibration plots and analysis.	Moderately organized report.	Poorly documented work.
	Total	100			

Rubrics for evaluation: CO5

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Understanding of Gas Analysis Systems	20	Excellent understanding of gas analyzers and industrial instrumentation.	Good conceptual understanding.	Weak understanding of gas analysis systems.
2.	Literature Review & Technical References	25	Uses high-quality instrumentation journals and standards.	Adequate technical references.	Limited references used.
3.	Industrial Instrumentation Analysis	20	Comprehensive industrial measurement and instrumentation analysis.	Moderate analysis.	Weak industrial relevance.
4.	Environmental & Safety Considerations	15	Strong discussion on environmental monitoring and safety systems.	Moderate discussion.	Poor environmental/safety analysis.
5.	Technical Communication & Defense	20	Excellent presentation and technical defense.	Adequate communication skills.	Weak technical communication.
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

COs	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
CO1	14	14	–	–	10	2
CO2	12	36	–	–	20	2
CO3	34	10	–	–	20	2
CO4	–	–	40	–	25	3
CO5	–	–	–	40	25	3
Total	60	60	40	40	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26TH204	DESIGN OF HEAT EXCHANGERS			SEMESTER		II	
Prerequisites			Category	ES(PC)	Credits	3	
- Advanced Heat Transfer - Thermodynamics - Fluid Mechanics			Hours/ Semester	L	T	P	TH
				45	0	0	45
COURSE OBJECTIVES							
1.	To provide knowledge on the fundamentals and classification of heat exchangers.						
2.	To impart knowledge on thermal and hydraulic design methods of heat exchangers.						
3.	To provide insights into compact and extended surface heat exchangers.						
4.	To develop the ability to analyze phase change heat exchangers and thermal systems.						
5.	To expose students to modern heat exchanger design practices and industrial applications.						
UNIT - I		FUNDAMENTALS OF HEAT EXCHANGERS					9
Classification of heat exchangers, heat transfer mechanisms, overall heat transfer coefficient, fouling factors, LMTD method, effectiveness–NTU method, thermal performance analysis.							
UNIT - II		THERMAL DESIGN OF HEAT EXCHANGERS					9
Thermal design of shell and tube heat exchangers, flow arrangements, pressure drop analysis, heat transfer correlations, design standards and optimization techniques.							
UNIT - III		COMPACT AND EXTENDED SURFACE HEAT EXCHANGERS					9
Compat heat exchangers, plate heat exchangers, finned tube heat exchangers, regenerators and recuperators, effectiveness and industrial applications.							
UNIT - IV		PHASE CHANGE HEAT EXCHANGERS					9
Boilers, condensers, evaporators, cooling towers and refrigeration heat exchangers, boiling and condensation heat transfer analysis.							
UNIT - V		INDUSTRIAL APPLICATIONS AND MODERN DESIGN					9
Heat exchanger networks, thermal system integration, CFD analysis in heat exchanger design, energy conservation techniques, industrial case studies and recent advancements.							
Total:45 Hours							
Weightage: Continuous Assessment 40% End Semester Examinations 60%							
REFERENCE BOOKS:							
1.	Kuppan T., Heat Exchanger Design Handbook, CRC Press, 2013.						
2.	Shah R.K. and Sekulic D.P., Fundamentals of Heat Exchanger Design, Wiley, 2003.						
3.	Sadik Kakac and Hongtan Liu, Heat Exchangers: Selection, Rating and Thermal Design, CRC Press, 2002.						
4.	Holman J.P., Heat Transfer, McGraw-Hill Education, 2010.						
5.	Incropera F.P. and DeWitt D.P., Fundamentals of Heat and Mass Transfer, Wiley, 2011.						

E-RESOURCES:					
1.	NPTEL – Heat Transfer				
2.	NPTEL – Heat Exchanger Design				
3.	MIT OpenCourseWare – Thermal Engineering				
4.	ASME Heat Transfer Division Resources				
5.	ANSYS Fluent Tutorials for Heat Exchanger Analysis				
COURSE OUTCOMES (COs) / At the end of the course, the students will have the ability to			Mapping POs	Mapping PSOs	
CO1	Apply heat exchanger fundamentals and thermal analysis methods.		PO1, PO3	PSO1	
CO2	Analyze thermal and hydraulic performance of shell and tube heat exchangers.		PO1, PO3	PSO1	
CO3	Evaluate compact and extended surface heat exchanger systems.		PO1, PO3	PSO1	
CO4	Develop phase change heat exchanger models for engineering applications.		PO1, PO2, PO3	PSO1, PSO2	
CO5	Investigate industrial heat exchanger systems and energy optimization techniques.		PO1, PO2, PO3	PSO1, PSO2	
The Course Articulation Matrix (CAM) for defined COs					
COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	3	—	3	3	—
CO2	3	—	3	3	—
CO3	3	—	3	3	—
CO4	3	2	3	2	3
CO5	3	3	3	2	3
AVERAGE	3.0	2.5	3.0	2.6	3.0
Activities:					
1.	Thermal design calculations for shell and tube heat exchangers.				
2.	Performance evaluation of compact heat exchangers.				

Rubrics for evaluation: C04

Sl. No.	Criterion	Marks	Excellent (14–20)	Good (7–13)	Satisfactory (1–6)
1.	Technical Understanding	20	Comprehensive and accurate definition of thermal design objectives, geometry allocations, fluid routing paths, and system constraints.	Clear baseline setup of multi-pass constraints with minor omissions in detailing secondary parameters.	Erroneous or weak identification of design parameters and system nodes.
2.	Industrial Data Analysis	20	Flawless calculation setups tracking fluid properties, stream variations, shell-side Reynolds numbers, and accurate convective values.	Baseline mathematical analysis tracking primary thermal loops with minor numerical variations.	Poor computational layout showing major sizing calculation steps missing.
3.	Sustainability & Economic Evaluation	20	Highly professional selection of shell configuration configurations with solid structural and technical justification.	Satisfactory equipment selection matching basic parameters but lacking robust engineering support.	Incorrect or unguided material selection with missing justification parameters.
4.	Presentation & Communication	20	Exhaustive performance evaluation profiling fluid velocities, multi-tube heat fluxes, and overall system limits.	Fair analysis mapping direct temperature profiles without thorough parameter verification checking loops.	Weak or flawed analysis failing to evaluate baseline operational conditions.
5.	Report Quality & References	20	Professional technical report compilation displaying clean engineering schematics, dimensional drawings, and reference standards.	Moderately organized brief layout containing secondary data labeling oversights.	Disorganized document missing essential verification data blocks and drawings.
	Total	100			

Rubrics for evaluation: C05

Sl. No.	Criterion	Marks	Excellent (14–20)	Good (7–13)	Satisfactory (1–6)
1.	Innovation & Design	20	Outstanding formulation of compact core topologies, extended fin variables, and boundary flow arrangements.	Rational setup of surface geometries with sparse optimization constraints.	Conventional or unguided design loop setup missing baseline specifications.

2.	Functionality of Model	20	Fully functional and highly reliable execution of effectiveness–NTU mathematical scripting models or calculation tool macros.	Calculation script loops run with minor property block initialization anomalies or speed lags.	Non-converging calculation loops resulting from fundamentally flawed matrix indices.
3.	Engineering Analysis	20	Exceptional comparative validation tracking modeled data trends directly against standard industrial and TEMA specifications.	Baseline verification checking core heat fluxes without comprehensive parameter trend lines.	Flawed output readings missing verification loops or support data plots.
4.	Use of Modern Tools	20	Effective use of advanced engineering equation solver software codes and compact design macro workbooks.	Standard configuration of simulation layout sheets and general interface screens.	Minimal or unguided utilization of contemporary engineering tool systems.
5.	Documentation & Demonstration	20	Highly clear summary documentation highlighting concise pressure drops, compact optimization plots, and professional layouts.	Well-organized summary structure with tiny scaling errors on final trend charts.	Disorganized progress documents with missing structural formulas and plots.
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
CO1	14	14	—	—	10	2
CO2	10	36	—	—	20	2
CO3	36	10	—	—	20	2
CO4	—	—	40	—	25	3
CO5	—	—	—	40	25	3
Total	60	60	40	40	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26TH205	ANALYSIS & SIMULATION LABORATORY			SEMESTER		II	
Prerequisites			Category	ES(PC)	Credits		2
- Thermal Engineering Fundamentals - Numerical Methods - Thermal Systems			Hours/ Semester	L	T	P	TH
				0	0	60	60
COURSE OBJECTIVES							
1.	To conduct simulation and analysis related to heat transfer and thermal systems using modern engineering software.						
2.	To analyze conduction, convection and radiation heat transfer problems using computational approaches.						
3.	To evaluate thermal system performance through simulation-based engineering methods.						
4.	To develop problem solving and technical reporting skills through laboratory activities.						
5.	To provide a platform to learn and get familiar with the modelling, analysis and simulation of thermal engineering systems.						
LIST OF EXPERIMENTS:							
1.	Numerical and simulation analysis of steady state heat conduction problems.						
2.	Convection heat transfer analysis – Velocity boundary layer.						
3.	Convection heat transfer analysis – Internal flow systems.						
4.	Radiation heat transfer analysis – Emissivity determination.						
5.	Simulation and analysis of critical radius of insulation.						
6.	Lumped heat transfer system analysis.						
7.	Heat exchanger analysis using NTU method.						
8.	Heat exchanger analysis using LMTD method.						
9.	Performance study on different types of solar flat plate collectors.						
10.	Performance study on stand-alone solar PV panel.						
11.	Performance study of solar PV panel including shading effects.						
Total:60 Hours							
LIST OF EQUIPMENT							
1.	High performance computing systems						
2.	ANSYS Fluent / CFD Software						
3.	MATLAB / Python numerical tools						
4.	OpenFOAM simulation environment						
5.	Data visualization and plotting software						
6.	Thermal analysis workstation						
Weightage: Observation & Record 60% Activities/Internal Test 40%							

REFERENCE BOOKS:

1.	Theodore L. Bergman, Adrienne S. Lavine, Frank P. Incropera and David P. DeWitt, <i>Fundamentals of Heat and Mass Transfer</i> , Wiley 8th Edition
2.	Frank P. Incropera, David P. DeWitt, Theodore L. Bergman and Adrienne S. Lavine, Incropera's Principles of Heat and Mass Transfer, Wiley 8th Edition, 2018
3.	John H. Lienhard IV and John H. Lienhard V, A Heat Transfer Textbook, 6th Edition.
4.	H.K. Versteeg and W. Malalasekera, An Introduction to Computational Fluid Dynamics: The Finite Volume Method, 2nd Edition.
5.	J.H. Ferziger, M. Perić and R.L. Street, Computational Methods for Fluid Dynamics, 4th edition.

E-RESOURCES:

1.	https://ocw.mit.edu/courses/2-051-introduction-to-heat-transfer-fall-2015/pages/syllabus
2.	https://nptel.ac.in/courses/112106186
3.	https://ansys.synopsys.com/products/fluids/ansys-fluent/resources
4.	https://www.openfoam.com/documentation/tutorial-guide/1-introduction
5.	https://ansys.synopsys.com/en-in/academic/learning-resources

COURSE OUTCOMES (COs) /**At the end of the course, the students will have the ability to****Mapping
POs****Mapping
PSOs**

CO1	Develop simulation and analysis models for steady state heat conduction, convection and radiation problems.	PO1, PO3	PSO1, PSO2
CO2	Analyze thermal systems involving insulation and lumped heat transfer methods.	PO1, PO3	PSO1
CO3	Evaluate the performance of heat exchangers using NTU and LMTD methods.	PO1, PO3	PSO1
CO4	Develop simulation-based solutions for solar thermal and photovoltaic systems.	PO1, PO2, PO3	PSO1, PSO2
CO5	Interpret simulation results and prepare technical reports for thermal engineering applications.	PO1, PO2, PO3	PSO1, PSO2

The Course Articulation Matrix (CAM) for defined COs

COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	2	—	2	2	2
CO2	2	—	2	2	—
CO3	2	—	2	2	—
CO4	2	2	2	2	2
CO5	2	2	2	2	2
AVERAGE	2.0	2.0	2.0	2.0	2.0

Activities:

1.	Simulation and performance evaluation of thermal systems using modern engineering software tools.
2.	Experimental analysis and technical presentation based on heat transfer and thermal engineering applications.

Rubrics for evaluation: CO4

Sl. No	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1	Solar Thermal/PV System Modelling	20	Correct model with appropriate system components and parameters	Minor modelling issues	Major modelling errors
2	Input Parameters and Operating Conditions	20	Appropriate and accurate input and operating conditions	Minor errors in input parameters	Incorrect or incomplete inputs
3	Simulation and Performance Analysis	20	Accurate simulation with comprehensive performance evaluation	Adequate simulation with minor issues	Incomplete or incorrect simulation
4	Effect of Operating Conditions	20	Clearly evaluates effects of irradiation, temperature and shading	Partial evaluation with minor errors	Poor or incomplete evaluation
5	Result Presentation and Report	20	Professional graphs, comparison and technical documentation	Adequate presentation and documentation	Poor presentation or documentation
	Total	100			

Rubrics for evaluation: CO5

Sl. No	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1	Interpretation of Simulation Results	20	Correct and comprehensive interpretation with engineering justification	Adequate interpretation with minor errors	Limited or incorrect interpretation
2	Graphical Representation and Data Visualization	20	Accurate, clear and meaningful graphs/plots	Adequate graphs with minor issues	Poor or incomplete graphs
3	Comparison and Error Analysis	20	Accurate comparison with appropriate error analysis	Basic comparison with minor errors	Incomplete or incorrect comparison
4	Technical Discussion and Conclusion	20	Logical discussion with valid engineering conclusions	Adequate discussion and conclusions	Poor or unsupported conclusions
5	Technical Report and Presentation	20	Professional, well-organized report and effective presentation	Adequate report and presentation	Poor documentation and presentation
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

CO	Laboratory component		Percentage allocation	Mapping Strength
	Evaluation of Student Work, Observation of Record and Model Test	Activities		
CO1	20	20	20	2
CO2	20	20	20	2
CO3	20	20	20	2
CO4	20	20	20	2
CO5	20	20	20	2
Total	100	100	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26TH206	APPLIED THERMAL ENGINEERING LABORATORY		SEMESTER			II
Prerequisites		Category	ES(PC)	Credits		2
- Engineering Thermodynamics - Heat Transfer - Fluid Mechanics - Basics of Instrumentation and Measurement Techniques		Hours/ Semester	L	T	P	TH
			0	0	60	60
COURSE OBJECTIVES						
1.	To conduct experiments on thermal engineering systems and instrumentation techniques.					
2.	To analyze thermal systems using experimental methods and performance evaluation procedures.					
3.	To evaluate thermal and fluid flow characteristics using modern laboratory equipment and testing methods.					
4.	To develop practical skills in thermal measurements, renewable energy systems, and energy conversion devices.					
5.	To enhance technical report writing, interpretation of experimental data, and presentation skills through laboratory activities.					
LIST OF EXPERIMENTS:						
1.	Calibration of Temperature Transducers (Thermocouple, RTD & Thermistors).					
2.	Calibration of Pressure Transducers.					
3.	Determination of Fluid and Thermal Transfer Properties of Liquid Fuels / Heat Transfer Fluids.					
4.	Experimental Studies on Pool Boiling of Water using Flow Visualization Technique.					
5.	Experimental Studies on Fluidization of Solid Fuels.					
6.	Studies on Absorption Refrigeration System.					
7.	Performance Testing of Solar Water Heater.					
8.	Performance Evaluation of Engine using Biodiesel.					
9.	Experimental Study on Heat Pipe Solar Collector.					
						Total: 60 Hours
LIST OF EQUIPMENT						
1.	Temperature Transducer Calibration Setup					
2.	Pressure Transducer Calibration Setup					
3.	Thermal Properties Measurement Apparatus					
4.	Pool Boiling and Flow Visualization Setup					
5.	Fluidization Test Rig					
6.	Absorption Refrigeration Test Setup					
7.	Solar Water Heating System					
8.	IC Engine Test Rig with Biodiesel Arrangement					
9.	Heat Pipe Solar Collector Setup					
Weightage: Observation & Record 60% Activities/Internal Test 40%						

COURSE OUTCOMES (COs) / At the end of the course, the students will have the ability to		Mapping POs	Mapping PSOs
CO1	Apply thermal engineering principles and instrumentation techniques for experimental analysis of thermal systems.	PO1, PO3	PSO1
CO2	Evaluate the performance characteristics of refrigeration, renewable energy, and thermal energy conversion systems.	PO1, PO3	PSO1
CO3	Analyze thermal and fluid flow behavior using experimental techniques and performance calculations.	PO1, PO3	PSO1
CO4	Develop practical skills in thermal measurements, calibration procedures, and energy analysis.	PO1, PO2, PO3	PSO1, PSO2
CO5	Prepare technical reports and interpret experimental data related to advanced thermal engineering applications	PO1, PO2, PO3	PSO1, PSO2

The Course Articulation Matrix (CAM) for defined COs

COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	2	—	2	2	—
CO2	2	—	2	2	—
CO3	2	—	2	2	—
CO4	2	2	2	2	2
CO5	2	2	2	2	2
AVERAGE	2.0	2.0	2.0	2.0	2.0

Activities:

1.	Experimental analysis and performance evaluation of thermal engineering systems using laboratory instruments and renewable energy setups.
2.	Technical presentation and report preparation based on thermal engineering laboratory experiments and industrial applications.

Rubrics for evaluation: CO4

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Thermal Measurement and Instrument Handling	20	Accurate measurement and proper handling of instruments	Minor measurement or handling errors	Major measurement errors or improper handling
2.	Calibration Procedure	20	Correct calibration procedure with accurate observations	Calibration performed with minor errors	Incorrect or incomplete calibration
3.	Experimental Data Collection	20	Systematic and accurate data collection	Adequate data collection with minor omissions	Incomplete or inaccurate data collection
4.	Energy Analysis and Performance Calculation	20	Accurate calculations and effective interpretation of energy/performance parameters	Minor calculation or interpretation errors	Major calculation errors or poor interpretation

5.	Practical Skills and Safety	20	Excellent practical skills with proper safety practices	Good practical skills with minor safety lapses	Poor practical skills or inadequate safety practices
	Total	100			

Rubrics for evaluation: CO5

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Technical Report Preparation	20	Complete, well-structured and technically accurate report	Adequate report with minor omissions	Incomplete or poorly structured report
2.	Experimental Data Presentation	20	Accurate tables, graphs and appropriate presentation of data	Adequate data presentation with minor errors	Incomplete or inappropriate data presentation
3.	Data Interpretation and Discussion	20	Clear, logical and technically sound interpretation of results	Reasonable interpretation with minor limitations	Poor or incorrect interpretation of results
4.	Results and Conclusion	20	Results are accurately discussed and conclusions are well supported	Results and conclusions are generally appropriate	Results are unclear or conclusions are unsupported
5.	Technical Presentation and Communication	20	Professional presentation with clear communication and confident responses	Adequate presentation and communication	Poor presentation and limited technical communication
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

COs	Laboratory component		Percentage allocation	Mapping Strength
	Evaluation of Student Work, Observation of Record and Model Test	Activities		
CO1	20	20	20	2
CO2	20	20	20	2
CO3	20	20	20	2
CO4	20	20	20	2
CO5	20	20	20	2
Total	100	100	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26TH301	DISSERTATION PHASE - I		SEMESTER		III	
Prerequisites		Category	SD	Credits		8
- Thermal Engineering fundamentals - CFD and instrumentation - Simulation techniques - Engineering research methodology		Hours/ Semester	L	T	P	TH
			0	0	240	240
COURSE OBJECTIVES						
1.	To build student autonomy for surveying refereed journals and selecting research problems with distinct individual scientific potential.					
2.	To apply technical documentation rules to construct problem statements, literature reviews, and research frameworks.					
3.	To apply modern engineering tool packages, simulation codes, or analytical matrices to configure study benchmarks.					
4.	To evaluate experimental designs, test rig parameters, or numerical convergence steps before review bodies.					
5.	To execute localized testing or baseline audits on engineering components to synthesize valid validation conclusions.					
CONTENTS:						
1.	The Project Work will start in semester III and should preferably be a problem with research potential and should involve scientific research, design, generation/collection and analysis of data, determining solution and must preferably bring out the individual contribution.					
2.	The seminar should be based on the area in which the candidate has undertaken the dissertation work as per the common instructions for all branches of M. E.					
3.	The examination shall consist of the preparation of a report consisting of a detailed problem statement and a literature review.					
4.	The preliminary results (if available) of the problem may also be discussed in the report. The work has to be presented in front of the examiner's panel set by Head and PG coordinator.					
5.	The candidate has to be in regular contact with his guide and the topic of the dissertation must be mutually decided by the guide and student.					
Total:240 Hours						
Weightage: Continuous Assessment 60% End Semester Examinations 40%						

REFERENCE BOOKS:

1. <https://nptel.ac.in/courses/110105091>
2. <https://nptel.ac.in/courses/121106007>

COURSE OUTCOMES (COs) /**At the end of the course, the students will have the ability to****Mapping
POs****Mapping
PSOs**

CO1	Apply index screening rules, referee matrix criteria, and source tracking lines to compile a scholarly survey report.	PO1, PO3	PSO1, PSO2
CO2	Analyze research gaps, testing boundary parameters, and experimental conditions to outline investigative frameworks.	PO1, PO3	PSO1, PSO2
CO3	Analyze modelling setups, solver codes, and computational matrix grids to configure research baselines.	PO1, PO3	PSO1, PSO2
CO4	Apply specialized engineering software engines, fabrication tools, or scripting environments to design experimental test rigs.	PO1, PO2, PO3	PSO1, PSO2
CO5	Evaluate output data trends, baseline calculation errors, and data distributions to state verification conclusions.	PO1, PO2, PO3	PSO1, PSO2

The Course Articulation Matrix (CAM) for defined COs

COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	2	—	2	3	2
CO2	2	—	2	3	2
CO3	2	—	2	3	2
CO4	2	2	2	2	3
CO5	2	2	2	2	3
AVERAGE	2.0	2.0	2.0	2.6	2.4

Activities:

1. Writing localized design scripts or setting up convergence tests for project geometries.
2. Presenting initial findings, literature metrics, and problem descriptions before the review panel.

Rubrics for evaluation: CO4

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Technical Understanding	20	Comprehensive and accurate analysis of geometric parameters and localized design script variables.	Good understanding of meshing arrays or boundary settings with minor technical errors.	Basic understanding of geometry setup constraints and scripts.
2.	Industrial Data Analysis	20	Excellent interpretation using real computational datasets and grid node tracking outputs.	Adequate analysis of localized convergence histories and matrix trends.	Limited interpretation of simulation convergence data or residual plots.

3.	Sustainability & Economic Evaluation	20	Strong techno-economic assessment mapping localized parameters and computational efficiency targets.	Moderate evaluation of processing bounds and structural modeling limits.	Limited discussion tracking validation economies or scale limits.
4.	Presentation & Communication	20	Highly professional and engaging slide delivery displaying explicit 3D grid layouts.	Clear visual presentation layout with minor formatting inconsistencies.	Moderate delivery showing weak control of script debugging vocabulary.
5.	Report Quality & References	20	Well-organized with quality references extracted from premier engineering simulation archives.	Adequate documentation with minor syntax script formatting differences.	Basic report structure omitting essential model convergence check loops.
	Total	100			

Rubrics for evaluation: C05

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Innovation & Design	20	Highly innovative and optimized research problem identification frameworks.	Good design methodology tracking research gap constraints and study variables.	Conventional approach repeating baseline established problem descriptions.
2.	Functionality of Model	20	Fully functional and reliable execution model layout returning true initial findings flawlessly.	Functional model block configuration experiencing minor tracking script delays.	Partially functional structure displaying matrix initialization faults.
3.	Engineering Analysis	20	Strong theoretical validation checking project scopes against exact literature metrics.	Adequate validation tracking basic empirical field lines correctly.	Limited analysis missing continuous validation checking paths.
4.	Use of Modern Tools	20	Effective use of modern engineering simulation engines and layout toolkits.	Moderate use of specialized sizing codes and standard design systems.	Minimal usage of advanced project evaluation tools.
5.	Documentation & Demonstration	20	Excellent report compilation and flawless oral slide defense before the review panel.	Good record summary layout handling basic panel defense questions correctly.	Fragmented data presentation with poor technical vocabulary control.
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

CO	Core Research Activity: Report Documentation & Review I	Technical Assessment Activity: Presentation Viva & Review II	Percentage allocation	Mapping Strength
C01	20	20	20	2
C02	20	20	20	2
C03	20	20	20	2
C04	20	20	20	2
C05	20	20	20	2
Total	100	100	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26TH401	DISSERTATION PHASE - II		SEMESTER			IV
Prerequisites		Category	SD	Credits		14
• Completion of Dissertation Phase – I • Knowledge of Research Methodology and Technical Documentation • Familiarity with simulation, experimentation, and engineering analytical tools • Ability to interpret engineering data and technical literature		Hours/ Semester	L	T	P	TH
			0	0	420	420
COURSE OBJECTIVES						
1.	To develop the ability to execute independent research work through experimentation, modelling, simulation, and analytical validation.					
2.	To train students in interpreting technical data, validating research outcomes, and preparing high-quality dissertation reports.					
3.	To enable students to present and defend research findings effectively before expert review committees.					
4.	To encourage students to evaluate engineering systems considering sustainability, safety, economic feasibility, and practical implementation.					
5.	To enhance professional ethics, technical communication, and lifelong learning skills through dissertation activities.					
CONTENTS:						
1.	The dissertation work initiated during Phase – I shall be continued in Semester IV through experimentation, simulation, fabrication, validation, optimization, and analytical investigations related to the selected research problem.					
2.	The candidate shall collect and analyze experimental or numerical data, evaluate system performance parameters, compare benchmark standards, and derive meaningful engineering conclusions.					
3.	The dissertation shall involve the application of modern engineering tools, computational techniques, statistical methods, and scientific interpretation of research outcomes.					
4.	The student shall prepare and present a comprehensive dissertation report containing problem statement, literature review, methodology, validation studies, results, discussions, conclusions, references, and future scope before the examiner’s panel through reviews and viva voce examinations.					
5.	The candidate shall maintain continuous interaction with the research supervisor, demonstrate individual contribution, and evaluate sustainability, environmental, safety, and techno-economic aspects wherever applicable.					
Total: 420 Hours						
Weightage: Continuous Assessment 60% End Semester Examinations 40%						
REFERENCE BOOKS:						
1.	https://nptel.ac.in/courses/110105091					
2.	https://nptel.ac.in/courses/121106007					

COURSE OUTCOMES (COs) / At the end of the course, the students will have the ability to		Mapping POs	Mapping PSOs
CO1	Analyze experimental data, simulation outputs, and engineering parameters to interpret technical performance trends.	PO1, PO2, PO3	PSO1, PSO2
CO2	Evaluate thermal systems, numerical models, or engineering components using validation procedures and benchmark standards.	PO1, PO2, PO3	PSO1, PSO2
CO3	Design optimized engineering solutions by integrating analytical methods, computational tools, and experimental observations.	PO1, PO2, PO3	PSO1, PSO2
CO4	Formulate comprehensive dissertation reports and technical presentations using professional research documentation standards.	PO1, PO3	PSO1, PSO2
CO5	Evaluate sustainability, safety, environmental, and economic aspects of engineering systems to justify practical implementation.	PO1, PO2, PO3	PSO1, PSO2

The Course Articulation Matrix (CAM) for defined COs

COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	2	2	2	3	2
CO2	2	2	2	3	2
CO3	2	2	2	3	2
CO4	2	–	2	2	3
CO5	2	2	2	2	3
AVERAGE	2.0	2.0	2.0	2.6	2.4

Activities:

1.	Conducting experimentation, simulation studies, optimization analysis, or prototype validation related to the dissertation problem.
2.	Presenting technical findings, performance analysis, validation results, and implementation feasibility before the departmental review committee.

Rubrics for evaluation: CO4

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Research Methodology & Organization	20	Dissertation is systematically organized with clear objectives, methodology, validation flow, and technical coherence.	Adequate organization with minor issues in sequencing or methodology explanation.	Poorly structured report with incomplete methodology and weak technical organization.

2.	Technical Analysis & Interpretation	25	Detailed interpretation of results supported by equations, graphs, validation, and engineering reasoning.	Satisfactory analysis with moderate technical justification and limited validation.	Weak analysis with inadequate interpretation of engineering data.
3.	Engineering Tool Utilization	20	Advanced utilization of simulation software, experimental setups, computational tools, or analytical packages.	Moderate use of engineering tools with minor execution limitations.	Inadequate or improper use of engineering tools and software environments.
4.	Documentation Quality & References	15	Professional formatting with proper technical language, citations, figures, tables, and standard referencing style.	Acceptable formatting with minor citation or documentation inconsistencies.	Poor technical writing with missing references and improper formatting.
5.	Technical Presentation & Viva Voce	20	Excellent presentation delivery with confident responses to technical queries and strong domain knowledge.	Clear presentation with satisfactory responses to examiner questions.	Weak presentation skills and inability to defend technical findings effectively.
	Total	100			

Rubrics for evaluation: CO5

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Sustainability Assessment	20	Comprehensive evaluation of energy efficiency, environmental impact, exergy losses, and sustainability measures.	Basic sustainability discussion with moderate technical assessment.	Minimal or no discussion on sustainability and environmental considerations.
2.	Safety & Reliability Analysis	20	Thorough evaluation of operational safety, reliability parameters, and risk mitigation strategies.	Basic analysis of safety aspects and operational considerations.	Inadequate understanding of safety and reliability concerns.
3.	Economic Feasibility Evaluation	20	Detailed techno-economic analysis including cost estimation, lifecycle evaluation, and implementation feasibility.	Moderate economic analysis with limited feasibility interpretation.	Poor or missing economic feasibility analysis.
4.	Validation & Practical Applicability	20	Strong validation using benchmark standards, experimental verification, or industrial comparisons.	Partial validation with acceptable engineering comparisons.	Weak validation and unrealistic practical interpretation.

5.	Innovation & Research Contribution	20	Significant originality with clear research contribution and future scope recommendations.	Moderate innovation with acceptable contribution to the research domain.	Limited originality and weak research contribution.
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

CO	Core Research Activity: Report Documentation & Review I	Technical Assessment Activity: Presentation Viva & Review II	Percentage allocation	Mapping Strength
CO1	20	20	20	2
CO2	20	20	20	2
CO3	20	20	20	2
CO4	20	20	20	2
CO5	20	20	20	2
Total	100	100	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26THE01	THERMAL MANAGEMENT OF ELECTRIC VEHICLE BATTERY SYSTEMS			SEMESTER		II
Prerequisites			Category	ES(PE)	Credits	3
- Engineering Thermodynamics - Heat Transfer and Batteries			Hours/ Semester	L	T	P
				45	0	0
COURSE OBJECTIVES						
1.	To develop structural insights into cell electrochemical characteristics, aging paths, and degradation markers of EV traction batteries.					
2.	To apply passive thermal control solutions using organic and inorganic phase change material matrices.					
3.	To build numerical validation protocols and testing configurations to examine submodule fluid-thermal properties.					
4.	To compute comprehensive energy and exergy efficiency equations across active and passive thermal management configurations.					
5.	To execute localized thermal solutions evaluating transcritical fluid cycles and transient peak load conditions through case records.					
UNIT - I	VEHICLE BATTERY TECHNOLOGIES					9
Introduction, Current Battery Technologies: Lead Acid Batteries, Nickel Cadmium Batteries, Nickel Metal Hydride Batteries, Lithium-Ion Batteries, Battery Technologies under Development, Zinc-Air Batteries, Sodium-Air Batteries, Lithium-Sulphur Batteries, Aluminium-Air Batteries, Lithium-Air Batteries, Battery Environmental Impact, Impact of Various Loads and Environmental Conditions, Battery Management Systems, Safety Management/Fault Diagnosis/ Thermal Management.						
UNIT - II	PHASE CHANGE MATERIALS FOR PASSIVE TMS's					9
Basic Properties and Types of PCMs, Organic PCMs, Inorganic PCMs, Measurement of Thermal Properties of PCMs, Heat Transfer Enhancements, Cost and Environmental Impact of Phase Change Materials, Applications of PCMs.						
Case Study 1: Heat Exchanger Design and Optimization Model for EV Batteries using PCMs						
Case Study 2: Melting and Solidification of Paraffin in a Spherical Shell from Forced External Convection						
UNIT - III	SIMULATION AND EXPERIMENTAL INVESTIGATION OF BATTERY TMS's					9
Numerical Model Development for Cell and Submodules, Cell and Module Level Experimentation Set Up and Procedure, Vehicle Level Experimentation Set Up and Procedure, Illustrative Example: Simulations and Experimentations on the Liquid Battery Thermal Management System Using PCMs, Simulation and Experimentations Between the Cells in the Submodule, Thermal Conductivity Enhancement by Nanoparticles.						
UNIT - IV	ENERGY AND EXERGY ANALYSES OF BATTERY TMSs					9
TMS Comparison, Modeling of Major TMS Components, Energy and Exergy Analyses, Illustrative Example: Liquid Battery Thermal Management Systems, Case Study: Trans critical CO ₂ -Based Electric Vehicle BTMS.						
UNIT - V	CASE STUDIES ON THERMAL MANAGEMENT SOLUTIONS OF ELECTRIC BATTERIES					9
Case Study 1: Experimental and Theoretical Investigation of Temperature Distributions in a Prismatic Lithium-Ion Battery						
Case Study 2: Thermal Management Solutions for Electric Vehicle Lithium-Ion Batteries based on Vehicle Charge and Discharge Cycles						
Case Study 3: Heat Transfer and Thermal Management of Electric Vehicle Batteries with Phase Change Materials						
Case Study 4: Experimental and Theoretical Investigation of Novel Phase Change Materials for Thermal Applications.						
Total:45 Hours						

Weightage:

Continuous Assessment 40%

End Semester Examinations 60%

REFERENCE BOOKS:

1.	Ibrahim Dincer, Halil S. Hamut, Nader Javani, Thermal Management of Electric Vehicle Battery Systems, C, 2017.
2.	Halil S. Hamut, Nader Javani, Ibrahim Dincer, Thermal Management of Electric Vehicle Battery Systems, Wiley, 2016.
3.	Weixiang Shen, Rui Xiong, Advanced Battery Management Technologies for Electric Vehicles, John Wiley and sons, First edition 2019
4.	Chitra A., Sanjeevikumar Padmanaban, Jens Bo Holm-Nielsen, Artificial Intelligent Techniques for Electric and Hybrid Electric Vehicles, John Wiley and sons, First edition 2020
5.	Bruno Scrosati, Jurgen Garche, Werner Tillmetz, Advances in Battery Technologies for Electric Vehicles, Woodhead Publishing, 2015

E-RESOURCES:

1.	NPTTEL – Fundamentals of Electric Vehicles: Technology & Economics
2.	MIT OpenCourseWare – Electrochemical Energy Storage Systems
3.	Journal of Energy Storage (ScienceDirect Simulation Research Databases)
4.	SAE International – Electric Vehicle Battery Thermal Standards Archive

COURSE OUTCOMES (COs) /**At the end of the course, the students will have the ability to****Mapping****POs****Mapping****PSOs**

CO1	Apply electrochemical thermal parameters, environmental load configurations, and BMS diagnostics to define pack constraints.	PO1, PO3	PSO1
CO2	Analyze organic-inorganic PCM properties, heat transfer enhancement loops, and melting boundaries inside shell configurations.	PO1, PO3	PSO1
CO3	Analyze numerical submodule mesh profiles, vehicle-level test layouts, and thermal enhancements.	PO1, PO3	PSO1, PSO2
CO4	Apply specialized thermal analysis tools, fluid scripting packages, or solver engines to calculate pack exergy destruction balances.	PO1, PO2, PO3	PSO1, PSO2
CO5	Evaluate transcritical carbon dioxide operations, prismatic temperature spreads, and duty cycle limits via an independent presentation study.	PO1, PO2, PO3	PSO1, PSO2

The Course Articulation Matrix (CAM) for defined COs

COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	2	—	2	2	—
CO2	2	—	2	2	—
CO3	2	—	2	2	2
CO4	3	3	3	3	3
CO5	3	3	3	2	3
AVERAGE	2.4	3.0	2.4	2.2	2.7

Activities:

1. Model and calculate battery pack exergy destruction using specialized thermal analysis software.
2. Independent presentation study evaluating transcritical carbon dioxide operations and duty cycle limitations.

Rubrics for evaluation: C04

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Technical Understanding	20	Explicitly captures spatial heat generation parameters, cooling paths, and boundary conditions.	Reasonable definition of module dimensions and core boundary criteria.	Erroneous input settings or unquantified heat definitions.
2.	Industrial Data Analysis	20	Excellent interpretation using real drive cycle configurations and performance metrics.	Adequate analysis of localized temperature distribution spreads.	Limited interpretation of battery monitoring system logs.
3.	Sustainability & Economic Evaluation	20	Strong techno-economic assessment mapping pack life cycle improvements and mass boundaries.	Moderate evaluation of material optimization limits and weight bounds.	Limited discussion on environmental footprint values or cost restrictions.
4.	Presentation & Communication	20	Highly professional and engaging slide delivery using clean thermal contour fields.	Clear communication with minor presentation format inconsistencies.	Moderate delivery with shallow domain vocabulary control.
5.	Report Quality & References	20	Professional calculation summary containing crisp contour maps, charts, and clean configurations.	Adequate reporting format containing minor layout or scaling errors.	Disorganized documentation missing critical modeling codes.
Total		100			

Rubrics for evaluation: C05

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Innovation & Design	20	Highly innovative and optimized phase change cooling structural geometries.	Good design methodology tracking latent heat encapsulation boundaries.	Conventional approach using baseline unenhanced passive layouts.
2.	Functionality of Prototype / Model	20	Fully functional and reliable transient solver setup or computational module run.	Functional layout displaying minor tracking model instabilities.	Partially functional structure experiencing solver matrix divergence.

3.	Engineering Analysis	20	Strong theoretical and experimental validation matching published prismatic cell curves.	Adequate validation tracking primary temperature lines without deep error checks.	Limited analysis ignoring system degradation markers or losses.
4.	Use of Modern Tools	20	Effective use of modern computational thermal tools and scripting package arrays.	Moderate use of software toolboxes and standard interface blocks.	Minimal usage of advanced simulation or graphic systems.
5.	Documentation & Demonstration	20	Excellent report and crisp demonstration of simulated phase fronts.	Good documentation with minor chart formatting gaps.	Basic presentation structure with missing structural formulas.
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
CO1	14	14	—	—	10	2
CO2	10	36	—	—	20	2
CO3	36	10	—	—	20	2
CO4	—	—	40	—	25	3
CO5	—	—	—	40	25	3
Total	60	60	40	40	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26THE02	OPTIMIZATION TECHNIQUES IN ENGINEERING			SEMESTER		II		
Prerequisites				Category	ES(PE)	Credits	3	
- Engineering Mathematics - Numerical Methods - Operations Research				Hours/ Semester	L	T	P	TH
					45	0	0	45
COURSE OBJECTIVES								
1.	To introduce structural problem classifications, design constraint surfaces, and multilevel formulation boundaries.							
2.	To apply hierarchical methods, utility models, and goal programming to multi-objective decision trees.							
3.	To analyze standard simplex tableaux, minimization parameters, and multi-variable canonical optimization bounds.							
4.	To evaluate unconstrained multi-variable spaces and Karush-Kuhn-Tucker condition lines through numerical solver scripts.							
5.	To analyze swarm heuristics, simulated annealing structures, and fuzzy neural network solvers from modern engineering journals.							
UNIT - I		INTRODUCTION						9
Classification of optimization problems, concepts of design vector, design constraints, constrains surface, objective function, surface and multi-level optimization, parametric linear programming.								
UNIT - II		DECISION ANALYSIS						9
Decision Trees, utility theory, game theory, multi-objective Optimization, MCDM- Goal Programming, analytic hierarchy process and ANP.								
UNIT - III		LINEAR PROGRAMMING						9
Standard form of linear programming problem; Canonical form of LP problem; Assumptions in LP Models; Elementary operations Graphical method for two variable optimization problem; Examples Motivation of simplex method, Simplex algorithm and construction of simplex tableau; Simplex criterion; Minimization versus maximization problems								
UNIT - IV		NON-LINEAR OPTIMIZATION						9
Unconstrained single variable and multi variable optimization, KKT Conditions, constrained optimization, quadratic programming, convex programming, Separable programming, Geometric programming, non-convex programming								
UNIT - V		NON-TRADITIONAL OPTIMIZATION						9
Genetic algorithms, simulated annealing, neural network-based optimization, particle swarm optimization, ant Colony Optimization, Optimization of Fuzzy Systems								
Total:45 Hours								
Weightage: Continuous Assessment 40% End Semester Examinations 60%								

REFERENCE BOOKS:

1. Singiresu S. Rao, "Engineering optimization – Theory and practices", John Wiley and Sons, 1996.
2. Ravindran – Phillips –Solberg, "Operations Research – Principles and Practice", John Wiley India, 2006.
3. Kalymanoy Deb, "Optimization for Engineering Design", PHI, 2003.
4. Fredrick S.Hillier and G.J.Liberman, "Introduction to Operations Research", McGraw Hill Inc. 1995.
5. G. Hadley, "Linear programming", Narosa Publishing House, New Delhi, 1990.

E-RESOURCES:

1. NPTEL – Optimization Methods for Engineering Design
2. MIT OpenCourseWare – Mathematical Optimization Algorithms
3. Journal of Optimization Theory and Applications (Springer Archives)
4. INFORMS (Institute for Operations Research and the Management Sciences) Learning Databases

COURSE OUTCOMES (COs) /**At the end of the course, the students will have the ability to****Mapping
POs****Mapping
PSOs****CO1**

Apply design vector criteria, boundary constraints, and objective surfaces to model engineering domains.

PO1,
PO3

PSO1

CO2

Analyze game matrices, analytic hierarchy loops, and multi-criteria multi-objective goal trees.

PO1,
PO3PSO1,
PSO2**CO3**

Analyze graphical constraints, simplex tableaus, operations criteria, and linear duality equations.

PO1,
PO3

PSO1

CO4

Apply specialized mathematical code libraries, optimizer toolboxes, or constraint solvers to calculate multi-variable KKT points.

PO1,
PO2,
PO3PSO1,
PSO2**CO5**

Evaluate evolutionary genetic paths, particle swarms, and neural network updates via a specialized research seminar.

PO1,
PO2,
PO3PSO1,
PSO2**The Course Articulation Matrix (CAM) for defined COs****COs / POs****PO1****PO2****PO3****PSO1****PSO2****CO1**

2

—

2

2

—

CO2

2

—

2

2

2

CO3

2

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2

2

—

CO4

3

3

3

3

3

CO5

3

3

3

2

3

AVERAGE**2.4****3.0****2.4****2.2****2.7**

Activities:

1. Compute multivariable KKT optimality points using specialized mathematical programming libraries.
2. Producing a formal technical report detailing a metaheuristic implementation for energy systems.

Rubrics for evaluation: CO4

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Technical Understanding	20	Objective models, equality limits, and variable bounds are perfectly defined with zero syntax gaps.	Consistent definition of variable matrices and solver bounds.	Incomplete formulations or loose parameter tracking arrays.
2.	Industrial Data Analysis	20	Excellent interpretation using real manufacturing arrays or operations research data.	Adequate analysis of simplex tableaus or objective vectors.	Limited interpretation of multi-criteria decision variables.
3.	Sustainability & Economic Evaluation	20	Strong techno-economic assessment mapping structural material reductions and cost parameters.	Moderate evaluation of processing bounds or optimization tolerances.	Limited discussion tracking system scale anomalies.
4.	Presentation & Communication	20	Highly professional and engaging delivery using explicit convergence charts.	Clear communication with minor presentation format inconsistencies.	Moderate delivery with loose control of statistical vocabulary.
5.	Report Quality & References	20	Well-organized with quality references extracted from high-impact algorithm archives.	Adequate documentation with minor template style variations.	Basic report structure omitting essential code block listings.
	Total	100			

Rubrics for evaluation: CO5

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Innovation & Design	20	Masterful command over mutation mechanisms, particle updates, or stochastic cooling criteria.	Baseline structural knowledge of fuzzy rules or network optimization states.	Weak grasp of basic heuristic update formulations.
2.	Functionality of Prototype / Model	20	Optimization script compiles correctly; terminates smoothly with strong objective convergence.	Script model processes data arrays with minor scaling or convergence delays.	Failure to converge due to poor solver parameter initialization.

3.	Engineering Analysis	20	Model optimum endpoints are rigorously checked against classic exact closed global benchmarks.	Primary verification graphs check baseline convergence trends correctly.	Flawed target identification or unverified search data.
4.	Use of Modern Tools	20	Effective use of modern mathematical solvers and custom script toolboxes.	Moderate use of open-source algorithmic structures and frameworks.	Minimal usage of advanced programming environments.
5.	Documentation & Demonstration	20	Professional calculation summary displaying clean search histories, contour paths, and code arrays.	Standard summary report featuring minor layout or labeling errors.	Disorganized reporting layout missing essential code blocks.
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

CO	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
CO1	14	14	—	—	10	2
CO2	10	36	—	—	20	2
CO3	36	10	—	—	20	2
CO4	—	—	40	—	25	3
CO5	—	—	—	40	25	3
Total	60	60	40	40	100	

**Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);**

26THE03	ELECTRIC AND HYBRID VEHICLE TECHNOLOGY			SEMESTER		II		
Prerequisites				Category	ES(PE)	Credits	3	
- Basic Electrical Engineering - Automobile Technology				Hours/ Semester	L	T	P	TH
					45	0	0	45
COURSE OBJECTIVES								
1.	To introduce traction mechanics, power block characterizations, and drivetrain environmental impact metrics.							
2.	To build power flow control equations and fuel efficiency analyses for parallel and series architectures.							
3.	To evaluate configuration controls and efficiency bounds across permanent magnet, induction, and switched reluctance motors.							
4.	To evaluate fuel cell configurations, supercapacitor links, and hybrid storage matching via vehicle simulation tools.							
5.	To analyze machine-engine matching metrics, propulsion motor scaling, and control rules using elite automotive records.							
UNIT - I		INTRODUCTION						9
Basics of vehicle performance, vehicle power source characterization, transmission characteristics, History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies.								
UNIT - II		HYBRID ELECTRIC DRIVE TRAINS						9
Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive train topologies, fuel efficiency analysis. Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis.								
UNIT - III		CONTROL OF AC & DC DRIVES						9
Introduction to electric components used in hybrid and electric vehicles, Configuration and control - DC Motor drives, Induction Motor drives, Permanent Magnet Motor drive, and Switch Reluctance Motor drives, drive system efficiency.								
UNIT - IV		ENERGY STORAGE						9
Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Energy storage and its analysis - Battery based, Fuel Cell based, and Super Capacitor based, Hybridization of different energy storage devices								
UNIT - V		DRIVE SIZING AND ENERGY MANAGEMENT STRATEGIES						9
Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selection of appropriate energy storage technology, Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification and comparison of energy management strategies, implementation issues.								
Total:45 Hours								
Weightage:								
Continuous Assessment 40%								
End Semester Examinations 60%								

REFERENCE BOOKS:

1	Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003
2	James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003
3	Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004
4	Rand D.A.J, Woods, R & Dell RM Batteries for Electric vehicles, John Wiley & Sons, 1998

E-RESOURCES:

1.	NPTEL – Electric Vehicles - Part 1
2.	MIT Open Courseware – Introduction to Transportation Systems / Power Electronics
3.	IEEE Transactions on Transportation Electrification (Digital Library Archives)
4.	International Energy Agency (IEA) Advanced Motor Fuels Learning Portals

COURSE OUTCOMES (COs) /**At the end of the course, the students will have the ability to****Mapping
POs****Mapping
PSOs**

CO1	Apply transmission variables, traction power formulas, and environmental loads to characterize drivetrain baselines.	PO1, PO3	PSO1
CO2	Analyze power flow splits, fuel efficiency gains, and topological control configurations for hybrid vehicles.	PO1, PO3	PSO1
CO3	Analyze motor torque curves, drive inverter efficiencies, permanent magnet configurations, and reluctance fields.	PO1, PO3	PSO1, PSO2
CO4	Apply specialized vehicle longitudinal simulation tools, powertrain code script blocks, or sizing scripts to calculate hybridization profiles.	PO1, PO2, PO3	PSO1, PSO2
CO5	Evaluate engine-motor matching bounds, drive machine scaling rules, and economic management rules via an independent seminar study.	PO1, PO2, PO3	PSO1, PSO2

The Course Articulation Matrix (CAM) for defined COs

COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	2	—	2	2	—
CO2	2	—	2	2	—
CO3	2	—	2	2	2
CO4	3	3	3	3	3
CO5	3	3	3	2	3
AVERAGE	2.4	3.0	2.4	2.2	2.7

Activities:

1. Compute and analyze vehicle hybridization profiles using specialized longitudinal simulation tools.
2. Independent seminar study evaluating engine-motor matching constraints and scaling laws.

Rubrics for evaluation: CO4

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Technical Understanding	20	Mass, aerodynamic coefficients, rolling limits, and drivetrain inertias are explicitly defined.	Satisfactory definition of base cycle velocities and wheel bounds.	Loose parameter structures or unquantified friction targets.
2.	Industrial Data Analysis	20	Excellent interpretation using standard multi-mode drive cycles and velocity arrays.	Adequate analysis of motor torque lines or wheel bounds.	Limited interpretation of regenerated braking curves or signals.
3.	Sustainability & Economic Evaluation	20	Strong techno-economic assessment profiling drivetrain weight limits and efficiency gains.	Moderate evaluation of hybridization costs and cell sizing rules.	Limited discussion tracking greenhouse gas targets or offsets.
4.	Presentation & Communication	20	Highly professional and engaging delivery using clear force balance charts.	Clear communication with minor presentation layout template omissions.	Moderate delivery with shallow control of vehicle vocabulary.
5.	Report Quality & References	20	High-quality presentation of sizing results, force balance charts, and formatted tables.	Standard report summary layout with small graph formatting issues.	Disorganized reporting presentation lacking critical verification formulas.
	Total	100			

Rubrics for evaluation: CO5

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Innovation & Design	20	Complete mastery over engine-motor load maps, flux configurations, and fuel efficiency indices.	Baseline structural knowledge of driver control strategies and split topologies.	Weak grasp of core electro-mechanical traction parameters.
2.	Functionality of Prototype / Model	20	Simulation script loops process velocity datasets smoothly; shows zero convergence errors.	Sizing maps resolve with secondary code execution lags or tracking delays.	Tool fails due to disorganized matrix loop structuring.

3.	Engineering Analysis	20	Model calculated peaks match standard industrial production vehicle tracking statistics.	Core power distribution checks follow basic trends without deeper verification curves.	Erroneous mechanical readings or mismatched output fields.
4.	Use of Modern Tools	20	Effective use of modern vehicle simulation codes and control toolsets.	Moderate use of sizing macros and standard system interfaces.	Minimal usage of advanced automotive software platforms.
5.	Documentation & Demonstration	20	Well-organized with quality references extracted from high-impact transportation libraries.	Adequate documentation with minor font formatting differences.	Basic report structure lacking essential validation equations.
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
CO1	14	14	—	—	10	2
CO2	10	36	—	—	20	2
CO3	36	10	—	—	20	2
CO4	—	—	40	—	25	3
CO5	—	—	—	40	25	3
Total	60	60	40	40	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26THE04	ELECTRONIC ENGINE MANAGEMENT SYSTEMS			SEMESTER		II	
Prerequisites			Category	ES(PE)	Credits	3	
- Internal Combustion Engines - Automotive Engineering - Sensors and Instrumentation			Hours/ Semester	L	T	P	TH
				45	0	0	45
COURSE OBJECTIVES							
1.	To introduce electrical network laws, semiconductor diode operations, and integrated microcontroller architectures.						
2.	To apply calibration routines and functional tracking to diagnostic powertrain sensors and brushless actuator motors.						
3.	To evaluate solid-state ignition fundamentals, lookup table maps, and electronic spark timing arrays.						
4.	To compute transient fuel injection profiles and closed-loop lookup limits using automated powertrain simulation software tools.						
5.	To analyze common rail networks, piezoelectric injection units, and heat release dynamics from high-impact combustion journals.						
UNIT - I		ELECTRICAL AND ELECTRONICS PRINCIPLES					9
Voltage, current and resistance – Electrical components in series and parallel – Electrical Energy and Power – Direct Current and Alternating Current – Inductance and Capacitance – Diodes and Bipolar Junction and Field Effect Transistors – Analog and Digital Integrated circuits. Comparator- Logic gates – Microcontroller – Basics of Analog to Digital and Digital to Analog Converters, Potentiometer – Wheatstone bridge.							
UNIT - II		SENSORS AND ACTUATORS					9
Sensors - Camshaft Position, Crank Position, Throttle Position, Air flow, Pressure, Temperature, Speed, and Exhaust gas Oxygen, Knock and Oxides of nitrogen, Principle of operation, construction and characteristics. Actuators – Intake throttle valves Pneumatic, EGR Valve, Waste Gate, Brushless DC motor and stepper motor, calibration of electronic sensors and actuators.							
UNIT - III		IGNITION SYSTEMS					9
Ignition fundamentals, Solid state ignition systems, High energy ignition systems, electronic spark timing and control. Combined ignition and fuel management systems. Dwell angle calculation, ignition timing calculation, Engine mapping, Lookup tables and maps.							
UNIT - IV		GASOLINE INJECTION SYSTEMS					9
Open loop and closed loop systems, Single-point, Multi-point, Direct injection systems and Air assisted systems – Principles and Features, Types of injection systems, Idle speed, lambda, knock and spark timing control, simple fuel injection calculation, Fuel injection volume control for different engine operation.							
UNIT - V		DIESEL INJECTION SYSTEMS					9
Heat release, control of fuel injection, Inline injection pump, Rotary Pump and Injector – Construction and principle of operation, electronic control, Common rail, unit injector and Piezoelectric fuel injector- Principle – Construction and principle of operation.							
Total:45 Hours							
Weightage:							
Continuous Assessment 40%							
End Semester Examinations 60%							

REFERENCE BOOKS:

- | | |
|----|---|
| 1. | Eric Chowanietz, Automobile Electronics, SAE Publications 1995 |
| 2. | Robert Bosch, Gasoline Engine Management, Third Edition, Bentley Publications, 2004 |
| 3. | Robert Bosch, Diesel Engine Management, Fourth Edition, Newness Publications, 2005 |
| 4. | Tom Denton, Automotive Electrical and Electronic Systems, 4th Edition, Taylor and Francis Group, 2004 |
| 5. | William B. Ribbens, Understanding Automotive Electronics, Sixth Edition, Elsevier Inc, 2002 |

E-RESOURCES:

- | | |
|----|--|
| 1. | NPTEL – IC Engines and Gas Turbines / Automotive Systems |
| 2. | MIT OpenCourseWare – Internal Combustion Engines |
| 3. | Bosch Mobility Media Automotive Engineering Databases |
| 4. | International Journal of Engine Research (SAGE Archives) |

COURSE OUTCOMES (COs) /**At the end of the course, the students will have the ability to****Mapping
POs****Mapping
PSOs**

CO1	Apply power circuit rules, semiconductor thresholds, and digital logic gate steps to model electrical loops.	PO1, PO3	PSO1, PSO2
CO2	Analyze sensor waveform frequencies, calibration scaling, and brushless actuator displacement fields.	PO1, PO3	PSO1
CO3	Analyze engine spark timing calculations, dwell angles, map lookup variables, and combined controls.	PO1, PO3	PSO1
CO4	Apply specialized electronic control design software, powertrain scripting toolsets, or calibration scripts to calculate injection pulse volumes.	PO1, PO2, PO3	PSO1, PSO2
CO5	Evaluate common rail dynamics, piezo stacks, heat release profiles, and common-pump flows via an independent seminar study.	PO1, PO2, PO3	PSO1, PSO2

The Course Articulation Matrix (CAM) for defined COs

COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	2	—	2	2	2
CO2	2	—	2	2	—
CO3	2	—	2	2	—
CO4	3	3	3	3	3
CO5	3	3	3	2	3
AVERAGE	2.4	3.0	2.4	2.2	2.7

Activities:

1. Optimize fuel injection pulse volumes using specialized electronic control system design software.
2. Independent seminar study evaluating common rail fuel system dynamics and injector behavior.

Rubrics for evaluation: C04

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Technical Understanding	20	Input metrics, lookup step boundaries, and initial duty cycles are defined flawlessly.	Satisfactory definition of engine speed arrays and base sensors.	Loose boundaries or unquantified lookup settings.
2.	Industrial Data Analysis	20	Excellent interpretation using real transient mass airflow and engine speed datasets.	Adequate analysis of ignition lookup tables or voltage charts.	Limited interpretation of wave frequencies or electronic signals.
3.	Sustainability & Economic Evaluation	20	Strong techno-economic assessment profiling air-fuel matching gains and device bounds.	Moderate evaluation of duty cycle limits and calibrator offsets.	Limited discussion tracking emission reductions or green indexes.
4.	Presentation & Communication	20	Highly professional and engaging delivery displaying explicit 3D engine maps.	Clear communication with minor graphical template layout omissions.	Moderate delivery using weak automotive electronic terminology.
5.	Report Quality & References	20	High-quality presentation displaying explicit 3D lookup maps, pulse curves, and data.	Adequate reporting format containing minor chart scaling oversights.	Disorganized data presentation with unscaled mapping blocks.
	Total	100			

Rubrics for evaluation: C05

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Innovation & Design	20	Complete mastery over rail wave physics, nozzle discharge metrics, and heat fractions.	Baseline structural knowledge of pilot injection settings and fuel flows.	Weak grasp of fundamental combustion fluid dynamics.
2.	Functionality of Prototype / Model	20	Simulation scripts compute parameters efficiently; tracking lines show no matrix instability.	Engine control maps solve with secondary timing delays or indexing offsets.	Model fails to execute due to poor matrix indexing.

3.	Engineering Analysis	20	Calibrated pulse outputs match published benchmark industrial performance curves.	Fuel maps check against baseline empirical curves without depth checks.	Erroneous fuel volume readings or incorrect trend tracking paths.
4.	Use of Modern Tools	20	Effective use of modern powertrain simulation software and control models.	Moderate use of calibration scripts and standard driver interfaces.	Minimal usage of advanced electronic design environments.
5.	Documentation & Demonstration	20	Well-organized with quality references compiled from elite combustion societies.	Adequate documentation with tiny data formatting anomalies.	Basic report structure omitting essential calibration formulas.
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

CO	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
CO1	14	14	—	—	10	2
CO2	10	36	—	—	20	2
CO3	36	10	—	—	20	2
CO4	—	—	40	—	25	3
CO5	—	—	—	40	25	3
Total	60	60	40	40	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26THE05	ADVANCED ENERGY STORAGE TECHNOLOGIES		SEMESTER			II
Prerequisites		Category	ES(PE)	Credits		3
- Engineering Thermodynamics - Electrochemistry - Heat Transfer - Materials Science		Hours/ Semester	L	T	P	TH
			45	0	0	45
COURSE OBJECTIVES						
1.	To introduce storage mechanism constraints, capacity profiles, and deployment criteria across utility systems.					
2.	To apply system simulation toolsets to evaluate porous storage arrays and phase change pack models.					
3.	To build thermodynamic evaluations tracking cell safety limits, charge densities, and electro-chemical states.					
4.	To evaluate metal hydride options and compressed gas storage frameworks using automated process simulation software.					
5.	To analyze ultra-capacitor mechanisms, flywheel operations, and hybrid storage networks from top-tier energy science journals.					
UNIT - I	INTRODUCTION					9
Necessity of energy storage – types of energy storage – comparison of energy storage technologies – Applications.						
UNIT - II	THERMAL STORAGE SYSTEM					9
Thermal storage – Types – Modelling of thermal storage units – Simple water and rock bed storage system – pressurized water storage system – Modelling of phase change storage system – Simple units, packed bed storage units - Modelling using porous medium approach, Use of TRNSYS.						
UNIT - III	ELECTRICAL ENERGY STORAGE					9
Fundamental concept of batteries – measuring of battery performance, charging and discharging of a battery, storage density, energy density, and safety issues. Types of batteries – Lead Acid, Nickel – Cadmium, Zinc Manganese dioxide and modern batteries for example (i) zinc-Air (ii) Nickel Hydride, (iii) Lithium Battery.						
UNIT - IV	HYDROGEN AND BIOGAS STORAGE					9
Hydrogen storage options – compressed gas – liquid hydrogen – Metal Hydrides, chemical Storage, Biogas storage - comparisons. Safety and management of hydrogen and Biogas storage - Applications.						
UNIT - V	ALTERNATE ENERGY STORAGE TECHNOLOGIES					9
Flywheel, Super capacitors, Principles & Methods – Applications, Compressed air Energy storage, Concept of Hybrid Storage – Applications.						
Total:45 Hours						
Weightage: Continuous Assessment 40% End Semester Examinations 60%						

REFERENCE BOOKS:

1.	Ibrahim Dincer and Mark A. Rosen, Thermal Energy Storage Systems and Applications, John Wiley & Sons 2002.
2.	James Larminie and Andrew Dicks, Fuel cell systems Explained, Wiley publications, 2003.
3.	Luisa F. Cabeza, Advances in Thermal Energy Storage Systems: Methods and Applications, Elsevier Woodhead Publishing, 2015.
4.	Robert Huggins, Energy Storage: Fundamentals, Materials and Applications, 2nd edition, Springer, 2015
5.	Ru-shiliu, Leizhang, Xueliang sun, Electrochemical technologies for energy storage and conversion, Wiley publications, 2012.

E-RESOURCES:

1.	NPTEL – Energy Storage Technologies / Energy Resources
2.	MIT OpenCourseWare – Electrochemical Energy Storage Systems
3.	TRNSYS Simulation Documentation and Thermal Validation Portal Access
4.	International Journal of Energy Storage (Elsevier Database Gateways)

COURSE OUTCOMES (COs) /**At the end of the course, the students will have the ability to****Mapping
POs****Mapping
PSOs**

CO1	Apply necessity metrics, capacity scales, and performance limits to establish storage allocation boundaries.	PO1, PO3	PSO1
CO2	Analyze rock bed structures, packed boundary fields, porous media formulations, and unit loop variables.	PO1, PO3	PSO1
CO3	Analyze cell loading rates, discharge densities, safety controls, and modern lithium-air systems.	PO1, PO3	PSO1
CO4	Apply specialized process simulation platforms, storage scripting toolkits to configure hydride gas storage systems.	PO1, PO2, PO3	PSO1, PSO2
CO5	Evaluate kinetic flywheel balances, ultra-capacitor nodes, and multi-component hybrid storage grids via an independent case seminar.	PO1, PO2, PO3	PSO1, PSO2

The Course Articulation Matrix (CAM) for defined COs

COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	2	—	2	3	—
CO2	2	—	2	3	—
CO3	2	—	2	3	—
CO4	3	3	3	2	3
CO5	3	3	3	2	3
AVERAGE	2.4	3.0	2.4	2.6	3.0

Activities:

1. Model and configure metal hydride-based gas storage systems using process simulation platforms.
2. Independent case seminar evaluating flywheel storage, ultra-capacitors, and hybrid grids.

Rubrics for evaluation: CO4

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Technical Understanding	20	Domain nodes, fluid flow rates, and initial temperature layers are mapped with zero errors.	Baseline identification of storage units and target parameters.	Weak block definitions or unquantified boundary settings.
2.	Industrial Data Analysis	20	Excellent interpretation using real operational plant data arrays or cell histories.	Adequate analysis of thermal storage porous fronts or beds.	Limited interpretation of storage capacity or loading graphs.
3.	Sustainability & Economic Evaluation	20	Flawless mathematical tracking of fluid-solid heat exchange lines, phase fronts, and source paths.	Minor logic errors in transient calculation sequences or material properties.	Flawed selection of core thermodynamic balancing equations.
4.	Presentation & Communication	20	Highly professional and engaging delivery using clean temperature vectors.	Clear communication with minor presentation format inconsistencies.	Moderate delivery with loose grasp of thermophysical storage indices.
5.	Report Quality & References	20	Professional calculation summary displaying clean search histories, contour paths, and code arrays.	Standard summary report featuring minor layout or labeling errors.	Disorganized data presentation with missing charts.
	Total	100			

Rubrics for evaluation: CO5

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Innovation & Design	20	Complete mastery over phase change tracking, cell kinetics, and flywheel stress equations.	Baseline structural knowledge of grid balancing and storage methods.	Weak grasp of core thermophysical storage principles.
2.	Functionality of Prototype / Model	20	Simulation script processes data smoothly; hits target parameters without convergence failure.	Model deck resolves with minor execution lag or system tracking delays.	Script failure caused by poor matrix setup.

3.	Engineering Analysis	20	Precise assessment of round-trip storage efficiency, degradation curves, and loss bounds.	Simplistic calculation loops assuming zero operational degradation.	Missing calculations or flawed verification tracking data.
4.	Use of Modern Tools	20	Effective use of modern TRNSYS simulation blocks and script toolkits.	Moderate use of open-source storage models and evaluation layouts.	Minimal usage of advanced simulation or data software engines.
5.	Documentation & Demonstration	20	Comprehensive extraction referencing top-tier international energy archives and premier storage journals.	Standard reference grouping from limited textbook sources.	Inadequate search citations or non-peer internet source usage.
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

CO	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
CO1	14	14	—	—	10	2
CO2	10	36	—	—	20	2
CO3	36	10	—	—	20	2
CO4	—	—	40	—	25	3
CO5	—	—	—	40	25	3
Total	60	60	40	40	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

REFERENCE BOOKS:					
1.	Duffie, J.A. and Beckman, W.A., Solar Engineering of Thermal Processes, 5th Edition, Wiley, 2020.				
2.	Kalogirou, S.A., Solar Energy Engineering: Processes and Systems, 3rd Edition, Academic Press, 2021.				
3.	Manwell, J.F., McGowan, J.G. and Rogers, A.L., Wind Energy Explained, 3rd Edition, Wiley, 2023.				
4.	Hau, E., Wind Turbines: Fundamentals, Technologies, Application and Economics, Springer, 2020.				
5.	Twidell, J. and Weir, T., Renewable Energy Resources, 4th Edition, Routledge, 2021.				
E-RESOURCES:					
1.	NPTEL – Solar Energy Engineering				
2.	NPTEL – Non-Conventional Energy Resources				
3.	MIT OpenCourseWare – Renewable Energy Systems				
4.	IEA Renewable Energy Reports				
5.	National Renewable Energy Laboratory (NREL) Learning Resources				
COURSE OUTCOMES (COs) / At the end of the course, the students will have the ability to			Mapping POs	Mapping PSOs	
CO1	Analyze solar radiation characteristics, collector performance, and solar thermal energy conversion mechanisms for renewable thermal applications.		PO1, PO3	PSO1	
CO2	Evaluate the performance of photovoltaic systems, MPPT techniques, and energy storage systems under varying operating conditions.		PO1, PO3	PSO1	
CO3	Analyze wind resource characteristics, aerodynamic principles, and wind turbine operating parameters for efficient energy extraction.		PO1, PO3	PSO1	
CO4	Design and develop simulation-based or programming-oriented solar/wind/hybrid renewable energy systems using modern engineering tools considering sustainability and economic constraints.		PO1, PO2, PO3	PSO1, PSO2	
CO5	Evaluate contemporary renewable energy technologies through seminar, project, or open-ended experimental studies considering environmental, societal, and sustainability impacts.		PO1, PO2, PO3	PSO1, PSO2	
The Course Articulation Matrix (CAM) for defined COs					
COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	2	–	3	3	—
CO2	3	–	3	3	—
CO3	2	–	3	3	—
CO4	3	2	3	2	3
CO5	3	3	3	2	3
AVERAGE	2.6	2.5	3.0	2.6	3.0
Activities:					
1.	Model Building Activity on Solar, Wind, or Hybrid Renewable Energy Systems (CO4)				
2.	Technical Seminar Presentation (CO5) (Independent study)				

Rubrics for evaluation: C04

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Problem Identification & Objective Formulation	20	Problem clearly identified with well-defined objectives	Objectives reasonably defined	Problem definition unclear
2.	Design Methodology & Technical Analysis	25	Systematic design with accurate engineering analysis	Minor errors in analysis/design	Incomplete or weak analysis
3.	Model Development / Experimental Setup	25	Functional and innovative model developed successfully	Model developed with minor issues	Incomplete or poorly functioning model
4.	Interpretation of Results & Feasibility	15	Results critically interpreted with sustainability considerations	Basic interpretation provided	Poor interpretation and justification
5.	Report Documentation & Presentation	15	Professional report and effective presentation	Adequate presentation and documentation	Poor communication and formatting
	Total	100			

Rubrics for evaluation: C05

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Understanding of Renewable Energy Concepts	20	Concepts explained critically with technical depth	Adequate understanding demonstrated	Limited understanding
2.	Literature Review & Self-Learning	25	Extensive use of journals, standards, and technical resources	Moderate technical references used	Very limited references
3.	Experimental / Analytical Evaluation	20	Accurate analysis and interpretation of results	Partial analysis performed	Weak evaluation
4.	Sustainability & Societal Impact Assessment	15	Environmental and societal impacts comprehensively evaluated	Basic discussion provided	Poor explanation
5.	Presentation & Technical Communication	20	Highly effective communication with strong technical clarity	Acceptable presentation quality	Poor presentation skills
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
CO1	14	14	—	—	10	2
CO2	10	36	—	—	20	2
CO3	36	10	—	—	20	2
CO4	—	—	40	—	25	3
CO5	—	—	—	40	25	3
Total	60	60	40	40	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26THE07	DESIGN AND ANALYSIS OF TURBO MACHINES		SEMESTER		II
Prerequisites		Category	ES(PE)	Credits	3
- Engineering Thermodynamics - Fluid Mechanics - Heat Transfer fundamentals		Hours/ Semester	L	T	P
			45	0	0
COURSE OBJECTIVES					
1.	To analyze the energy transfer mechanisms and thermodynamic principles governing turbo machines.				
2.	To evaluate the operating characteristics and performance of compressors and turbines.				
3.	To analyze combustion systems and propulsion cycles used in turbo machinery applications.				
4.	To design turbo machine components and evaluate their performance under varying operating conditions.				
5.	To investigate contemporary developments in gas turbines and propulsion systems for sustainable energy applications.				
UNIT - I	INTRODUCTION				9
Basics of isentropic flow — static and stagnation properties — diffuser and nozzle configurations — area ratio — mass flow rate — critical properties — energy transfer between fluid and rotor — velocity triangles for generalized turbo machines — velocity diagrams — Euler's equation for turbo machines and its different forms — degree of reaction in turbo machines — various efficiencies: isentropic, mechanical, thermal, overall and polytropic.					
UNIT - II	CENTRIFUGAL AND AXIAL FLOW COMPRESSORS				9
Centrifugal compressor — configuration and working — slip factor — work input factor — ideal and actual work — pressure coefficient — pressure ratio — axial flow compressor — geometry and working — velocity diagrams — ideal and actual work — stage pressure ratio — free vortex theory — performance curves and losses.					
UNIT - III	COMBUSTION CHAMBER				9
Basics of combustion — structure and working of combustion chamber — combustion chamber arrangements — flame stability — fuel injection nozzles — flame stabilization — cooling of combustion chamber.					
UNIT - IV	AXIAL AND RADIAL FLOW TURBINES				9
Elementary theory of axial flow turbines — stage parameters — multi-staging — stage loading and flow coefficients — degree of reaction — stage temperature and pressure ratios — single and twin spool arrangements — performance — matching of components — blade cooling — radial flow turbines.					
UNIT - V	GAS TURBINE AND JET ENGINE CYCLES				9
Gas turbine cycle analysis — simple and actual cycles — reheated, regenerative and intercooled cycles for power plants — working of turbojet, turbofan, turboprop, ramjet, scramjet and pulsejet engines — cycle analysis — thrust, specific impulse, specific fuel consumption, thermal and propulsive efficiencies					
Total:45 Hours					
Weightage:					
Continuous Assessment 40%					
End Semester Examinations 60%					

REFERENCE BOOKS:

1.	Dixon, S.L. and Hall, C., Fluid Mechanics and Thermodynamics of Turbomachinery, 8th Edition, Butterworth-Heinemann, 2023.
2.	Cohen, H., Rogers, G.F.C. and Saravanamuttoo, H.I.H., Gas Turbine Theory, 7th Edition, Pearson, 2020.
3.	Mattingly, J.D., Elements of Gas Turbine Propulsion, McGraw Hill, 2019.
4.	Logan, E. Jr., Handbook of Turbomachinery, CRC Press, 2021.
5.	Yahya, S.M., Turbines, Compressors and Fans, 5th Edition, McGraw Hill, 2018.

E-RESOURCES:

1.	NPTEL – Turbo Machines
2.	NPTEL – Aircraft Propulsion
3.	MIT Open CourseWare – Gas Turbine Engineering

COURSE OUTCOMES (COs) /**At the end of the course, the students will have the ability to****Mapping
POs****Mapping
PSOs**

CO1	Analyze the thermodynamic principles, velocity triangles, and energy transfer mechanisms in turbo machines for performance evaluation.	PO1, PO3	PSO1
CO2	Evaluate the operating characteristics and performance parameters of centrifugal, axial flow compressors, and combustion chambers under varying conditions.	PO1, PO3	PSO1
CO3	Analyze the aerodynamic behavior, stage performance, and flow characteristics of axial and radial flow turbines for efficient energy conversion.	PO1, PO3	PSO1
CO4	Design and develop turbo machine components or experimental models for compressors, turbines, or combustion systems considering engineering constraints and operational efficiency through model-building/project activities.	PO1, PO2, PO3	PSO1, PSO2
CO5	Evaluate the performance of gas turbine and jet propulsion systems through seminar, project, or open-ended experimental investigations considering sustainability, fuel economy, and industrial applications.	PO1, PO2, PO3	PSO1, PSO2

The Course Articulation Matrix (CAM) for defined COs

	PO1	PO2	PO3	PSO1	PSO2
CO1	2	—	3	3	—
CO2	3	—	3	3	—
CO3	2	—	3	3	—
CO4	3	2	3	2	3
CO5	3	3	3	2	3
AVERAGE	2.6	2.5	3.0	2.6	3.0

Activities:

1.	Design and Development of Turbo Machinery Components / Experimental Models (CO4)
2.	Seminar on Contemporary Developments in Turbo Machinery and Propulsion Systems (CO5) (Independent study)

Rubrics for evaluation: CO4

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Problem Identification & Objective Formulation	20	Problem clearly identified with measurable objectives	Objectives reasonably defined	Problem statement unclear
2.	Design Methodology & Engineering Analysis	25	Systematic design with accurate technical analysis	Minor design or analytical errors	Weak or incomplete analysis
3.	Model Development / Experimental Setup	25	Functional and innovative model successfully developed	Model functional with minor issues	Incomplete or poorly functioning model
4.	Interpretation of Results & Feasibility Analysis	15	Results critically interpreted with engineering justification	Basic interpretation provided	Poor interpretation
5.	Report Documentation & Presentation	15	Professional report and effective presentation	Adequate documentation and presentation	Poor communication and formatting
	Total	100			

Rubrics for evaluation: CO5

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Understanding of Turbo Machinery Concepts	20	Concepts explained critically with strong technical depth	Adequate understanding demonstrated	Limited understanding
2.	Literature Review & Self-Learning	25	Extensive use of journals, standards, and technical references	Moderate technical references used	Very limited references
3.	Experimental / Analytical Evaluation	20	Accurate analysis and interpretation of results	Partial analysis performed	Weak evaluation
4.	Sustainability & Industrial Relevance	15	Industrial applications and sustainability aspects comprehensively evaluated	Basic discussion provided	Poor explanation
5.	Presentation & Technical Communication	20	Highly effective communication with technical clarity	Acceptable presentation quality	Poor presentation skills
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
CO1	14	14	—	—	10	2
CO2	10	36	—	—	20	2
CO3	36	10	—	—	20	2
CO4	—	—	40	—	25	3
CO5	—	—	—	40	25	3
Total	60	60	40	40	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26THE08	COMBUSTION IN IC ENGINES		SEMESTER		II	
Prerequisites		Category	ES(PE)	Credits		3
- Engineering Thermodynamics - Heat Transfer - Fluid Mechanics - Internal Combustion Engines - Fundamentals of Chemical Thermodynamics		Hours/ Semester	L	T	P	TH
			45	0	0	45
COURSE OBJECTIVES						
1.	To analyze the combustion characteristics and thermodynamic principles governing IC engine combustion processes.					
2.	To evaluate fuel-air mixture preparation, ignition phenomena, combustion chamber design, and emission formation mechanisms in SI and CI engines.					
3.	To analyze advanced combustion concepts, fuel injection systems, and heat release characteristics for enhanced engine performance.					
4.	To design combustion-related experimental setups and develop engineering solutions for improved combustion efficiency and emission reduction.					
5.	To investigate contemporary combustion technologies, alternative fuels, low-temperature combustion strategies, and emission control techniques for sustainable IC engine applications.					
UNIT - I	ENGINE BASICS & LOW TEMPERATURE REACTIONS					9
Principles of engine operation — torque and power characteristics — intake and exhaust flows — fuel characteristics — stoichiometric and equivalence ratios — combustion thermodynamics — low-temperature reaction mechanisms — ignition delay — heat release analysis — introduction to hydrogen-assisted combustion and synthetic fuels.						
UNIT - II	COMBUSTION IN SI ENGINES					9
Combustion in spark ignition engines — homogeneous and stratified charge combustion — flame propagation — abnormal combustion — detonation and pre-ignition — combustion chamber design — turbulence effects — emission formation and control — gasoline direct injection (GDI) systems — lean burn combustion strategies.						
UNIT - III	COMBUSTION IN CI ENGINES					9
Stages of combustion — delay period measurement — fuel injection characteristics — atomization and spray formation — combustion chamber design — combustion rates — diesel combustion modeling — exhaust emissions — smoke formation — biodiesel and renewable diesel combustion characteristics.						
UNIT - IV	COMBUSTION CONCEPTS IN LOW TEMPERATURE IC ENGINES					9
HCCI combustion — PCCI combustion — RCCI combustion — dual-fuel combustion — combustion instability — combustion noise — combustion diagnostics — optical combustion analysis — simulation-based combustion analysis using modern engineering tools.						
UNIT - V	EMISSIONS, ALTERNATIVE FUELS AND SUSTAINABILITY					9
Emission formation mechanisms — NOx, HC, CO, PM emissions — catalytic converters — EGR systems — SCR systems — combustion optimization for emission reduction — alternative fuels: hydrogen, methanol, ethanol, ammonia, biodiesel — sustainability aspects of IC engines — future mobility and net-zero emission technologies.						
L:45 Total:45 Hours						

Weightage:

Continuous Assessment 40%

End Semester Examinations 60%

REFERENCE BOOKS:

- | | |
|----|--|
| 1. | Heywood, J.B., Internal Combustion Engine Fundamentals, 2nd Edition, McGraw Hill Education, 2018. |
| 2. | Turns, S.R., An Introduction to Combustion: Concepts and Applications, 4th Edition, McGraw Hill, 2021. |
| 3. | Stone, R., Introduction to Internal Combustion Engines, 5th Edition, Palgrave Macmillan, 2012. |
| 4. | Obert, E.F., Internal Combustion Engines and Air Pollution, Harper & Row Publishers, 2018. |
| 5. | Pulkrabek, W.W., Engineering Fundamentals of the Internal Combustion Engine, 3rd Edition, Pearson Education, 2014. |

E-RESOURCES:

- | | |
|----|---|
| 1. | NPTEL – Internal Combustion Engines |
| 2. | NPTEL – Combustion and Flame |
| 3. | MIT OpenCourseWare – Combustion |
| 4. | SAE International – Technical Papers on IC Engines and Combustion Systems |

COURSE OUTCOMES (COs) /**At the end of the course, the students will have the ability to****Mapping
POs****Mapping
PSOs**

CO1	Analyze combustion thermodynamics, ignition phenomena, flame propagation, and heat release mechanisms in SI and CI engines for performance evaluation.	PO1, PO3	PSO1
CO2	Evaluate combustion chamber characteristics, fuel injection systems, abnormal combustion behavior, and emission formation under varying engine operating conditions.	PO1, PO3	PSO1
CO3	Analyze advanced combustion concepts, low-temperature combustion strategies, and alternative fuel combustion characteristics for efficient and sustainable engine operation.	PO1, PO3	PSO1
CO4	Design and develop combustion-related experimental setups, working models, or simulation-based combustion studies for IC engine applications considering engineering and environmental constraints through project/model-building activities.	PO1, PO2, PO3	PSO1, PSO2
CO5	Evaluate contemporary combustion technologies, emission reduction strategies, and sustainable IC engine systems through seminar, open-ended experimental investigations, or industry case studies considering societal and environmental impacts.	PO1, PO2, PO3	PSO1, PSO2

The Course Articulation Matrix (CAM) for defined COs

	PO1	PO2	PO3	PSO1	PSO2
CO1	2	—	3	3	—
CO2	3	—	3	3	—
CO3	2	—	3	3	—
CO4	3	2	3	2	3
CO5	3	3	3	2	3
AVERAGE	2.6	2.5	3.0	2.6	3.0

Activities:

1.	Design and Development of Combustion Chamber / Fuel Injection / Alternative Fuel Experimental Model (CO4)
2.	Technical Seminar Presentation on Contemporary Combustion Technologies and Sustainable IC Engine Systems (CO5) (Independent study)

Rubrics for evaluation: CO4

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Problem Identification & Objective Formulation	20	Clearly defined engineering problem with measurable objectives	Objectives reasonably defined	Problem statement unclear
2.	Design Methodology & Technical Analysis	25	Accurate design methodology with strong engineering analysis	Minor technical errors	Weak/incomplete analysis
3.	Model Development / Experimental Setup	25	Functional and innovative model successfully developed	Functional with minor issues	Poorly functioning model
4.	Result Interpretation & Sustainability Consideration	15	Results critically analyzed with sustainability justification	Basic interpretation	Poor interpretation
5.	Technical Report & Presentation	15	Professional documentation and excellent presentation	Adequate presentation	Poor communication
	Total	100			

Rubrics for evaluation: C05

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Understanding of Combustion Concepts	20	Strong technical depth and critical understanding	Adequate understanding	Limited understanding
2.	Literature Review & Self-Learning	25	Extensive use of journals and technical references	Moderate references	Very limited references
3.	Experimental / Industrial Analysis	20	Accurate analysis and interpretation	Partial analysis	Weak evaluation
4.	Sustainability & Environmental Impact	15	Comprehensive sustainability assessment	Basic discussion	Poor explanation
5	Technical Communication & Presentation	20	Highly effective communication and presentation	Acceptable presentation	Poor presentation
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
C01	14	14	—	—	10	2
C02	10	36	—	—	20	2
C03	36	10	—	—	20	2
C04	—	—	40	—	25	3
C05	—	—	—	40	25	3
Total	60	60	40	40	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26THE09	WASTE TO ENERGY		SEMESTER			II
Prerequisites		Category	ES(PE)	Credits		3
- Engineering Thermodynamics - Heat Transfer - Fluid Mechanics - Energy Engineering Fundamentals - Environmental Engineering Basics		Hours/ Semester	L	T	P	TH
			45	0	0	45
COURSE OBJECTIVES						
1.	To analyze various waste resources and their energy conversion potential for sustainable energy generation.					
2.	To evaluate biomass conversion technologies, gasification systems, and pyrolysis processes under varying operating conditions.					
3.	To analyze combustion, biochemical, and thermochemical waste to energy conversion mechanisms for efficient energy recovery.					
4.	To design and develop waste-to-energy systems, working models, or experimental setups considering environmental and operational constraints.					
5.	To investigate contemporary waste-to-energy technologies, industrial applications, and sustainability practices for circular economy and net-zero energy systems.					
UNIT - I	INTRODUCTION TO EXTRACTION OF ENERGY FROM WASTE					9
Classification of waste as fuel — agro waste, forest residue, industrial waste, municipal solid waste (MSW) — waste characterization techniques — conversion devices — incinerators, gasifiers, digesters — waste handling and pre—processing techniques — RDF preparation.						
UNIT - II	BIOMASS PYROLYSIS					9
Pyrolysis principles — slow, fast, and flash pyrolysis — manufacture of charcoal — pyrolysis oil production — yields and applications — biochar production — reactor configurations — thermal degradation kinetics — product upgrading techniques.						
UNIT - III	BIOMASS GASIFICATION					9
Gasifiers — fixed bed, fluidized bed, downdraft and updraft gasifiers — gasification chemistry — gasification kinetics — producer gas cleaning — gasifier burner arrangement for thermal heating — gasifier engine arrangement and electrical power generation — gasification efficiency and performance analysis.						
UNIT - IV	BIOMASS COMBUSTION					9
Biomass stoves — improved chulhas — types and combustion characteristics — fixed bed combustion — fluidized bed combustion — combustion and operation of biomass combustors — emission formation — co-firing of biomass with coal — waste heat recovery systems.						
UNIT - V	BIO ENERGY AND SUSTAINABILITY					9
Properties of biomass — biomass resources and composition — biogas plant technology and operation — bioenergy systems — digestion and constructional features — biomass resources and classification — biomass conversion processes — thermo-chemical conversion — direct combustion — biomass gasification — pyrolysis and liquefaction — biochemical conversion.						
L:45 Total:45 Hours						

Weightage:

Continuous Assessment 40%

End Semester Examinations 60%

REFERENCE BOOKS:

1.	Khandelwal, K.C. and Mahdi, S.S., Biogas Technology – A Practical Handbook, Tata McGraw Hill Publishing Co. Ltd., 2019.
2.	Rezaiyan, J. and Cheremisinoff, N.P., Gasification Technologies: A Primer for Engineers and Scientists, CRC Press, 2020.
3.	Basu, P., Biomass Gasification, Pyrolysis and Torrefaction, 3rd Edition, Academic Press, 2018.
4.	Bridgwater, A.V., Biomass Fast Pyrolysis, CPL Press, 2019.
5.	Rao, S. and Parulekar, B.B., Energy Technology, Khanna Publishers, 2017.

E-RESOURCES:

1.	NPTEL – Biomass Energy Conversion Technologies
2.	MIT OpenCourseWare – Sustainable Energy Systems
3.	NPTEL – Renewable Energy Engineering
4.	ASME Digital Collection – Energy Conversion and Biomass Systems
5.	IEA Bioenergy Task Reports

COURSE OUTCOMES (COs) /**At the end of the course, the students will have the ability to****Mapping
POs****Mapping
PSOs**

CO1	Analyze waste characteristics, biomass properties, and thermochemical conversion principles for sustainable energy generation applications.	PO1, PO3	PSO1
CO2	Evaluate the performance of biomass pyrolysis, gasification, and combustion systems under varying operating and environmental conditions.	PO1, PO3	PSO1
CO3	Analyze biochemical and thermo-chemical waste-to-energy conversion technologies, emission characteristics, and energy recovery mechanisms for efficient resource utilization.	PO1, PO3	PSO1
CO4	Design and develop waste-to-energy systems, working models, or experimental setups for biomass conversion and energy recovery considering engineering, environmental, and sustainability constraints through project/model-building activities.	PO1, PO2, PO3	PSO1, PSO2
CO5	Evaluate contemporary waste-to-energy technologies, industrial case studies, and sustainable bioenergy systems through seminar, open-ended experimental investigations, or industry-oriented studies considering societal and environmental impacts.	PO1, PO2, PO3	PSO1, PSO2

The Course Articulation Matrix (CAM) for defined COs

	P01	P02	P03	PS01	PS02
CO1	2	—	3	3	—
CO2	3	—	3	3	—
CO3	2	—	3	3	—
CO4	3	2	3	2	3
CO5	3	3	3	2	3
AVERAGE	2.6	2.5	3.0	2.6	3.0

Activities:

1.	Design and Development of Biomass Gasifier / Pyrolysis Reactor / Waste to Energy Experimental Model (CO4)
2.	Technical Seminar Presentation on Waste to Energy Technologies and Sustainable Bioenergy Systems (CO5)

Rubrics for evaluation: CO4

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Problem Identification & Objective Formulation	20	Clearly defined engineering problem with measurable objectives	Objectives reasonably defined	Problem statement unclear
2.	Design Methodology & Technical Analysis	25	Accurate design methodology with strong engineering analysis	Minor technical errors	Weak/incomplete analysis
3.	Model Development / Experimental Setup	25	Functional and innovative model successfully developed	Functional with minor issues	Poorly functioning model
4.	Result Interpretation & Sustainability Consideration	15	Results critically analyzed with sustainability justification	Basic interpretation	Poor interpretation
5	Technical Report & Presentation	15	Professional documentation and excellent presentation	Adequate presentation	Poor communication
	Total	100			

Rubrics for evaluation: C05

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Understanding of Combustion Concepts	20	Strong technical depth and critical understanding	Adequate understanding	Limited understanding
2.	Literature Review & Self-Learning	25	Extensive use of journals and technical references	Moderate references	Very limited references
3.	Experimental / Industrial Analysis	20	Accurate analysis and interpretation	Partial analysis	Weak evaluation
4.	Sustainability & Environmental Impact	15	Comprehensive sustainability assessment	Basic discussion	Poor explanation
5.	Technical Communication & Presentation	20	Highly effective communication and presentation	Acceptable presentation	Poor presentation
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
CO1	14	14	—	—	10	2
CO2	10	36	—	—	20	2
CO3	36	10	—	—	20	2
CO4	—	—	40	—	25	3
CO5	—	—	—	40	25	3
Total	60	60	40	40	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26THE10	ADVANCED REFRIGERATION SYSTEMS			SEMESTER		II		
Prerequisites				Category	ES(PE)	Credits	3	
- Engineering Thermodynamics - Refrigeration and Air Conditioning - Heat Transfer - Basic Knowledge of HVAC Systems - Renewable Energy Applications				Hours/ Semester	L	T	P	TH
					45	0	0	45
COURSE OBJECTIVES								
1.	To impart knowledge on thermodynamic principles, refrigeration cycles, refrigerants, and environmental impacts of refrigeration systems.							
2.	To explain the working principles, components, and performance of solar refrigeration and cooling technologies.							
3.	To analyze low-temperature refrigeration, cryogenic systems, and gas liquefaction cycles.							
4.	To study advanced refrigeration systems including supercritical CO ₂ , magnetic, thermoelectric, vortex tube, pulse tube, and thermo-acoustic refrigeration.							
5.	To evaluate refrigeration system controls, cooling load estimation, system performance, and energy conservation techniques.							
UNIT - I		INTRODUCTION						9
Carnot cycle – Refrigerator – Heat pump – Heat transformer – Refrigerants: classification and historical developments – Low GWP and natural refrigerants – Environmental impacts – Thermodynamic processes – Energy and exergy analysis of refrigeration systems.								
UNIT - II		SOLAR REFRIGERATION SYSTEMS						9
Solar thermal collectors – Thermal energy storage (Sensible, Latent and Thermochemical) – Solar absorption, adsorption, desiccant and ejector refrigeration systems – Photovoltaic (PV) driven vapour compression refrigeration systems – Thermoelectric refrigeration – Photovoltaic thermal (PVT) systems – Performance, energy, environmental and thermo-economic analysis of solar refrigeration systems.								
UNIT - III		LOW TEMPERATURE REFRIGERATION						9
Low temperature refrigeration and cryogenics – Temperature limits and applications of low temperature refrigeration – Joule–Thomson effect and inversion temperature – Carnot, Linde–Hampson and Claude liquefaction cycles – Figure of Merit (FOM) and yield of liquefaction systems – Components and performance of gas liquefaction systems.								
UNIT - IV		OTHER REFRIGERATION SYSTEMS						9
Introduction to Supercritical CO ₂ refrigeration system – Vapour absorption refrigeration system – Steam jet refrigeration system – Thermoelectric refrigeration – Vortex tube refrigeration – Magnetic refrigeration – Pulse tube refrigeration – Thermo-acoustic refrigeration – Applications and performance characteristics of advanced refrigeration systems.								
UNIT - V		REFRIGERATION SYSTEM CONTROLS AND PERFORMANCE						9
Electrical controls – Thermostats, pressure switches, relays and motor protection devices – System balancing and matching of condensing unit with evaporator – Performance evaluation of refrigeration systems – Cooling load estimation – Heat gain through transmission, infiltration and product load – Energy conservation techniques in refrigeration systems.								
Total:45 Hours								

Weightage:

Continuous Assessment 40%

End Semester Examinations 60%

REFERENCE BOOKS:

- | | |
|---|--|
| 1 | Arora, R.C., Refrigeration & Air Conditioning, PHI Pvt Ltd, 2010 |
| 2 | Principles of Refrigeration by Roy J. Dossat and Thomas J. Horan, Pearson, 2019. |
| 3 | Solar Refrigeration and Air Conditioning by C.P. Arora, McGraw Hill, 2021. |
| 4 | Refrigeration and Air Conditioning by R.S. Khurmi and J.K. Gupta, S. Chand Publications, 2020. |

E-RESOURCES:

- | | |
|---|---|
| 1 | NPTEL – Solar Energy Engineering |
| 2 | NPTEL – Refrigeration and Air Conditioning |
| 3 | MIT Open CourseWare – Solar Energy Systems |
| 4 | ASHRAE – Technical Resources on HVAC and Refrigeration Systems |
| 5 | International Energy Agency – Solar Heating and Cooling Programme |

COURSE OUTCOMES (COs) /**At the end of the course, the students will have the ability to****Mapping
POs****Mapping
PSOs**

- | | | | |
|------------|---|---------------------|---------------|
| CO1 | Apply power circuit rules, semiconductor thresholds, and digital logic gate steps to model electrical loops. | PO1,
PO3 | PSO1,
PSO2 |
| CO2 | Analyze sensor waveform frequencies, calibration scaling, and brushless actuator displacement fields. | PO1,
PO3 | PSO1 |
| CO3 | Analyze engine spark timing calculations, dwell angles, map lookup variables, and combined controls. | PO1,
PO3 | PSO1 |
| CO4 | Apply specialized electronic control design software, powertrain scripting toolsets, or calibration scripts to calculate injection pulse volumes. | PO1,
PO2,
PO3 | PSO1,
PSO2 |
| CO5 | Evaluate common rail dynamics, piezo stacks, heat release profiles, and common-pump flows via an independent seminar study. | PO1,
PO2,
PO3 | PSO1,
PSO2 |

The Course Articulation Matrix (CAM) for defined COs

COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	2	—	2	2	2
CO2	2	—	2	2	—
CO3	2	—	2	2	—
CO4	3	3	3	3	3
CO5	3	3	3	2	3
AVERAGE	2.4	3.0	2.4	2.2	2.7

Activities:

1. Comparative analysis of advanced refrigeration systems such as Supercritical CO₂, Magnetic, Pulse Tube, Thermoelectric, Steam Jet, and Vapour Absorption refrigeration using simulation tools or industrial case studies.
2. Cooling load estimation and performance evaluation of a refrigeration or HVAC system, including system balancing, energy conservation analysis, and controller selection.

Rubrics for evaluation: C04

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Technical Understanding	20	Comprehensive and accurate analysis	Good understanding with minor errors	Basic understanding
2.	Industrial Data Analysis	20	Excellent interpretation using real data	Adequate analysis	Limited interpretation
3.	Sustainability & Economic Evaluation	20	Strong techno-economic assessment	Moderate evaluation	Limited discussion
4.	Presentation & Communication	20	Highly professional and engaging	Clear communication	Moderate delivery
5.	Report Quality & References	20	Well-organized with quality references	Adequate documentation	Basic report structure
	Total	100			

Rubrics for evaluation: C05

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Innovation & Design	20	Highly innovative and optimized	Good design methodology	Conventional approach
2.	Functionality of Prototype / Model	20	Fully functional and reliable	Functional with minor issues	Partially functional
3.	Engineering Analysis	20	Strong theoretical and experimental validation	Adequate validation	Limited analysis
4.	Use of Modern Tools	20	Effective use of modern tools	Moderate use	Minimal usage
5.	Documentation & Demonstration	20	Excellent report and demonstration	Good documentation	Basic presentation
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

CO	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
CO1	14	14	—	—	10	2
CO2	10	36	—	—	20	2
CO3	36	10	—	—	20	2
CO4	—	—	40	—	25	3
CO5	—	—	—	40	25	3
Total	60	60	40	40	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26THE11		ENVIRONMENTAL AND POLLUTION CONTROL		SEMESTER		III	
Prerequisites			Category	ES(PE)	Credits		3
- Environmental Engineering - Heat Transfer - Fluid Mechanics			Hours/ Semester	L	T	P	TH
				45	0	0	45
COURSE OBJECTIVES							
1.	To impart advanced knowledge on environmental pollution, climate change and sustainable environmental practices.						
2.	To explain the sources, effects and control techniques of air pollution and atmospheric contaminants.						
3.	To develop understanding of water pollution monitoring, treatment technologies and wastewater management.						
4.	To provide knowledge on solid, hazardous and industrial waste management systems.						
5.	To enable students to analyze modern environmental protection technologies and pollution control strategies.						
UNIT - I		ENVIRONMENTAL SCIENCE AND SUSTAINABILITY					9
Global environmental issues – Climate change and greenhouse effect – Ozone depletion – Carbon footprint – Environmental chemistry and ecology – Material and energy balance – Environmental legislations and standards – Sustainable development goals – Environmental impact assessment.							
UNIT - II		AIR POLLUTION AND CONTROL TECHNOLOGIES					9
Sources and classification of air pollutants – Atmospheric dispersion – Indoor air quality – Air pollution meteorology – Particulate and gaseous pollutants – Air sampling and monitoring – Electrostatic precipitators, scrubbers and filters – Noise pollution and control techniques – Industrial case studies.							
UNIT - III		WATER AND WASTEWATER TREATMENT					9
Water resources and water quality standards – Physical, chemical and biological characteristics of wastewater – Water treatment systems – Industrial wastewater treatment – Sludge treatment and disposal – Membrane separation technologies – Monitoring and compliance with environmental standards.							
UNIT - IV		SOLID AND HAZARDOUS WASTE MANAGEMENT					9
Solid waste generation and characterization – Hazardous waste management – Biomedical and e-waste management – Collection, transportation and processing methods – Recycling and resource recovery – Waste minimization techniques – Energy recovery from waste – Environmental safety practices.							
UNIT - V		MODERN ENVIRONMENTAL PROTECTION TECHNOLOGIES					9
Pollution prevention technologies – Cleaner production techniques – Radiation pollution and control – Environmental monitoring instruments – GIS and remote sensing applications – Smart environmental management systems – AI and IoT in pollution monitoring – Recent advancements and industrial applications.							
Total:45 Hours							
Weightage:							
Continuous Assessment 40%							
End Semester Examinations 60%							

REFERENCE BOOKS:

1. Peavy H.S., Rowe D.R. and Tchobanoglous G., Environmental Engineering, McGraw Hill, 2017.
2. Gilbert M. Masters, Introduction to Environmental Engineering and Science, Pearson Education, 2018.
3. Arcadio P. Sincero and Gregoria A. Sincero, Environmental Engineering – A Design Approach, Prentice Hall, 2016.
4. Bishop P., Pollution Prevention: Fundamentals and Practice, McGraw Hill, 2015.
5. Rao C.S., Environmental Pollution Control Engineering, New Age International, 2017.
6. Tchobanoglous G., Integrated Solid Waste Management, McGraw Hill, 2018.

E-RESOURCES:

1. NPTEL – Environmental Engineering
2. NPTEL – Air Pollution and Control
3. MIT OpenCourseWare – Environmental Systems
4. CPCB Environmental Standards and Guidelines
5. UNEP Environmental Management Resources

COURSE OUTCOMES (COs) /**At the end of the course, the students will have the ability to****Mapping
POs****Mapping
PSOs****CO1**

Apply principles of environmental science, pollution control, waste management, sustainability, and modern environmental protection technologies to solve environmental engineering problems.

PO1

PSO1

CO2

Analyze environmental issues, pollutant characteristics, treatment processes, waste management practices, and monitoring systems using appropriate engineering and scientific methods.

PO1,
PO2

PSO1

CO3

Evaluate the performance of air pollution control systems, water and wastewater treatment processes, waste management techniques, and environmental protection technologies against regulatory and sustainability requirements.

PO1,
PO2,
PO3

PSO1

CO4

Design suitable environmental management strategies, pollution control systems, and resource recovery solutions for industrial and societal applications

PO1,
PO2,
PO3PSO1,
PSO2**CO5**

Investigate complex environmental problems using environmental monitoring tools, GIS, remote sensing, AI, IoT, and emerging technologies to support decision-making and sustainable development.

PO1,
PO2,
PO3PSO1,
PSO2

The Course Articulation Matrix (CAM) for defined COs

COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	3	—	—	3	—
CO2	3	3	—	2	—
CO3	2	3	2	2	—
CO4	2	2	3	2	3
CO5	2	3	2	2	3
AVERAGE	2.4	2.8	2.3	2.2	3.0

Activities:

1.	Environmental Management Case Study and Solution Design
2.	Emerging Technology Review and Environmental Innovation Project

Rubrics for evaluation: CO4

Sl. No.	Criterion	Marks	Excellent (14–20)	Good (7–13)	Satisfactory (1–6)
1.	Problem Identification	20	Extensive and relevant sources reviewed	Good literature coverage	Insufficient review
2.	Technical Analysis	20	Demonstrates deep understanding	Good understanding	Weak understanding
3.	Solution Design	20	Comprehensive comparison and evaluation	Good evaluation	Little evaluation
4.	Sustainability Consideration	20	Highly innovative and practical	Practical with moderate innovation	No innovation
5.	Presentation and Documentation	20	Excellent clarity and response to questions	Good presentation	Poor presentation
	Total	100			

Rubrics for evaluation: CO5

Sl. No.	Criterion	Marks	Excellent (14–20)	Good (7–13)	Satisfactory (1–6)
1.	Literature Survey	20	Extensive and relevant sources reviewed	Good literature coverage	Insufficient review
2.	Technical Understanding	20	Demonstrates deep understanding	Good understanding	Weak understanding
3.	Critical Evaluation	20	Comprehensive comparison and evaluation	Good evaluation	Little evaluation
4.	Innovation & Applicability	20	Highly innovative and practical	Practical with moderate innovation	No innovation

5.	Presentation & Discussion	20	Excellent clarity and response to questions	Good presentation	Poor presentation
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
CO1	18	12	–	–	12	2
CO2	12	30	–	–	18	2
CO3	30	18	–	–	20	2
CO4	–	–	40	–	25	2
CO5	–	–	–	40	25	2
Total	60	60	40	40	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26THE12	NANOTECHNOLOGY		SEMESTER			III
Prerequisites		Category	ES(PE)	Credits		3
- Engineering Materials - Applied Physics - Material Science		Hours/ Semester	L	T	P	TH
			45	0	0	45
COURSE OBJECTIVES						
1.	To impart advanced knowledge on nanoscience, nanomaterials and their engineering applications.					
2.	To explain modern synthesis and fabrication techniques of nanomaterials and nanostructures.					
3.	To develop understanding of characterization methods used for nano-scale materials and devices.					
4.	To provide knowledge on nano sensors, nano devices and MEMS/NEMS technologies.					
5.	To enable students to analyze nanofluids, nano systems and emerging nanotechnology applications					
UNIT - I	FUNDAMENTALS OF NANOTECHNOLOGY					9
Introduction to nanotechnology – Evolution and importance of nanoscience – Bottom-up and top-down approaches – Size dependent properties of nanomaterials – Electronic, optical, magnetic, thermal and mechanical properties – Quantum confinement – Nano structures and applications in engineering systems.						
UNIT - II	SYNTHESIS AND FABRICATION OF NANOMATERIALS					9
Physical synthesis methods – Ball milling – Inert gas condensation – Chemical vapour deposition – Electrochemical synthesis – Sol-gel techniques – Nanolithography – E-beam and ion beam lithography – Thin film deposition – Oxidation and metallization processes – Industrial fabrication methods.						
UNIT - III	CHARACTERIZATION OF NANOMATERIALS					9
Scanning Electron Microscopy (SEM) – Transmission Electron Microscopy (TEM) – Scanning Probe Microscopy (SPM) – X-Ray Diffraction (XRD) – UV-Visible and IR spectroscopy – EDAX analysis – Surface characterization methods – Band gap measurements – Interpretation of nano-scale properties.						
UNIT - IV	NANO SENSORS AND NANO DEVICES					9
Micro and nano sensors – MEMS and NEMS technologies – Biosensors – Nano actuators – Packaging and integration techniques – Pressure and accelerometer sensors – Nano electronics – Smart sensor systems – Aerospace and biomedical applications – Nano cutting and nano machining tools.						
UNIT - V	NANOFLUIDS AND ADVANCED APPLICATIONS					9
Preparation and characterization of nanofluids – Brownian motion and heat transfer enhancement – Thermal conductivity of nanofluids – Applications in thermal systems – Nano coatings – Nano energy systems – Environmental and biomedical applications – Challenges, safety and ethical issues in nanotechnology.						
Total:45 Hours						
Weightage:						
Continuous Assessment 40%						
End Semester Examinations 60%						

REFERENCE BOOKS:

1.	B.S. Murthy, P. Shankar, Baldev Raj and James Murday, Text Book of Nanoscience and Nanotechnology, Universities Press, 2013.
2.	Guozhong Cao, Nanostructures and Nanomaterials: Synthesis, Properties and Applications, Imperial College Press, 2011.
3.	Bharat Bhushan, Springer Handbook of Nanotechnology, Springer, 2017.
4.	Charles P. Poole Jr. and Frank J. Owens, Introduction to Nanotechnology, Wiley, 2018.
5.	M.J. Madou, Fundamentals of Microfabrication and Nanotechnology, CRC Press, 2018.
6.	Rainer Waser, Nanoelectronics and Information Technology, Wiley-VCH, 2016.

E-RESOURCES:

1.	NPTEL – Nanotechnology and Nanoscience
2.	NPTEL – MEMS and NEMS
3.	MIT OpenCourseWare – Nanotechnology
4.	IEEE Nano Technology Resources
5.	ANSYS and COMSOL Tutorials for Nano System Simulation

COURSE OUTCOMES (COs) /**At the end of the course, the students will have the ability to****Mapping
POs****Mapping
PSOs**

CO1	Apply the fundamental concepts of nanotechnology and explain the size-dependent properties of nanomaterials in engineering applications.	PO1	PSO1
CO2	Analyze various synthesis and fabrication techniques used for the production of nanomaterials and nanostructures for engineering systems.	PO1, PO2	PSO1
CO3	Analyze characterization techniques to determine the structural, optical, thermal and surface properties of nanomaterials.	PO1, PO2	PSO1
CO4	Evaluate the performance of nano sensors, MEMS/NEMS devices and nano-electronic systems for industrial and biomedical applications.	PO1, PO2, PO3	PSO1, PSO2
CO5	Assess the thermal and functional characteristics of nanofluids and nano-enabled energy systems for engineering applications.	PO1, PO2, PO3	PSO1, PSO2

The Course Articulation Matrix (CAM) for defined COs

COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	3	—	—	3	—
CO2	2	3	—	2	—
CO3	3	3	—	3	—
CO4	2	3	2	2	3
CO5	1	2	2	2	3
AVERAGE	2.2	2.8	2.0	2.4	3.0

Activities:

1. Case study of a nano-enabled device/system
2. Analysis of nanofluid or nano-enabled energy system through literature survey, simulation, experimental data analysis, or case study.

Rubrics for evaluation: C04

Sl. No.	Criterion	Marks	Excellent (14–20)	Good (7–13)	Satisfactory (1–6)
1.	Understanding of Nano Device/Sensor	20	Demonstrates comprehensive understanding	Demonstrates adequate understanding	Demonstrates limited understanding
2.	Technical Analysis	20	Accurate and detailed analysis	Reasonably accurate analysis	Inadequate analysis
3.	Application Evaluation	20	Clearly evaluates engineering applications	Identifies applications with limited evaluation	Limited application understanding
4.	Safety & Ethical Considerations	20	Clearly discusses safety and ethical issues	Discusses some issues	Minimal discussion
5.	Presentation & Communication	20	Well-organized and effective	Moderately organized	Poorly organized
	Total	100			

Rubrics for evaluation: C05

Sl. No.	Criterion	Marks	Excellent (14–20)	Good (7–13)	Satisfactory (1–6)
1.	Literature Review	25	Uses relevant and sufficient sources	Uses adequate sources	Uses limited sources
2.	Technical Evaluation	25	Accurate and comprehensive evaluation	Reasonable evaluation	Inadequate evaluation
3.	Engineering Conclusions	25	Conclusions are well-supported	Conclusions are partially supported	Conclusions are weak
4.	Report & Presentation	25	Professional and clear	Acceptable quality	Poor quality
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

Test / Activity	Test I	Test II	Activity I	Activity II	Percentage Allocation	Mapping Strength
CO1	18	12	–	–	12	2
CO2	12	30	–	–	18	2
CO3	30	18	–	–	20	2
CO4	–	–	40	–	25	2
CO5	–	–	–	40	25	2
Total	60	60	40	40	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
 Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26THE13	SOLAR ENERGY FOR INDUSTRIAL PROCESS HEATING		SEMESTER		III		
Prerequisites			Category	ES(PE)	Credits	3	
- Thermodynamics - Heat Transfer - Renewable Energy Systems			Hours/ Semester	L	T	P	TH
				45	0	0	45
COURSE OBJECTIVES							
1.	To impart knowledge on the design, construction and performance of various solar thermal collectors.						
2.	To explain the working principles and applications of solar water heating systems.						
3.	To develop understanding of solar absorption cooling and refrigeration technologies.						
4.	To provide knowledge on solar powered vapor compression and hybrid cooling systems.						
5.	To enable students to analyze implementation techniques and modern applications of solar energy systems.						
UNIT - I	SOLAR THERMAL COLLECTORS						9
Solar radiation fundamentals – Solar thermal energy conversion – Flat plate collectors – Evacuated tube collectors – Concentrating collectors – Thermal performance analysis – Solar fluids and thermal storage systems – Design considerations – Industrial process heating applications.							
UNIT - II	SOLAR WATER HEATING SYSTEMS						9
Solar water heating principles – Integral collector storage systems – Thermosyphon systems – Open loop and closed loop systems – Drain down and drain back systems – Antifreeze systems – Solar heated pools and industrial water heating – Performance evaluation and energy efficiency analysis.							
UNIT - III	SOLAR ABSORPTION COOLING SYSTEMS						9
Principles of absorption refrigeration – Solar operated absorption cooling systems – Vapor absorption refrigeration cycle – Lithium bromide-water absorption system – Aqua-ammonia absorption system – Open cycle absorption and desorption cooling – Refrigerant storage systems – Solar cooling applications.							
UNIT - IV	SOLAR REFRIGERATION AND HYBRID COOLING SYSTEMS						9
Vapor compression refrigeration systems – Solar assisted vapor compression systems – Rankine and Stirling cycle based cooling systems – Hybrid refrigeration systems – Thermal modelling of solar refrigeration – Continuous and intermittent cooling systems – Solar air-conditioning technologies.							
UNIT - V	IMPLEMENTATION TECHNIQUES AND MODERN APPLICATIONS						9
PV powered refrigeration systems – Solar thermoelectric cooling – Free cooling systems – Energy economics of solar cooling systems – Thermal energy storage – Smart solar monitoring systems – AI and IoT in solar thermal applications – Industrial case studies and recent advancements.							
Total:45 Hours							
Weightage:							
Continuous Assessment 40%							
End Semester Examinations 60%							

REFERENCE BOOKS:

1.	Duffie J.A. and Beckman W.A., Solar Engineering of Thermal Processes, Wiley, 2019.
2.	ASHRAE Handbook – HVAC Systems and Equipment, ASHRAE Publications, 2021.
3.	McVeigh J.C. and Sayigh A.A.M., Solar Air Conditioning and Refrigeration, Pergamon Press, 2017.
4.	Rakosh Das Begamudre, Energy Conversion Systems, New Age International, 2018.
5.	Reinhard Radermacher, Absorption Chillers and Heat Pumps, CRC Press, 2016.
6.	Tom P. Hough, Solar Energy: New Research, Nova Publishers, 2019.

E-RESOURCES:

1.	NPTEL – Solar Energy Engineering
2.	NPTEL – Refrigeration and Air Conditioning
3.	MIT OpenCourseWare – Renewable Energy Systems
4.	IEA Solar Heating and Cooling Programme
5.	ANSYS Fluent Tutorials for Solar Thermal Analysis

COURSE OUTCOMES (COs) /**At the end of the course, the students will have the ability to****Mapping
POs****Mapping
PSOs**

CO1	Apply principles of solar thermal energy conversion, heat transfer, thermodynamics, and refrigeration engineering to analyze the performance of solar collectors, water heating systems, cooling systems, refrigeration systems, and thermal storage technologies.	PO2	PSO1
CO2	Analyze the operational characteristics, energy flow mechanisms, system configurations, and performance factors influencing solar thermal heating, cooling, refrigeration, and hybrid energy systems under varying conditions.	PO1	PSO1
CO3	Evaluate the technical performance, energy efficiency, economic viability, environmental benefits, and sustainability of solar thermal heating, cooling, refrigeration, and smart energy systems for practical applications.	PO3	PSO1, PSO2
CO4	Design integrated solar thermal heating, cooling, and refrigeration systems incorporating collectors, thermal storage units, hybrid configurations, and advanced control strategies for industrial and commercial applications.	PO2	PSO1, PSO2
CO5	Investigate the performance, reliability, optimization opportunities, and techno-economic aspects of solar thermal and refrigeration systems through experimental studies, simulations, and industrial case analyses.	PO1	PSO1, PSO2

The Course Articulation Matrix (CAM) for defined COs

COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	—	3	—	3	—
CO2	3	—	—	3	—
CO3	—	—	3	2	3
CO4	—	3	—	1	2
CO5	3	—	—	2	—
AVERAGE	3.0	3.0	3.0	2.2	2.5

Activities:

1.	Design an integrated solar thermal heating/cooling/refrigeration system for an industrial or commercial application incorporating: - Solar thermal collectors - Water heating subsystem - Cooling/refrigeration subsystem - Thermal energy storage - AI/IoT-based monitoring and control features
2.	Case study to investigate a solar cooling/refrigeration to evaluate Thermal performance, Energy efficiency, Economic feasibility, Environmental benefits and Scope for system improvement

Rubrics for evaluation: CO4

Sl. No.	Criterion	Marks	Excellent (14–20)	Good (7–13)	Satisfactory (1–6)
1.	System Design	25	Complete and optimized design	Adequate design	Incomplete design
2.	Technical Accuracy	25	Accurate calculations and analysis	Minor errors	Significant errors
3.	Innovation & Smart Features	25	Effective AI/IoT integration	Partial integration	Minimal integration
4.	Report Quality and References	25	Professional report with standards, technical references and documentation.	Moderately organized report with minor issues.	Poorly organized report
	Total	100			

Rubrics for evaluation: CO5

Sl. No.	Criterion	Marks	Excellent (14–20)	Good (7–13)	Satisfactory (1–6)
1.	Technical Investigation	20	Comprehensive analysis	Adequate analysis	Limited analysis
2.	Economic & Sustainability Assessment	20	Detailed and justified assessment	Partial assessment	Inadequate assessment
3.	Recommendations & Improvement Strategies	20	Innovative and feasible recommendations	Acceptable recommendations	Weak recommendations
4.	Result and Presentation	20	Professional documentation with clear interpretation and conclusions.	Organized report with minor deficiencies.	Poor documentation and presentation.
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

Test / Activity	Test I	Test II	Activity I	Activity II	Percentage Allocation	Mapping Strength
CO1	18	12	–	–	12	2
CO2	12	30	–	–	18	2
CO3	30	18	–	–	20	2
CO4	–	–	40	–	25	2
CO5	–	–	–	40	25	2
Total	60	60	40	40	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26THE14	ENERGY EFFICIENT BUILDINGS DESIGN			SEMESTER		III		
Prerequisites				Category	ES(PE)	Credits	3	
- Heat Transfer - Thermodynamics - Building Services Engineering				Hours/ Semester	L	T	P	TH
					45	0	0	45
COURSE OBJECTIVES								
1.	To impart advanced knowledge on green building concepts and sustainable building design practices.							
2.	To explain building envelope design and thermal performance of energy efficient buildings.							
3.	To develop understanding of passive heating, cooling and daylighting techniques.							
4.	To provide analytical knowledge on heat transfer mechanisms and thermal load estimation in buildings.							
5.	To enable students to integrate renewable energy technologies into modern building systems.							
UNIT - I		GREEN BUILDINGS AND SUSTAINABLE DESIGN						9
Climate responsive architecture – Green building concepts – Sustainable site planning – Water efficiency and conservation – Energy efficient building practices – Materials and resources – Indoor Environmental Quality (IEQ) – ECBC and green building rating systems – Net zero energy buildings								
UNIT - II		BUILDING ENVELOPE AND THERMAL PERFORMANCE						9
Building envelope design – Energy efficient landscape design – Microclimate and shading devices – Thermal properties of building materials – Thermal mass and thermal lag – Thermal Time Constant (TTC) – Solar radiation effects on buildings – Insulation materials and techniques – Building energy performance analysis								
UNIT - III		PASSIVE HEATING, COOLING AND DAYLIGHTING						9
Principles of passive solar design – Solar geometry and sun path diagrams – Direct and indirect heating systems – Isolated gain systems – Natural ventilation strategies – Stack and wind driven ventilation – Evaporative cooling – Radiative cooling – Daylighting design and performance evaluation.								
UNIT - IV		HEAT TRANSFER AND BUILDING ENERGY ANALYSIS						9
Heat transfer through building components – Overall Thermal Transmittance (U-value) – Infiltration and ventilation heat transfer – Building cooling and heating load estimation – Steady state and transient methods – Numerical techniques for thermal analysis – Thermal storage integration in buildings.								
UNIT - V		RENEWABLE ENERGY IN BUILDINGS						9
Building Integrated Photovoltaics (BIPV) – Solar water heating systems – Small wind energy systems – Hybrid renewable energy systems – Smart energy management – Energy storage technologies – Economic analysis of renewable energy systems – Case studies on sustainable buildings.								
Total:45 Hours								
Weightage:								
Continuous Assessment 40%								
End Semester Examinations 60%								

REFERENCE BOOKS:					
1.	Baruch Givoni, Climate Considerations in Building and Urban Design, John Wiley & Sons, 2017.				
2.	Baruch Givoni, Passive and Low Energy Cooling of Buildings, Wiley, 2018.				
3.	Duffie J.A. and Beckman W.A., Solar Engineering of Thermal Processes, Wiley, 2019.				
4.	Kreider J.F., Heating and Cooling of Buildings: Design for Efficiency, CRC Press, 2018.				
5.	Lechner N., Heating, Cooling, Lighting: Sustainable Design Methods for Architects, Wiley, 2021.				
6.	ASHRAE Handbook – Fundamentals, ASHRAE Publications, 2021.				
E-RESOURCES:					
1.	NPTEL – Energy Efficient Buildings				
2.	NPTEL – Sustainable Architecture				
3.	MIT Open Course Ware – Building Energy Systems				
4.	Bureau of Energy Efficiency (BEE) Resources				
5.	ECBC Guidelines and Green Building Standards				
COURSE OUTCOMES (COs) / At the end of the course, the students will have the ability to		Mapping POs	Mapping PSOs		
CO1	Apply principles of sustainable building design, building envelope optimization, passive solar techniques, heat transfer analysis, and renewable energy integration for improving building energy performance.	PO1	PSO1		
CO2	Analyze the influence of climate-responsive architecture, thermal characteristics of building materials, passive heating and cooling strategies, heat transfer mechanisms, and renewable energy technologies on building sustainability.	PO1, PO2	PSO1		
CO3	Evaluate the effectiveness of green building practices, thermal performance enhancement measures, passive design solutions, building energy conservation techniques, and renewable energy systems based on technical, environmental, and economic criteria.	PO1, PO2	PSO1, PSO2		
CO4	Design energy-efficient building solutions incorporating sustainable site planning, optimized building envelopes, passive solar features, thermal storage systems, and renewable energy technologies to achieve enhanced energy performance.	PO1, PO2, PO3	PSO1, PSO2		
CO5	Integrate building energy analysis methods, thermal comfort strategies, smart energy management systems, and hybrid renewable energy technologies for sustainable building applications.	PO2, PO3	PSO1, PSO2		
The Course Articulation Matrix (CAM) for defined COs					
COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	3	—	—	3	—
CO2	3	2	—	3	—
CO3	2	3	—	2	3
CO4	2	2	3	2	3
CO5	1	3	2	-	3
AVERAGE	2.2	2.5	2.5	2.5	3.0

Activities:

1. Development of a conceptual design of a sustainable building (residential, commercial, or institutional) incorporating:
 - Climate-responsive architecture
 - Sustainable site planning
 - Energy-efficient building envelope
 - Passive heating, cooling, and daylighting strategies
 - Thermal insulation and thermal storage measures
 - Building-integrated renewable energy systems
2. Net-Zero Energy Building Case Study and Optimization

Rubrics for evaluation: CO4, CO5

Sl. No.	Criterion	Marks	Excellent (14–20)	Good (7–13)	Satisfactory (1–6)
1.	Technical Analysis	20	Basic analysis with significant errors	Adequate analysis with minor errors	Comprehensive and accurate analysis
2.	Design/Integration	20	Limited application of concepts	Moderate integration of concepts	Effective and innovative integration
3.	Sustainability Evaluation	20	Basic evaluation	Reasonable evaluation with justification	Detailed evaluation with strong justification
4.	Report & Presentation	20	Incomplete documentation	Satisfactory documentation	Professional and well-organized presentation
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

Test / Activity	Test I	Test II	Activity I	Activity II	Percentage Allocation	Mapping Strength
CO1	18	12	–	–	12	2
CO2	12	30	–	–	18	2
CO3	30	18	–	–	20	2
CO4	–	–	40	–	25	2
CO5	–	–	–	40	25	2
Total	60	60	40	40	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
 Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

22THE15	ANALYSIS OF THERMAL POWER CYCLES		SEMESTER		III	
Prerequisites		Category	ES(PE)	Credits		3
- Engineering Thermodynamics - Fluid Mechanics - Heat Transfer fundamentals		Hours/ Semester	L	T	P	TH
			45	0	0	45
COURSE OBJECTIVES						
1.	To demonstrate the working of steam power cycles and calculations of efficiency.					
2.	To provide techniques to modify the steam cycles and estimate efficiencies.					
3.	To impart the knowledge to analyse the air cycles with variable specific heats.					
4.	To impart the knowledge to analyse the performance of Brayton cycle with regeneration and reheating.					
5.	To study and analyse various refrigeration cycles.					
UNIT - I	STEAM POWER CYCLES					9
Steam power plant cycle – Rankine cycle – Reheat cycle – Regenerative cycle with one and more feed heaters – Types of feed heaters – Open and closed types – Steam traps types.						
UNIT - II	MODIFIED STEAM POWER CYCLES					9
Cogeneration – Condensing turbines – Combined heat and power – Combined cycles – Brayton cycle Rankine cycle combinations – Binary vapour cycle.						
UNIT - III	AIR CYCLES					9
Air standard cycles – Cycles with variable specific heat – Fuel air cycle – Deviation from actual cycle.						
UNIT - IV	MODIFIED BRAYTON CYCLES					9
Brayton cycle – Open cycle gas turbine – Closed cycle gas turbine – Regeneration – Inter cooling and reheating between stages.						
UNIT - V	REFRIGERATION CYCLES					9
Refrigeration Cycles – Vapour compression cycles – Cascade system – Vapour absorption cycles – GAX Cycle						
Total:45 Hours						
Weightage: Continuous Assessment 40% End Semester Examinations 60%						
REFERENCE BOOKS:						
1.	Culp, R., Principles of Energy Conversion, McGraw-Hill, 2000.					
2.	Nag, P.K., Power Plant Engineering, 2nd Tata McGraw-Hill, 2002.					
3.	Nag, P.K., Engineering Thermodynamics, 3rd ed., Tata McGraw-Hill, 2005.					
4.	Arora, C.P., Refrigeration and Air Conditioning, 2nd ed., Tata McGraw-Hill, 2004.					

E-RESOURCES:					
1.	NPTEL – Power Plant Engineering				
2.	NPTEL – Engineering Thermodynamics				
3.	NPTEL – Gas Turbine Engineering				
4.	NPTEL – Refrigeration and Air Conditioning				
5.	MIT OpenCourseWare – Thermal Systems Engineering				
COURSE OUTCOMES (COs) / At the end of the course, the students will have the ability to			Mapping POs	Mapping PSOs	
CO1	Analyze the steam power cycle efficiency and work done and techniques to improve them.		PO1, PO3	PSO1	
CO2	Analyze the modified steam power cycle efficiency and work done.		PO1, PO3	PSO1	
CO3	Derive the equation for efficiency and work done and analyze the deviation from actual cycles.		PO1, PO3	PSO1	
CO4	Analyze the Rankine cycle efficiency and work done and techniques to improve them.		PO1, PO2, PO3	PSO1, PSO2	
CO5	Analyze various refrigeration cycles and their performances.		PO1, PO2, PO3	PSO1, PSO2	
The Course Articulation Matrix (CAM) for defined COs					
COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	2	—	3	3	—
CO2	3	—	3	3	—
CO3	2	—	3	3	—
CO4	3	2	3	2	3
CO5	3	3	3	2	3
AVERAGE	2.6	2.5	3.0	2.6	3.0
Activities:					
1.	Analyze the performance of steam power cycles using engineering software or thermodynamic simulation tools.				
2.	Conduct a case study on modern thermal power plants or refrigeration systems and present the performance analysis.				

Rubrics for evaluation: CO4

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Technical Understanding	20	Excellent understanding of Brayton and Rankine cycle analysis	Good understanding with minor errors	Basic understanding
2.	Industrial Data Analysis	25	Accurate thermodynamic analysis	Adequate analysis	Limited analysis
3.	Software Application	25	Excellent use of simulation tools	Moderate software usage	Basic software usage
4.	Presentation & Communication	15	Professional presentation	Good presentation	Basic presentation
5.	Report Quality & References	15	Well-documented report	Good documentation	Basic report
	Total	100			

Rubrics for evaluation: CO5

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Technical Analysis	20	Excellent Refrigeration cycle Analysis	Good Analysis	Basic Analysis
2.	Performance Evaluation	25	Comprehensive performance calculation	Adequate Evaluation	Limited Evaluation
3.	Practical Application	20	Strong Industrial Application	Moderate Application	Basic Application
4.	Presentation	15	Excellent Presentation	Good Presentation	Basic Presentation
5.	Documentation	20	Excellent report	Good report	Basic report
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

Test / Activity	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
CO1	14	14	—	—	10	2
CO2	10	36	—	—	20	2
CO3	36	10	—	—	20	2
CO4	—	—	40	—	25	3
CO5	—	—	—	40	25	3
Total	60	60	40	40	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26THE16	ADVANCED INTERNAL COMBUSTION ENGINES		SEMESTER			III
Prerequisites		Category	ES(PE)	Credits		3
- Engineering Thermodynamics, - Heat Transfer, - Renewable Energy Fundamentals		Hours/ Semester	L	T	P	TH
			45	0	0	45
COURSE OBJECTIVES						
1.	To study the working of Gasoline fuel injection systems and SI combustion.					
2.	To study the working of Diesel fuel injection systems and CI combustion.					
3.	To Identifying the source and measure it; explain the mechanism of emission formation and control methods.					
4.	To study the Selecting alternative fuel resources and its utilization techniques in IC engines.					
5.	To study the advanced combustion modes and future power train systems					
UNIT - I	COMBUSTION IN SI AND CI ENGINES					9
Mixture requirements – Stages of combustion – Normal and Abnormal combustion, Knock and Pre-ignition – Factors influencing knock – Gasoline and diesel Fuel injection systems Fuel Spray behaviour – Spray structure and spray penetration – Air motion: Tumble, Swirl & Squish – Different Combustion chamber geometries – Super charging and Turbo charging.						
UNIT - II	EMISSION FORMATION AND CONTROL					9
Sources – Formation of Carbon Monoxide, Unburnt hydrocarbon, Oxides of Nitrogen, Smoke and Particulate matter – Methods of controlling emissions – In-cylinder treatments – After treatment systems – Three Way Catalytic converter, Selective Catalytic Reduction, De-NOx Catalyst, Diesel Oxidation Catalyst and Particulate Traps.						
UNIT - III	ENGINE TESTING AND MEASUREMENT SYSTEMS					9
Test cells and dynamometers – Fuel and airflow measurement systems – In-cylinder pressure transducers and crank angle encoders – Emission standards and driving cycles – Methods and principles of emission measurement – Non-dispersive infrared (NDIR) gas analyzer, Chemiluminescence analyzer (CLA), Flame Ionization Detector (FID), Smoke meter and Soot analyzer						
UNIT - IV	ALTERNATE COMBUSTION CONCEPTS					9
Low Temperature Combustion (LTC) – Homogeneous Charge Compression Ignition (HCCI) – Reactivity Controlled Compression Ignition (RCCI) – Advanced Ignition Systems – Gasoline Compression Ignition (GCI) – Multi-stroke Engines – Recent Technological Developments in IC Engines.						
UNIT - V	ALTERNATIVE FUELS					9
Alcohol Fuels, Hydrogen, Compressed Natural Gas, Liquefied Petroleum Gas and Bio Diesel -Properties, Suitability, Merits and Demerits – Utilisation Methods – Engine Modifications.						
L:45, Total:45 Hours						
Weightage:						
Continuous Assessment 40%						
End Semester Examinations 60%						

REFERENCE BOOKS:

1.	Taylor, CF., The Internal Combustion Engine in theory and practice, MIT Press, Cambridge, 1985.
2.	Heywood, JB., Internal Combustion Engine Fundamentals, McGraw-Hill, 1988
3.	Gill, PWS., Smith, JR., and Ziurys, J., Fundamentals of internal combustion engines, Oxford and IBH, New Delhi, 1959.
4.	Duffy Smith, "Auto Fuel Systems", The Good Heart Wilcox Company, Inc., 2003.
5.	V. Ganesan, "Internal Combustion Engines", V Edition, Tata McGraw Hill, 2012.

E-RESOURCES:

1.	https://nptel.ac.in/courses/112103262?utm_source=chatgpt.com
2.	https://archive.nptel.ac.in/content/syllabus_pdf/112104033.pdf?utm_source=chatgpt.com
3.	https://archive.nptel.ac.in/content/storage2/courses/112104033/lecture2/2_2.htm?utm_source=chatgpt.com
4.	https://archive.nptel.ac.in/content/storage2/courses/112104033/lecture39/39_2.htm?utm_source=chatgpt.com
5.	https://archive.nptel.ac.in/content/storage2/courses/112104033/lecture33/33_2.htm?utm_source=chatgpt.com

COURSE OUTCOMES (COs) /**At the end of the course, the students will have the ability to****Mapping
POs****Mapping
PSOs**

CO1	Analyze SI and CI engine combustion characteristics, fuel injection systems, combustion chamber design, supercharging and turbocharging.	PO1, PO3	PSO1
CO2	Evaluate emission formation mechanisms, emission control techniques and after-treatment systems for internal combustion engines.	PO1, PO3	PSO1
CO3	Apply engine testing techniques, dynamometer testing, combustion diagnostics and emission measurement systems to evaluate engine performance.	PO1, PO3	PSO1
CO4	Analyze advanced combustion concepts including HCCI, RCCI, GCI, low temperature combustion and recent technological developments in IC engines.	PO1, PO2, PO3	PSO1, PSO2
CO5	Evaluate alternative fuels, their properties, engine modifications and future sustainable IC engine technologies.	PO1, PO2, PO3	PSO1, PSO2

The Course Articulation Matrix (CAM) for defined COs

COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	2	—	3	3	—
CO2	3	—	3	3	—
CO3	2	—	3	3	—
CO4	3	2	3	2	3
CO5	3	3	3	2	3
AVERAGE	2.6	2.5	3.0	2.6	3.0

Activities:

1.	Comparative analysis of advanced combustion technologies (HCCI, RCCI, GCI and LTC) using simulation software or industrial case studies.
2.	Performance and emission analysis of an IC engine operating with alternative fuels (Biodiesel, Hydrogen, CNG, LPG or Alcohol fuels) along with engine modification studies.

Rubrics for evaluation: CO4

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Problem Identification & Objective Formulation	20	Comprehensive project planning with clear objectives, scope and technical feasibility.	Adequate planning with minor omissions.	Limited understanding of project formulation.
2.	Design Methodology & Technical Analysis	25	Accurate feasibility analysis, cost estimation and financial evaluation.	Moderate analysis with minor errors.	Weak analysis and interpretation.
3.	Model Development / Experimental Setup	25	Excellent project appraisal with comprehensive risk and economic analysis.	Satisfactory evaluation with limited justification.	Weak risk assessment and economic analysis.
4.	Interpretation of Results & Feasibility	15	Professional project presentation with effective technical communication.	Moderate clarity and organization.	Poor presentation and communication.
5.	Report Documentation & Presentation	15	Well-structured project report with standards and references.	Moderately organized report with minor deficiencies.	Poorly documented report lacking technical details.
	Total	100			

Rubrics for evaluation: CO5

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Understanding of Renewable Energy Concepts	20	Comprehensive analysis of national and international energy policies.	Adequate policy evaluation with minor gaps.	Limited understanding of policy frameworks.
2.	Literature Review & Self-Learning	25	Excellent assessment of regulatory and governance mechanisms.	Moderate analysis with acceptable interpretation.	Weak analysis and conclusions.
3.	Experimental / Analytical Evaluation	20	Strong evaluation of energy security and sustainability implications.	Satisfactory evaluation with limited insights.	Weak strategic assessment.

4.	Sustainability & Societal Impact Assessment	15	Effective use of forecasting, optimization and analytical software tools.	Basic utilization of modern tools.	Minimal use of analytical tools.
5.	Presentation & Technical Communication	20	Professional documentation and presentation with clear recommendations.	Organized report with minor deficiencies.	Poor documentation and presentation.
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

Test / Activity	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
C01	18	12	–	–	10	2
C02	12	30	–	–	20	2
C03	30	18	–	–	20	2
C04	–	–	40	–	25	3
C05	–	–	–	40	25	3
Total	60	60	40	40	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26THE17	ENERGY MANAGEMENT AND ENVIRONMENTAL BENEFITS		SEMESTER		III		
Prerequisites			Category	ES(PE)	Credits	3	
- Energy Engineering - Environmental Science - Engineering Economics			Hours/ Semester	L	T	P	TH
				45	0	0	45
COURSE OBJECTIVES							
1.	To impart knowledge on national and global energy scenarios, conservation practices and energy security.						
2.	To explain energy management principles, energy auditing methodologies and performance assessment techniques.						
3.	To develop project management skills for energy conservation and efficiency improvement projects.						
4.	To provide knowledge on financial appraisal methods and economic evaluation of energy projects.						
5.	To enable students to analyze environmental benefits of energy conservation and sustainable development initiatives.						
UNIT - I		ENERGY SCENARIO AND CONSERVATION					9
Global and Indian energy scenarios – Energy resources and generation mix – Energy demand and consumption patterns – Energy pricing mechanisms – Energy security and sustainability – Energy Conservation Act – Energy efficiency initiatives – Per capita energy consumption – Future energy challenges.							
UNIT - II		ENERGY MANAGEMENT AND AUDITING					9
Principles of energy management – Energy audit objectives and methodology – Types of energy audits – Energy performance indicators – Energy costing and benchmarking – Demand side management – Energy monitoring and targeting – CUSUM techniques – Energy labelling and rating systems – Instrumentation for energy auditing.							
UNIT - III		PROJECT MANAGEMENT FOR ENERGY SYSTEMS					9
Project management fundamentals – Project life cycle – Scope definition and planning – Technical design and implementation – Project scheduling using Gantt charts – Critical Path Method (CPM) – Program Evaluation and Review Technique (PERT) – Performance monitoring and control – Case studies in energy projects.							
UNIT - IV		FINANCIAL MANAGEMENT OF ENERGY PROJECTS					9
Investment appraisal techniques – Simple payback period – Return on investment – Net Present Value (NPV) – Internal Rate of Return (IRR) – Discounted cash flow analysis – Risk and sensitivity analysis – Energy performance contracts – ESCO models – Financing options for energy conservation projects.							
UNIT - V		ENERGY, ENVIRONMENT AND SUSTAINABLE DEVELOPMENT					9
Greenhouse effect and carbon cycle – Climate change impacts – Carbon footprint assessment – UNFCCC framework – Kyoto Protocol and Paris Agreement – Emissions trading mechanisms – Clean Development Mechanism (CDM) – Carbon finance – Sustainable development goals – Environmental benefits of energy efficiency.							
Total:45 Hours							
Weightage:							
Continuous Assessment 40%							
End Semester Examinations 60%							

REFERENCE BOOKS:

1.	Bureau of Energy Efficiency (BEE), Energy Manager Training Manual, Ministry of Power, Government of India.
2.	Witte L.C., Schmidt P.S. and Brown D.R., Industrial Energy Management and Utilisation, Hemisphere Publishing.
3.	Turner W.C., Energy Management Handbook, Wiley Publications.
4.	Murphy W.R. and McKay G., Energy Management, Butterworths.
5.	Eastop T.D. and Croft D.R., Energy Efficiency for Engineers and Technologists, Longman Scientific.
6.	Capehart B.L., Turner W.C. and Kennedy W.J., Guide to Energy Management, CRC Press.

E-RESOURCES:

1.	NPTEL – Energy Management and Audit
2.	Bureau of Energy Efficiency (BEE) Learning Resources
3.	International Energy Agency (IEA) Publications
4.	Ministry of Power Energy Conservation Resources
5.	UNFCCC Climate Change Knowledge Portal

COURSE OUTCOMES (COs) /**At the end of the course, the students will have the ability to****Mapping
POs****Mapping
PSOs**

CO1	Apply principles of energy management, energy auditing, project planning, financial appraisal, and sustainability frameworks to address energy-related problems in industrial and utility sectors.	PO1	PSO1
CO2	Analyze energy consumption patterns, energy performance indicators, project schedules, financial viability, and environmental impacts of energy systems using appropriate analytical tools and methodologies.	PO1, PO2	PSO1
CO3	Evaluate alternative energy conservation measures, project management strategies, financing mechanisms, and sustainability initiatives based on technical, economic, and environmental criteria.	PO1, PO2, PO3	PSO1, PSO2
CO4	Develop integrated energy management and conservation plans incorporating audit findings, project implementation strategies, financial assessments, and environmental considerations.	PO1, PO2, PO3	PSO1, PSO2
CO5	Design sustainable energy projects by integrating energy efficiency technologies, project management tools, investment appraisal techniques, carbon mitigation measures, and policy requirements.	PO1, PO2, PO3	PSO1, PSO2

The Course Articulation Matrix (CAM) for defined COs

COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	3	–	–	3	–
CO2	2	3	–	3	–
CO3	–	3	–	2	2
CO4	2	2	3	2	2
CO5	2	2	3	2	3
AVERAGE	2.3	2.5	3.0	2.4	2.3

Activities:

1.	Energy assessment of a building, laboratory, industry, or commercial facility and develop: • Energy consumption analysis • Identification of energy-saving opportunities • Energy audit report • Project implementation plan • Financial feasibility analysis • Environmental benefit assessment (carbon reduction) • Sustainability recommendations
2.	Comprehensive proposal writing for an energy efficiency or renewable energy project incorporating: • Energy scenario analysis • Project management plan (Gantt/PERT/CPM) • Economic evaluation • Risk and sensitivity analysis • Carbon footprint reduction • Alignment with SDGs, Paris Agreement, and sustainability goals

Rubrics for evaluation: CO4

Sl. No.	Criterion	Marks	Excellent (14–20)	Good (7–13)	Satisfactory (1–6)
1.	Energy Audit Methodology	20	Comprehensive data collection and systematic analysis using appropriate audit tools	Adequate analysis with minor omissions	Limited data collection and analysis
2.	Identification of Energy Conservation Measures	20	Multiple feasible and well-justified conservation measures identified	Feasible measures identified with partial justification	Few or poorly justified measures identified
3.	Project Planning and Scheduling	20	Well-structured implementation plan with suitable scheduling tools	Reasonable plan with minor deficiencies	Incomplete or poorly structured plan
4.	Financial Feasibility Analysis	20	Accurate economic analysis with appropriate financial indicators	Basic financial analysis with minor errors	Limited or incorrect financial analysis
5.	Sustainability and Environmental Assessment	20	Comprehensive assessment of environmental benefits and sustainability impacts	Adequate assessment with some gaps	Limited sustainability assessment
	Total	100			

Rubrics for evaluation: C05 & C06

Sl. No.	Criterion	Marks	Excellent (14–20)	Good (7–13)	Satisfactory (1–6)
1.	Problem Definition and Technical Solution	20	Clearly defines problem and proposes an effective technical solution	Problem identified with reasonably appropriate solution	Problem and solution inadequately defined
2.	Project Design and Innovation	20	Innovative and technically sound project design	Functional design with moderate innovation	Limited innovation and weak design
3.	Economic and Risk Analysis	20	Comprehensive financial and risk assessment	Basic economic analysis with limited risk assessment	Inadequate economic analysis
4.	Sustainability and Policy Integration	20	Effectively integrates sustainability goals and policy considerations	Adequate integration with minor gaps	Limited consideration of sustainability aspects
5.	Presentation and Technical Defense	20	Professional presentation and confident defense of decisions	Clear presentation with satisfactory responses	Weak presentation and limited justification
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

Test / Activity	Test I	Test II	Activity I	Activity II	Percentage Allocation	Mapping Strength
C01	18	12	–	–	12	2
C02	12	30	–	–	18	2
C03	30	18	–	–	20	2
C04	–	–	40	–	25	2
C05	–	–	–	40	25	2
Total	60	60	40	40	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26THE18	SOLAR ENERGY APPLIANCES			SEMESTER		III
Prerequisites			Category	ES(PE)	Credits	3
- Renewable Energy Systems - Heat Transfer - Basic Electrical Engineering			Hours/ Semester	L	T	P
				45	0	0
COURSE OBJECTIVES						
1.	To impart knowledge on solar photovoltaic systems and solar lighting applications.					
2.	To explain the design, operation and performance of solar cooking systems.					
3.	To develop understanding of solar drying technologies and their industrial applications.					
4.	To provide knowledge on solar desalination systems and water purification technologies.					
5.	To enable students to analyze solar thermal appliances and advanced solar energy utilization systems.					
UNIT - I SOLAR PHOTOVOLTAIC LIGHTING SYSTEMS 9						
Solar radiation fundamentals – Photovoltaic effect – Solar cell construction and characteristics – PV modules and arrays – Solar home lighting systems – Solar street lighting systems – Solar lanterns – Battery storage systems – Rural electrification applications – Performance analysis and case studies.						
UNIT - II SOLAR COOKING TECHNOLOGIES 9						
Introduction to solar cooking – Types of solar cookers – Box type solar cookers – Parabolic dish cookers – Community solar cooking systems – Thermal performance evaluation – Testing standards – Energy efficiency analysis – Applications in domestic and industrial sectors.						
UNIT - III SOLAR DRYING TECHNOLOGIES 9						
Principles of solar drying – Heat and mass transfer in drying processes – Direct and indirect solar dryers – Mixed mode solar dryers – Forced circulation dryers – Hybrid solar drying systems – Solar timber drying – Agricultural and food processing applications – Performance assessment.						
UNIT - IV SOLAR DESALINATION AND WATER TREATMENT 9						
Need for desalination – Solar desalination techniques – Solar stills and their types – Basin type solar stills – Multi-effect desalination systems – Solar disinfection methods – Productivity enhancement techniques – Material selection and corrosion issues – Water purification applications.						
UNIT - V ADVANCED SOLAR THERMAL APPLIANCES 9						
Solar furnaces and concentrators – Heliostat systems – Sun tracking mechanisms – Single concentrator solar furnaces – Multi-heliostat solar furnaces – High temperature solar thermal systems – Industrial process heating applications – Emerging solar thermal technologies – Case studies.						
Total:45 Hours						
Weightage:						
Continuous Assessment 40%						
End Semester Examinations 60%						

REFERENCE BOOKS:

1.	Sukhatme S.P. and Nayak J.K., Solar Energy: Principles of Thermal Collection and Storage, McGraw Hill Education, 2018.
2.	Garg H.P. and Prakash J., Solar Energy: Fundamentals and Applications, Tata McGraw Hill, 2017.
3.	Rai G.D., Solar Energy Utilization, Khanna Publishers, 2019.
4.	Michael Grupp, Time to Shine: Applications of Solar Energy Technology, Wiley Publications, 2018.
5.	S.M. Sze and Kwok K. Ng, Physics of Semiconductor Devices, Wiley Publications, 2021.
6.	Kalogirou S.A., Solar Energy Engineering: Processes and Systems, Academic Press, 2020.

E-RESOURCES:

1.	NPTEL – Solar Energy Engineering
2.	NPTEL – Renewable Energy Technologies
3.	MIT OpenCourseWare – Solar Energy Systems
4.	MNRE Solar Energy Resources
5.	International Solar Energy Society (ISES) Publications

COURSE OUTCOMES (COs) /**At the end of the course, the students will have the ability to****Mapping
POs****Mapping
PSOs**

CO1	Apply the principles of solar photovoltaic lighting systems, solar cooking technologies, solar drying systems, solar desalination methods, and advanced solar thermal appliances to solve practical energy utilization problems.	PO1	PSO1
CO2	Analyze the performance characteristics, operational parameters, energy conversion processes, and application suitability of solar photovoltaic, cooking, drying, desalination, and advanced solar thermal systems under varying conditions.	PO1, PO2	PSO1
CO3	Evaluate the technical feasibility, energy efficiency, productivity, reliability, and sustainability of solar thermal and photovoltaic applications using appropriate performance indicators and standards.	PO1, PO2, PO3	PSO1, PSO2
CO4	Design integrated solar energy solutions incorporating photovoltaic lighting, solar cooking, solar drying, desalination, and thermal appliance technologies to meet specified user and environmental requirements.	PO1, PO2, PO3	PSO1, PSO2
CO5	Develop optimized configurations and operational strategies for solar energy systems by considering resource availability, thermal performance, storage requirements, economic factors, and application constraints.	PO1, PO2, PO3	PSO1, PSO2

The Course Articulation Matrix (CAM) for defined COs

COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	3	–	–	2	–
CO2	3	–	–	2	–
CO3	2	3	–	2	3
CO4	2	3	–	–	2
CO5	2	2	3	2	2
AVERAGE	2.40	2.7	3.0	2.0	2.3

Activities:

1.	Design project of an integrated solar energy solution involving any combination of PV lighting, solar cooking, drying, desalination, or thermal appliances for a selected application.
2.	Case study of an innovative solar application or critically study an emerging solar thermal technology and present implementation strategies.

Rubrics for evaluation: CO4

Sl. No.	Criterion	Marks	Excellent (14–20)	Good (7–13)	Satisfactory (1–6)
1.	System Design	20	Complete and technically sound design	Minor deficiencies in design	Incomplete or technically weak design
2.	Technical Analysis	20	Accurate calculations and justification	Partial analysis with minor errors	Limited analysis and major errors
3.	Optimization Approach	20	Appropriate optimization and performance improvement measures included	Basic optimization measures considered	No significant optimization effort
4.	Feasibility Assessment	20	Comprehensive technical and economic feasibility	Partial feasibility assessment	Inadequate feasibility assessment
	Total	100			

Rubrics for evaluation: CO5

Sl. No.	Criterion	Marks	Excellent (14–20)	Good (7–13)	Satisfactory (1–6)
1.	Innovation and Creativity	20	Highly innovative concept with clear novelty	Moderate innovation	Limited originality
2.	Technical Soundness	20	Strong technical justification and validation	Adequate technical basis	Weak technical justification
3.	Sustainability Impact	20	Significant environmental and societal benefits demonstrated	Moderate benefits identified	Benefits not clearly established

4.	Presentation and Documentation	20	Professional presentation and well-structured report	Adequate presentation and report	Poor organization and documentation
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

Test / Activity	Test I	Test II	Activity I	Activity II	Percentage Allocation	Mapping Strength
CO1	18	12	–	–	12.5	2
CO2	12	30	–	–	17.5	2
CO3	30	18	–	–	20	2
CO4	–	–	40	–	25	2
CO5	–	–	–	40	25	2
Total	60	60	40	40	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26THE19	COST MANAGEMENT OF ENGINEERING PROJECTS		SEMESTER		III	
Prerequisites		Category	ES(PE)	Credits		3
- Engineering Economics - Industrial Engineering - Basic Project Management		Hours/ Semester	L	T	P	TH
			45	0	0	45
COURSE OBJECTIVES						
1.	To introduce the costing concepts and their role in decision making.					
2.	To introduce the project management concepts and their various aspects.					
3.	To provide detailed knowledge for project execution and costing concepts.					
4.	To provide detailed knowledge on costing techniques in service sector and various budgetary control techniques.					
5.	To illustrate with quantitative techniques in cost management.					
UNIT - I		INTRODUCTION TO COSTING CONCEPTS				9
Objectives of a Costing System; Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost; Creation of a Database for operational control.						
UNIT - II		INTRODUCTION TO PROJECT MANAGEMENT				9
Project: meaning, Different types, why to manage, cost overruns centers, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and nontechnical activities, Detailed Engineering activities, Pre project execution main clearances and documents, Project team: Role of each member, Importance Project site: Data required with significance, Project contracts.						
UNIT - III		PROJECT EXECUTION AND COSTING CONCEPTS				9
Project execution: Project cost control, Bar charts and Network diagram, Project commissioning: mechanical and process, Cost Behavior and Profit Planning, Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis, Various decision-making problems, Pricing strategies: Pareto Analysis, Target costing, Life Cycle Costing.						
UNIT - IV		COSTING OF SERVICE SECTOR AND BUDGETARY CONTROL				9
Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis, Budgetary Control. Flexible Budgets; Performance budgets; Zero-based budgets.						
UNIT - V		QUANTITATIVE TECHNIQUES FOR COST MANAGEMENT				9
Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Learning Curve Theory.						
Total:45 Hours						
Weightage:						
Continuous Assessment 40%						
End Semester Examinations 60%						

REFERENCE BOOKS:

1.	Ashish K. Bhattacharya, Principles & Practices of Cost Accounting, A.H. Wheeler Publisher, 1991.
2.	Charles T. Horngren and George Foster, Advanced Management Accounting, 1988.
3.	Charles T. Horngren et al., Cost Accounting: A Managerial Emphasis, Prentice Hall of India, New Delhi, 2011.
4.	Robert S. Kaplan and Anthony A. Atkinson, Management & Cost Accounting, 2003.
5.	Vohra N.D., Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd., 2007.

E-RESOURCES:

1.	NPTEL – Cost Accounting
2.	NPTEL – Project Management
3.	NPTEL – Operations Research
4.	Project Management Institute (PMI) Learning Resources
5.	MIT OpenCourseWare – Project Management

COURSE OUTCOMES (COs) /**At the end of the course, the students will have the ability to****Mapping
POs****Mapping
PSOs**

CO1	Understand the costing concepts and their role in decision making.	PO1, PO3	PSO1
CO2	Understand the project management concepts and their various aspects in selection.	PO1, PO3	PSO1
CO3	Interpret costing concepts with project execution	PO1, PO3	PSO1, PSO2
CO4	Gain knowledge of costing techniques in service sector and various budgetary control techniques.	PO1, PO2, PO3	PSO1, PSO2
CO5	Become familiar with quantitative techniques in cost management.	PO1, PO2, PO3	PSO1, PSO2

The Course Articulation Matrix (CAM) for defined COs

COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	2	—	2	2	—
CO2	2	—	2	2	—
CO3	2	—	2	2	2
CO4	3	3	3	3	3
CO5	3	3	3	2	3
AVERAGE	2.4	3.0	2.4	2.2	2.7

Activities:

1. Prepare a cost estimation and budgeting report for an engineering project using spreadsheet/project management tools.
2. Conduct a case study on project cost control and scheduling using PERT/CPM techniques.

Rubrics for evaluation: CO4

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Costing Techniques	20	Excellent understanding and application	Good understanding	Basic understanding
2.	Budgetary Control	20	Comprehensive budget	Adequate analysis	Basic Budgeting
3.	Cost Analysis	20	Strong analytical ability	Moderate Analysis	Limited Analysis
4.	Presentation	20	Professional presentation	Good presentation	Basic presentation
5.	Documentation	20	Excellent report preparation	Good documentation	Basic report
	Total	100			

Rubrics for evaluation: CO5

Sl. No.	Criterion	Marks	Excellent (14-20)	Good (7-13)	Satisfactory (1-6)
1.	Problem Formulation	20	Excellent formulation of optimization	Good formulation	Basic formulation
2.	Quantitative Analysis	20	Accurate application of techniques	Moderate application	Limited application
3.	Decision Making	20	Excellent optimization and interpretation	Good optimization	Basic optimization
4.	Engineering Application	20	Strong practical relevance	Moderate relevance	Limited relevance
5.	Report & Presentation	20	Excellent report and presentation	Good report	Basic report
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

	Test I	Test II	Activity I	Activity II	Percentage allocation	Mapping Strength
CO1	18	12	–	–	10	2
CO2	12	30	–	–	20	2
CO3	30	18	–	–	20	2
CO4	–	–	40	–	25	3
CO5	–	–	–	40	25	3
Total	60	60	40	40	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26THE20	ADVANCED COMPOSITE MATERIALS			SEMESTER		III
Prerequisites			Category	ES(PE)	Credits	3
- Engineering Materials - Strength of Materials - Manufacturing Technology			Hours/ Semester	L	T	P
				45	0	0
COURSE OBJECTIVES						
1.	To impart knowledge on composite materials, reinforcement systems and constituent material selection.					
2.	To explain the processing, fabrication and manufacturing techniques of advanced composites.					
3.	To develop understanding of composite mechanics, design principles and structural analysis.					
4.	To provide knowledge on performance evaluation, failure analysis and industrial applications of composites.					
5.	To enable students to analyze nanocomposite materials and emerging composite technologies.					
UNIT - I FUNDAMENTALS OF COMPOSITE MATERIALS						
Introduction to composite materials – Classification of composites – Metal Matrix Composites (MMC), Polymer Matrix Composites (PMC) and Ceramic Matrix Composites (CMC) – Reinforcing fibers and particulate reinforcements – Matrix materials – Surface treatments and coupling agents – Interface characteristics – Selection of constituent materials						
UNIT - II PROPERTIES AND PERFORMANCE OF COMPOSITES						
Mechanical properties of composite materials – Microstructure of fiber reinforced composites – Glass, carbon, aramid and ceramic fibers – Polymer, metal and ceramic matrices – Rule of mixtures – Specific strength and stiffness – Stress-strain behavior – Thermal and environmental effects – Performance evaluation techniques.						
UNIT - III COMPOSITE MECHANICS AND MANUFACTURING						
Micromechanics and macromechanics of composites – Isotropic and anisotropic materials – Classical Lamination Plate Theory (CLPT) – Composite design principles – Pultrusion – Filament winding – Prepreg technology – Injection molding – Compression molding – Resin transfer molding – Manufacturing process optimization.						
UNIT - IV FAILURE ANALYSIS AND ENGINEERING APPLICATIONS						
Failure theories for composite materials – Hygrothermal stresses – Interlaminar stresses – Buckling analysis of laminated composites – Sandwich structures – First Order Shear Deformation Theory (FSDT) – Structural integrity assessment – Aerospace, automotive, marine and industrial applications.						
UNIT - V NANOCOMPOSITES AND ADVANCED MATERIAL SYSTEMS						
Introduction to nanocomposites – Polymer, ceramic and metal based nanocomposites – Core-shell nanostructures – Carbon nanotube reinforced composites – Graphene based composites – Synthesis techniques – Characterization methods – Advanced applications – Emerging trends and future developments.						
Total:45 Hours						
Weightage:						
Continuous Assessment 40%						
End Semester Examinations 60%						

REFERENCE BOOKS:

1.	Mallick P.K., Fibre Reinforced Composites: Materials, Manufacturing and Design, CRC Press, 2021.
2.	Krishan K. Chawla, Composite Materials: Science and Engineering, Springer, 2019.
3.	ASM Handbook, Volume 21: Composites, ASM International, 2020.
4.	Ajayan P.M., Schadler L.S. and Braun P.V., Nanocomposite Science and Technology, Wiley, 2018.
5.	Advani S.G. and Sozer E.M., Process Modelling in Composites Manufacturing, CRC Press, 2019.
6.	Daniel I.M. and Ishai O., Engineering Mechanics of Composite Materials, Oxford University Press, 2017.

E-RESOURCES:

1.	NPTEL – Composite Materials
2.	NPTEL – Advanced Manufacturing Processes
3.	MIT OpenCourseWare – Composite Structures
4.	ASM International Composite Resources
5.	ANSYS Composite PrepPost Tutorials

COURSE OUTCOMES (COs) /**At the end of the course, the students will have the ability to****Mapping
POs****Mapping
PSOs**

CO1	Apply the principles of composite materials, composite mechanics, manufacturing processes, failure analysis, and nanocomposite technologies to solve engineering problems involving advanced composite systems.	PO1	PSO1
CO2	Analyze the relationships among constituent materials, microstructure, processing methods, mechanical behavior, failure mechanisms, and performance characteristics of composite and nanocomposite materials.	PO1, PO2	PSO1
CO3	Evaluate the suitability, performance, reliability, and sustainability of composite materials and manufacturing techniques for diverse engineering applications under mechanical, thermal, and environmental conditions.	PO1, PO2	PSO1
CO4	Design composite material systems and laminated structures by integrating material selection, mechanics, manufacturing constraints, and performance requirements for specific engineering applications.	PO1, PO3	PSO1, PSO2
CO5	Investigate the effects of processing parameters, reinforcement architecture, environmental factors, and nanoscale modifications on the behavior and structural integrity of composite materials through analytical and experimental approaches.	PO1, PO2, PO3	PSO1, PSO2

The Course Articulation Matrix (CAM) for defined COs

COs / POs	PO1	PO2	PO3	PSO1	PSO2
CO1	3	–	–	2	–
CO2	3	2	–	3	–
CO3	3	2	–	–	–
CO4	2	–	3	–	2
CO5	2	3	2	2	3
AVERAGE	2.6	2.3	2.5	2.3	2.5

Activities:

1.	Design project for a composite component (aircraft panel, automobile body panel, wind turbine blade section, marine panel, etc.) by: • Selecting constituent materials • Designing laminate configuration • Choosing manufacturing process • Analyzing mechanical and thermal performance • Evaluating possible failure mechanisms • Justifying design decisions
2.	Literature review to investigate an advanced composite/nanocomposite technology such as: • CNT reinforced composites • Graphene composites • Core-shell nanostructures • Aerospace nanocomposites • Automotive lightweight composites • Smart composite materials

Rubrics for evaluation: CO4

Sl. No.	Criterion	Marks	Excellent (14–20)	Good (7–13)	Satisfactory (1–6)
1.	Material Selection	20	Appropriate materials selected with complete justification	Suitable materials selected with partial justification	Inappropriate or poorly justified selection
2.	Structural Design	20	Design satisfies all functional requirements	Design satisfies most requirements	Design does not satisfy requirements
3.	Performance Analysis	20	Comprehensive analysis with correct interpretation	Adequate analysis with minor errors	Limited or incorrect analysis
4.	Failure Assessment	20	Failure mechanisms correctly identified and evaluated	Partial identification of failure modes	Failure assessment inadequate
5.	Technical Presentation	20	Clear, professional and well-organized	Adequately organized	Poorly organized
	Total	100			

Rubrics for evaluation: CO5

Sl. No.	Criterion	Marks	Excellent (14–20)	Good (7–13)	Satisfactory (1–6)
1.	Literature Investigation	20	Extensive and relevant literature analyzed	Moderate literature review	Limited literature review
2.	Technical Analysis	20	Deep analysis supported by evidence	Adequate analysis with limited depth	Superficial analysis

3.	Innovation and Creativity	20	Highly innovative solution/application proposed	Moderately innovative proposal	Minimal innovation
4.	Feasibility Assessment	20	Proposal technically feasible and justified	Partially feasible with limited justification	Feasibility not established
5.	Communication Skills	20	Excellent technical communication and presentation	Satisfactory communication	Poor communication
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

Test / Activity	Test I	Test II	Activity I	Activity II	Percentage Allocation	Mapping Strength
CO1	18	12	–	–	12.5	2
CO2	12	30	–	–	17.5	2
CO3	30	18	–	–	20	2
CO4	–	–	40	–	15	2
CO5	–	–	–	40	15	2
Total	60	60	40	40	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26AC001	ENGLISH FOR RESEARCH PAPER WRITING M.E. (Common to all Branches)			SEMESTER		I/II
Prerequisites			Category	AC	Credits	
Basic proficiency in English and familiarity with academic and technical writing.			Hours/ Semester	L	T	P
				30	0	0
0						
COURSE OBJECTIVES						
1.	To develop awareness of the importance of English in academic and research communication.					
2.	To familiarize learners with the structure and organization of research papers.					
3.	To improve learners' ability to use appropriate academic language and expressions in research writing.					
4.	To help learners avoid common language errors and improve the quality of their research papers.					
5.	To enable learners to write and present research work using accepted academic conventions.					
UNIT - I FUNDAMENTALS OF RESEARCH AND ACADEMIC WRITING						
6						
Research and its significance. Purpose, characteristics, and structure of a research paper. Types of research publications. Identifying research problems and defining objectives. Features of academic English, including formal and objective style. Academic vocabulary, clear and concise sentence construction, and avoidance of redundancy and common grammatical errors. Selection of appropriate journals and conferences for publication.						
UNIT - II LANGUAGE PATTERNS IN RESEARCH WRITING						
6						
Common phrases for introducing research problems, stating objectives, describing methods, and presenting results. Use of active and passive voice. Appropriate tense forms in research writing. Cohesion and coherence through linking words and transitions.						
UNIT - III IMPROVING RESEARCH WRITING						
6						
Hedging in academic writing. Paraphrasing and summarizing techniques. Plagiarism and ethical writing practices. Identifying and correcting common language mistakes. Editing and proof reading strategies.						
UNIT - IV REVIEW WRITING AND REVIEW OF LITERATURE						
6						
Purpose and structure of review articles. Review of Literature (RoL): literature search, synthesis of findings, and identification of research gaps. Citation practices and avoidance of plagiarism. Practical exercises in organizing literature and drafting literature review sections.						
UNIT - V WRITING RESEARCH PAPER SECTIONS						
6						
Writing effective titles, abstracts, introductions and conclusions. Presenting findings and discussions clearly. Language for oral presentation of research. Useful phrase banks for different sections of a research paper and research presentations.						
L:30, Total:30 Hours						
Weightage: Continuous Assessment - 100%						

REFERENCE BOOKS:

1.	Wallwork, Adrian. English for Writing Research Papers. 3 rd ed., Springer, 2023.
2.	Swales, John M., and Christine B. Feak. Academic Writing for Graduate Students: Essential Tasks and Skills. 4 th ed., University of Michigan Press, 2020.
3.	Glasman-Deal, Hilary. Science Research Writing for Non-Native Speakers of English. 2 nd ed., Imperial College Press, 2020.
4.	Cargill, Margaret, and Patrick O'Connor. Writing Scientific Research Articles: Strategy and Steps. 3 rd ed., Wiley-Blackwell, 2021.
5.	Day, Robert A., Barbara Gastel, and Michelle Prince. How to Write and Publish a Scientific Paper. 9 th ed., Greenwood, 2022.

E-RESOURCES:

1.	Author Academy – https://authoracademy.springernature.com
2.	Researcher Academy – https://researcheracademy.elsevier.com
3.	Learn English (British Council) - https://learnenglish.britishcouncil.org/skills/writing
4.	Academic Phrase bank – https://www.phrasebank.manchester.ac.uk
5.	Committee on Publication Ethics (COPE) – https://publicationethics.org

COURSE OUTCOMES (COs) /**At the end of the course, the students will have the ability to****Mapping
POs****Mapping
PSOs**

CO1	Explain the significance of research communication and describe the structure, purpose, and types of research publications.	PO1, PO2	
CO2	Apply appropriate academic vocabulary, sentence structures, and language conventions in research writing.	PO1, PO2	
CO3	Use academic language patterns, cohesive devices, and appropriate grammatical structures to communicate research ideas effectively.	PO1, PO2	
CO4	Analyze research papers to identify writing styles, language patterns, and common grammatical error	PO1, PO2	
CO5	Demonstrate ethical research writing practices through effective paraphrasing, citation, referencing, and avoidance of plagiarism.	PO1, PO2	

The Course Articulation Matrix (CAM) for defined COs

	PO1	PO2	PO3	PSO1	PSO2
CO1	3	2			
CO2	3	3			
CO3	2	3			
CO4	2	3			
CO5	3	3			

Activities:

1.

(i) Assignment 1: Research Paper Analysis and Language Evaluation

Select a published research paper from your discipline and analyze its structure, purpose, and major components. Evaluate the use of academic vocabulary, sentence structures, language patterns, cohesive devices, and grammatical conventions. Comment on the effectiveness of the writing and identify areas for improvement.

(ii) Assignment 2: Academic Rewriting and Editing

Choose a technical text or an excerpt from a research article and revise it using appropriate academic vocabulary, formal style, cohesive devices, and correct grammatical structures. Explain the revisions made and discuss how they improve the quality and clarity of research communication.

(iii) Assignment 3: Review of Literature and Research Gap Identification

Select a research topic related to your specialization and review at least five recent research articles. Summarize the major findings using appropriate academic language and transitions, compare the studies, identify research gaps, and present the review in a coherent academic format.

(iv) Assignment 4: Analysis of Research Writing Conventions

Analyze two published research papers from your discipline and compare their writing conventions, language patterns, organization, and presentation of research findings. Examine the use of academic expressions, cohesion, citation practices, and ethical writing principles. Suggest improvements where necessary.

2.

PRESENTATION:

(i) Presentation 1: Ethical Issues in Research Writing

Discuss plagiarism, self-plagiarism, authorship issues, citation ethics, and the responsibilities of researchers in academic publishing. Illustrate the discussion with examples from published research articles and explain strategies for maintaining academic integrity.

(ii) Presentation 2: Paraphrasing, Citation, and Referencing in Research Writing

Present effective techniques for paraphrasing and summarizing research literature. Demonstrate the use of citation and referencing styles commonly adopted in academic publications and discuss methods for avoiding plagiarism.

(iii) Presentation 3: Review of Literature and Research Gap Identification

Select a research topic from your area of specialization and present a brief review of relevant literature. Summarize key findings from published studies, compare their contributions, identify research gaps, and explain how ethical citation practices are followed in the review process.

(iv) Presentation 4: Presenting Research Paper Sections

Prepare and present the title, abstract, introduction, methodology, findings, and conclusion of a selected research paper. Highlight the language conventions, organization, and presentation strategies used for effective research communication.

(v) Presentation 5: Research Conference and Poster Presentation

Design and deliver a short conference-style or poster presentation based on a research article or review paper. Demonstrate effective presentation techniques, audience engagement, response to questions, and adherence to ethical practices in reporting and acknowledging sources.

Rubrics for evaluation: C05

Sl. No.	Criterion	Marks	Excellent (3)	Good (2)	Satisfactory (1)
1.	Understanding and Application of Concepts	25	Shows excellent understanding of the topic	Shows good understanding with minor gaps	Shows basic understanding with several gaps
2.	Analysis and Critical Observation	25	Presents clear and relevant analysis	Adequate analysis with minor omissions	Limited analysis and observations
3.	Organization, Clarity and Coherence	25	Well-organized and easy to follow	Generally organized with minor issues	Organization is weak or inconsistent
4.	Academic Language and Accuracy	25	Accurate academic language with minimal errors	Few language errors that do not affect clarity	Frequent language errors but meaning is understandable
	Total	100			

The Internal Assessment Matrix (IAM) for the defined COs:

CO	Assignment	Presentation	Percentage allocation	Mapping Strength
C01	25		12.5	2
C02	25		12.5	2
C03	25		12.5	2
C04	25		12.5	2
C05		50	50	3
Total	100	100	100	

Note: Purely as an Example: Strength = 3 (if percentage >20%);
Strength = 2 (if percentage 10% to 20%); Strength = 1 (if percentage <10%);

26AC002		DISASTER MANAGEMENT		SEMESTER		I/II	
Prerequisites			Category	AC	Credits		0
			Hours/ Semester	L	T	P	TH
				30	0	0	30
COURSE OBJECTIVES							
1.	To have a critical understanding of key concepts in disaster risk reduction and humanitarian response and critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives. Develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations and evaluate the strengths and weaknesses of disaster management approaches. Planning and programming in different countries, particularly their home country or the countries they work in.						
UNIT - I		INTRODUCTION					6
Disaster: Definition, Factors and Significance; Difference Between Hazard and Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude. Disaster Prone Areas in India: Study of Seismic Zones; Area Prone to floods and droughts, Landslides and avalanches; Areas prone to cyclonic and coastal hazards with special reference to Tsunami; Post- Disaster diseases and epidemics.							
UNIT - II		REPERCUSSIONS OF DISASTERS AND HAZARDS					6
Economic Damage, Loss of Human and Animal Life, Destruction of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts and Famines, Landslides and Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks and Spills, Outbreaks of Disease and Epidemics, War and Conflicts.							
UNIT - III		DISASTER PREPAREDNESS AND MANAGEMENT					6
Preparedness: Monitoring of Phenomena Triggering a Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data from Meteorological and Other Agencies, Media Reports: Governmental and Community Preparedness.							
UNIT - IV		RISK ASSESSMENT					6
Disaster Risk: Concept And Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People's Participation in Risk Assessment. Strategies for Survival.							
UNIT - V		DISASTER MITIGATION					6
Meaning, Concept and Strategies of Disaster Mitigation, Emerging Trends in Mitigation. Structural Mitigation and Non-Structural Mitigation, Programs of Disaster Mitigation in India.							
L: 30, Total: 30 Hours							
Weightage:							
Continuous Assessment - 100%							

REFERENCE BOOKS:

- | | |
|----|---|
| 1. | R. Nishith, Singh AK 2012 Disaster Management in India: Perspectives, issues and strategies New Royal Book Company, Lucknow |
| 2. | Sahni, PardeepEt.Al. (Eds.) 2002 Disaster Mitigation Experiences and Reflections. Prentice Hall Of India, New Delhi |

COURSE OUTCOMES (COs) /**At the end of the course, the students will have the ability to****Mapping
POs****Mapping
PSOs****CO1**

Learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.

CO2

Critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.

CO3

develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations

CO4

Critically understand the strengths and weaknesses of disaster management approaches

26AC003	SANSKRIT FOR TECHNICAL KNOWLEDGE			SEMESTER		I/II	
Prerequisites			Category	AC	Credits		0
			Hours/ Semester	L	T	P	TH
				30	0	0	30
COURSE OBJECTIVES							
1.	To get a working knowledge in illustrious Sanskrit, the scientific language in the world. Learning Sanskrit to improve brain functioning. Learning Sanskrit to develop logic in mathematics, science & other subjects enhances the memory power. The engineering scholars equipped with Sanskrit will be able to explore the huge knowledge from ancient literature.						
UNIT - I	ALPHABETS						10
Alphabets in Sanskrit –Past/Present/Future Tense –Simple Sentences							
UNIT - II	LITERATURE						10
Order –Introduction of roots –Technical information about Sanskrit Literature							
UNIT - III	CONCEPTS						10
Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics							
L: 30, Total: 30 Hours							
Weightage: Continuous Assessment - 100%							
REFERENCE BOOKS:							
1.	"AbhyasaPustakam"- Dr.Vishwas, Samskrita- Bharati Publication, New Delhi						
2.	"Tech Yourself Sanskrit" PrathamaDeeksha-Vempatikutumbshastri,Rashtriya Sanskrit Sansthan, New Delhi Publication						
3.	India’s Glorious Scientific Tradition” Suresh Soni, Ocean books (P) Ltd., New Delhi.						
COURSE OUTCOMES (COs) / At the end of the course, the students will have the ability to				Mapping POs		Mapping PSOs	
CO1	Understanding basic Sanskrit language.						
CO2	Ancient Sanskrit literature about science & technology can be understood.						
CO3	Being a logical language will help to develop logic in students						

26AC004		VALUE EDUCATION		SEMESTER		I/II	
Prerequisites			Category	AC	Credits		0
			Hours/ Semester	L	T	P	TH
				30	0	0	30
COURSE OBJECTIVES							
1.	To understand the Importance of value education and self-development. To imbibe good values in students and also know about the importance of character.						
UNIT - I		BASIC VALUES					7
Values and self-development- Social values and individual attitudes-Work ethics, Indian vision of Humanism Moral and Non Moralvaluation-Standards and principles-Value judgments.							
UNIT - II		CONFIDENCE					7
Importance of cultivation of values- Sense of Duty-Devotion-Self-reliance-Confidence-Concentration-Truthfulness-CleanlinesHonesty-Humanity-Power of faith-National Unity-Patriotism-Love for nature-Discipline.							
UNIT - III		PERSONALITY DEVELOPMENT					8
Personality and Behavior Development-Soul and Scientific attitude - Positive – Thinking - Integrity and discipline -Punctuality – Love and Kindness - Avoid fault Thinking - Free from anger - Dignity of labor - Universal brotherhood and religious tolerance –True friendship –Happiness Vs. suffering –love for truth – Aware of self-destructive habits- Association and Cooperation –Doing best for saving nature.							
UNIT - IV		LOVE AND COMPASSION					8
Character and Competence –Holy books Vs. Blind faith –Self –management and Good health – Science of reincarnation –Equality – Non Violence –Humility -Role of Women –All religions and same message –Mind your Mind –Self -control –Honesty –Studying effectively.							
L: 30, Total: 30 Hours							
Weightage: Continuous Assessment - 100%							
REFERENCE BOOKS:							
1.	Chakraborty, S.K. "Values and Ethics for Organization Theory and Practice", Oxford University Press, New Delhi, 1998.						
COURSE OUTCOMES (COs) / At the end of the course, the students will have the ability to				Mapping POs		Mapping PSOs	
CO1	Knowledge of self-development.						
CO2	Learn the importance of Human values.						
CO3	Developing the overall personality.						

26AC005		CONSTITUTION OF INDIA		SEMESTER		I/II	
Prerequisites			Category	AC	Credits		0
			Hours/ Semester	L	T	P	TH
				30	0	0	30
COURSE OBJECTIVES							
1.	Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective. To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism. To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.						
UNIT - I		HISTORY OF MAKING OF INDIAN CONSTITUTION					5
History, Drafting Committee (Composition & working)							
UNIT - II		PHILOSOPHY OF THE INDIAN CONSTITUTION					5
Preamble, Salient Features							
UNIT - III		CONTOURS OF CONSTITUTIONAL RIGHTS & DUTIES					5
Fundamental rights, right to equality, right to freedom, right against exploitation, right to freedom of religion, cultural and education rights, right to constitutional remedies, directive principles of state policy, fundamental duties.							
UNIT - IV		ORGANS OF GOVERNANCE					5
Parliament, composition, qualifications and disqualifications, powers and functions, executive, president, governor, council of ministers, judiciary, appointment and transfer of judges, qualifications, powers and functions.							
UNIT - V		LOCAL ADMINISTRATION					5
Districts administration head: role and importance, municipalities: introduction, mayor and role of elected representative, CEO of municipal corporation. Panchayati raj: introduction, PRI: zila panchayat. Elected officials and their roles, CEO zila panchayat: position and role. Block level: organizational hierarchy (different departments), village level: role of elected and appointed officials, importance of grass root democracy.							
UNIT - VI		ELECTION COMMISSION					5
Election Commission: role and functioning. Chief election commissioner and election commissioners. State election commission: role and functioning. Institute and bodies for the welfare of SC/ST/OBC and women.							
L: 30, Total: 30 Hours							
Weightage: Continuous Assessment - 100%							
REFERENCE BOOKS:							
1.	The Constitution of India, 1950 (Bare Act), Government Publication						
2.	Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.						
3.	M. P. Jain, Indian Constitution Law, 7th Edn., LexisNexis, 2014.						
4.	D.D. Basu, Introduction to the Constitution of India, LexisNexis, 2015						

COURSE OUTCOMES (COs) / At the end of the course, the students will have the ability to		Mapping POs	Mapping PSOs
C01	Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics		
C02	Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.		
C03	Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution		
C04	Discuss the passage of the Hindu Code Bill of 1956		

26AC006		PEDAGOGY STUDIES			SEMESTER		I/II	
Prerequisites				Category	AC	Credits		0
				Hours/ Semester	L	T	P	TH
					30	0	0	30
COURSE OBJECTIVES								
1.	To Review existing evidence on the review topic to inform programme design and policy making undertaken by the DFID, other agencies and researchers. Identify critical evidence gaps to guide the development.							
UNIT - I		INTRODUCTION AND METHODOLOGY						6
Aims and rationale, Policy background, Conceptual framework and terminology, Theories of learning, Curriculum, Teacher education, Conceptual framework, Research questions, Overview of methodology and Searching								
UNIT - II		THEMATIC OVERVIEW						6
Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries, Curriculum, Teacher education.								
UNIT - III		EVIDENCE ON THE EFFECTIVENESS OF PEDAGOGICAL PRACTICES						6
Methodology for the in depth stage: quality assessment of included studies, How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? Theory of change. Strength and nature of the body of evidence for effective pedagogical practices, Pedagogic theory and pedagogical approaches, Teachers' attitudes and beliefs and Pedagogic strategies.								
UNIT - IV		PROFESSIONAL DEVELOPMENT						6
Alignment with classroom practices and follow-up support, Peer support, Support from the head teacher and the community, Curriculum and assessment, Barriers to learning: limited resources and large class sizes.								
UNIT - V		RESEARCH GAPS AND FUTURE DIRECTIONS						6
Research design, Contexts, pedagogy, teacher education, curriculum and assessment, dissemination and research impact.								
L: 30, Total: 30 Hours								
Weightage: Continuous Assessment - 100%								

REFERENCE BOOKS:			
1.	Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, Compare, 31 (2): 245-261.		
2.	Agrawal M (2004) Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3) 361-379.		
3.	Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID		
4.	Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic math and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33 (3): 272-282.		
5.	Alexander RJ (2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.		
COURSE OUTCOMES (COs) / At the end of the course, the students will have the ability to		Mapping POs	Mapping PSOs
CO1	What pedagogical practices are being used by teachers in formal and informal classrooms in developing countries?		
CO2	What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?		
CO3	How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?		

26AC007		STRESS MANAGEMENT BY YOGA			SEMESTER		I/II	
Prerequisites				Category	AC	Credits		0
				Hours/ Semester	L	T	P	TH
					30	0	0	30
COURSE OBJECTIVES								
1.	To create a healthy, strong willed and intelligent young society through yoga practices							
UNIT - I		PHYSICAL AND MENTAL HEALTH						6
Pain and disease - free life, Simplified Physical Exercise- Pranayama. Concentration on Pituitary gland- Practical, Goal fixing								
UNIT - II		REJUVENATION OF LIFE FORCE AND WILL POWER						6
Principle of kayakalpa yoga, mind, life force and Biomagnetism, Practical, Concentration on Muladhara- Practical, Analysis of thought –Will power								
UNIT - III		DEVELOPMENT OF VIRTUES						6
Activation of Dormant Brain cells- Practical, Moralization of dezire and its classification, Neutralization of Anger, Results of anger								
UNIT - IV		STREAM LINING OF MIND						6
Definition of Mind-Worries, Eradication of Worries. The science behind blessings. Blessing techniques. Benefits, five basic duties								
UNIT - V		CAUSE AND EFFECT SYSTEM						6
Law of nature, Hereditary Imprints, Fivefold and Two-fold culture, good values and Resolution for world peace								
L: 30, Total: 30 Hours								
Weightage: Continuous Assessment - 100%								
REFERENCE BOOKS:								
1.	"Thirukkural" , Pearls of Inspiration, Translation by Rajaram, Publisher :RUPA							
2.	"Bharathiyar Poems", Amazon Asia – Pacific Holdings Private Limited							
3.	"Yoga for Humane Excellence" ,Vethathiri Maharishi, Vision for Wisdom, Vethathiri Publications							
COURSE OUTCOMES (COs) / At the end of the course, the students will have the ability to					Mapping POs		Mapping PSOs	
CO1	Maintain good Physical health.							
CO2	Develop will power.							
CO3	Take quick and right decisions.							
CO4	Maintain good relationship with everyone around them his creating a Health Society							

26AC008	PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS				SEMESTER		I/II	
Prerequisites				Category	AC	Credits		0
				Hours/ Semester	L	T	P	TH
					30	0	0	30
COURSE OBJECTIVES								
1.	To learn to achieve the highest goal happily,							
2.	To become a person with stable mind, pleasing personality and determination,							
3.	To awaken wisdom in students.							
UNIT - I		NEETISATAKAM – HOLISTICS DEVELOPMENT OF PERSONALITY						6
Verses 19, 20, 21, 22 (Wisdom) - Verses 29, 31, 32 (Pride and Heroism) - Verses 26,28,63,65 (Virtue)								
UNIT - II		NEETISATAKAM — HOLISTIC DEVELOPMENT OF PERSONALITY (CONT'D)						6
Verses 52, 53, 59 (don'ts) - Verses 71.73.75 & 78 (do's) - Approach to day to day works and duties.								
UNIT - III		INTRODUCTION TO BHAGAVADGEETHA FOR PERSONALITY DEVELOPMENT						6
Shrimad Bhagavadgeetha: Chapter 2 — Verses 41, 47, 48 - Chapter 3 — Verses 13,21,27,35 - Chapter 6 - Verses 5,13,17,23,35 - Chapter 18 - Verses 45,40,48 Chapter - 6: Verses 5, 13, 17, 23, 35; Chapter - 18: Verses 45, 46, 48								
UNIT - IV		STATEMENTS OF BASIC KNOWLEDGE - SHRIMAD BHAGAVADGEETHA						6
Chapter 2- Verses 56, 62,68 - Chapter 12 — Verses 13, 14, 15, 16, 17, 18 - Personality of Role model from Shrimad Bhagawat Geeta.								
UNIT - V		ROLE OF BHAGAVADGEETHA IN THE PRESENT SCENARIO						6
Chapter 2 — Verses 17 - Chapter 3 — Verses 36, 37, 42 - Chapter 4 — Verses 18, 38, 39 - Chapter 18 — Verses 37, 38, 63.								
L: 30, Total: 30 Hours								
Weightage: Continuous Assessment - 100%								
REFERENCE BOOKS:								
1.	“Srimad Bhagavad Gita” by Swami Swarupananda Advaita Ashram (Publication Department), Kolkata							
2.	Bhartrihari’s Three Sataskam (Niti- Sringar – Vairagya), P.Gopinath, Rashtriya Sanskrit Sansthanam, New Delhi.							

E-RESOURCES:			
1.	NTPEL: http://nptel.ac.in/downloads/109104115		
COURSE OUTCOMES (COs) / At the end of the course, the students will have the ability to		Mapping POs	Mapping PSOs
C01	Develop their personality and achieve their highest goal of life.		
C02	Lead the nation and mankind to peace and prosperity.		
C03	Practice emotional self-regulation.		
C04	Develop a positive approach to work and duties.		
C05	Develop a versatile personality.		

26AC009	SUSTAINABLE DEVELOPMENT GOALS		SEMESTER			I/II
PREREQUISITES		Category	AC	Credits		0
		Hours/ Semester	L	T	P	TCP
			30	0	0	30
COURSE OBJECTIVES						
1.	To understand the concepts of Sustainable Development Goals					
2.	To study sustainability assessment methods, education for sustainable development					
3.	To analyze the problems and solution in environmental management.					
4.	To analyze the issues related to resource utilization.					
5.	To explore knowledge about life cycle assessment.					
UNIT - I	INTRODUCTION TO SUSTAINABLE DEVELOPMENT					6
Need and Importance of Sustainable Development - Historical & Policy perspectives of Sustainable Development - Sustainable Development: World and India Perspective - Introduction to 17 SDGs - Specific learning objectives for different SDGs - Challenges & strategies of attaining SDGs in developed and developing nations.						
UNIT - II	SDG QUALITY EDUCATION					6
Focus of NEP-2020 on SDG - Education for Sustainable Development - Berlin Declaration 2021 on ESD - Integration of ESD - Tools, Systems, and Innovation for Sustainability - Measuring Sustainability.						
UNIT - III	SUSTAINABLE COMMUNITIES AND RESOURCE CONSERVATION					6
Circular economy (basic model of reuse, recycle, and reduce) - Rural & urban Problems & Challenges - Sustainable production and consumption - Renewable energy - Health & Hygiene, water, sanitation & water management - Waste Management.						
UNIT - IV	CLIMATE CHANGE, ENERGY AND SUSTAINABLE DEVELOPMENT					6
The greenhouse effect: Causes and Consequences - Climate Change: A Threat to Sustainable Development - Adaptation to Current and Future Climate Regimes - Consequences: crop failure - Solutions technology and lifestyle changes - Mitigating Climate Change.						
UNIT - V	SUSTAINABLE BUSINESS PRACTICES					6
Corporate Social Responsibility - Sustainable products and services - Business and Environment - Corporations and Ecological Sustainability - Life Cycle Assessment: LCA Overview and Application - World peace and justice: United nations goals for peace and justice - World Government for peace.						
L:30, Total:30 Hours						
Weightage:						
Continuous Assessment - 100%						

REFERENCE BOOKS:	
1.	Onyeka Osuji, "Corporate Social Responsibility in Developing and Emerging Markets", Cambridge, 2022.
2.	Ram Kumar, Ch Lakshmi, Sandee, Janaki, "Smart Cities for Sustainable Development", Springer Switzerland, 2022.
3.	Surender Kumar and Shunsuke Managi, "The Economics of Sustainable Development: The Case of India (Natural Resource Management and Policy)", Springer Switzerland, 2009.
4.	Sushma Goyal, "Management of Resources for Sustainable Devpt", The Orient Blackswan, 2016.
5.	S. Ramaswamy Sathis G. Kumar, "Energy, Environment and Sustainable Development: Issues and Policies", Regal Publications, 2009.
E-RESOURCES:	
1.	https://www.un.org/sustainabledevelopment/
2.	https://www.aiu.ac.in/documents/AIU_Publications/UN-SDG goals
3.	https://www.unesco.org/en/education-sustainable-development
4.	https://onlinecourses.nptel.ac.in/noc23_hs57/preview
5.	https://www.iau-hesd.net/news/5180-berlin-declaration-education-sustainable development-adopted-unesco-esd-conference-17-19
COURSE OUTCOMES (COs) / At the end of the course, the students will have the ability to	
CO1	Explain the concepts of Sustainable Development and United Nations Sustainable Development Goals (SDGs), sustainability assessment methods, and their significance in national and global contexts.
CO2	Apply the challenges related to resource utilization, circular economy, renewable energy, sustainable production and consumption, environmental management, climate change, and their impact on society and sustainable development.
CO3	Analyze the sustainable business practices, corporate social responsibility, ecological sustainability, life cycle assessment, and global initiatives for achieving environmental protection, social equity, peace, and sustainable growth.
CO4	Design and develop a sustainability assessment project, case study, field survey, or community-based solution for a selected SDG.
CO5	Demonstrate professional competency through technical seminar presentations/group discussions, or preparation of technical reports on emerging trends, innovations, policies, and best practices related to SDG.