ANNA UNIVERSITY: : CHENNAI 600 025

UNIVERSITY DEPARTMENTS

M.E. THERMAL ENGINEERING WITH SPECIALISATION IN

ENGINES AND HYBRID TECHNOLOGIES

REGULATIONS – 2023

CHOICE BASED CREDIT SYSTEM

VISION

The Department of Mechanical Engineering strives to be recognized globally for excelling in engineering education and research leading to innovative, entrepreneurial, and competent graduates in Mechanical Engineering and allied disciplines.

MISSION

1. Providing world class education by fostering effective teaching learning process that is supported through pioneering and cutting-edge research to make impactful contribution to the society.
2. Attracting highly motivated students with enthusiasm, aptitude, and interest in the field of Mechanical and allied Engineering disciplines.
3. Expanding the frontiers of Engineering and Science in technological innovation while ensuring academic excellence and scholarly learning in a collegial environment.
4. Excelling in industrial consultancy and research leading to innovative technology development and transfer.
5. Serving the society with innovative and entrepreneurially competent graduates for the national and international community towards achieving the sustainable development goals.

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PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

The programme would prepare PG students for productive and rewarding careers in the field of engines and electric mobility. The PEOs are listed below:

(i) Acquire knowledge and employability with the requisite skills, facilitating quick progress in the graduand's career

(ii) Focus on advanced research for developing solutions for green and sustainable mobility

(iii) Uphold professional ethics in the field of work for societal upliftment.

PROGRAMME OUTCOMES (POs):

PO	Programme Outcomes
1	Ability to independently carry out innovative development to solve practical problems.
2	Ability to write and present a substantial technical report/document.
3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the programme.
4	Technically sound and competent to work in the mobility sector
5	Ability to transfer acquired knowledge through innovative and modern teaching methodologies
6	Capability to excel in core research at national and international institutions/laboratories

PEO & PO Mapping

PEO	PO					
	1	2	3	4	5	6
I.	3	3	3	3	2	3
II.	3	2	3	1	1	3
III.	2	2	2	3	3	3

PROGRAMME ARTICULATION MATRIX

		COURSE NAME	PO1	PO2	PO3	PO4	PO5	PO6
YEAR I	SEMESTER I	Advanced Numerical Methods						
		Advanced Thermodynamics	2.8	2.8	1.8	2.4	1.8	2
		Advanced Heat Transfer	2.4	2.6	2.2	2.6	2	2
		Measurements and Controls for Thermal systems	2.8	3	2.8	2.4	2.6	2
		Electric Vehicle Technology	3	2	-	-	3	1.5
		Research Methodology and IPR	2.4	2.6	2.2	2.2	2.2	2
		Technical Seminar	2.6	2.6	2	3	2.4	2.6
	SEMESTER II	Computational Fluid Dynamics	3	2	2	2	3	2
		Engine Combustion and Emissions	3	2	2	-	3	2
		Modern Engine Technologies	3	1.25	1	-	3	1
		Thermal Management of Battery Systems	2.75	2.25	3	3	2	3
		Professional Elective I						
		Industry-Oriented Course						
		Engines and Hybrid Technology Laboratory	3	2	3	3	2	2
		Simulation Laboratory	2.8	2.8	2.6	2.8	1.4	1.8
YEAR II	SEMESTER III	Professional Elective II						
		Professional Elective III						
		Open Elective						
		Summer Internship	2.4	2.4	1.8	2.2	2.4	2.6
		Project Work – I	2.4	3	2.4	2	2	2.4
	SEMESTER IV	Project Work – II	3	2.6	2.2	2	3	2

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CHOICE BASED CREDIT SYSTEM

CURRICULUM FOR SEMESTER I TO IV AND SYLLABI FOR SEMESTER I

SEMESTER I

S. No.	Course Code	Course Title	Category	Periods Per Week			Total Contact Periods	Credits
				L	T	P		
THEORY								
1.	MA3155	Advanced Numerical Methods	PCC	4	0	0	4	4
2.	EH3151	Advanced Thermodynamics	PCC	4	0	0	4	4
3.	EH3152	Advanced Heat Transfer	PCC	3	0	2	5	4
4.	EH3101	Measurements and Controls for Thermal Systems	PCC	3	0	0	3	3
5.	EH3102	Electric Vehicle Technology	PCC	3	0	0	3	3
6.	RM3151	Research Methodology and IPR	RMC	2	1	0	3	3
PRACTICALS								
7.	EH3111	Technical Seminar	EEC	0	0	2	2	1
			TOTAL	**18**	**0**	**4**	**22**	**22**

SEMESTER II

S. No.	Course Code	Course Title	Category	Periods Per Week			Total Contact Periods	Credits
				L	T	P		
THEORY								
1.		Computational Fluid Dynamics	PCC	3	0	2	5	4
2.		Engine Combustion and Emissions	PCC	3	0	0	3	3
3.		Modern Engine Technologies	PCC	3	0	0	3	3
4.	.	Thermal Management of Battery Systems	PCC	3	0	0	3	3
5.		Professional Elective I	PEC	3	0	0	3	3
6.		Industry-Oriented Course	IOC	1	0	0	1	1
PRACTICALS								
7.		Engines and Hybrid Technology Laboratory	PCC	0	0	4	4	2
8.		Simulation Laboratory	PCC	0	0	2	2	1
			TOTAL	**16**	**0**	**8**	**24**	**20**

SEMESTER III

S. No.	Course Code	Course Title	Category	Periods Per Week			Total Contact Periods	Credits
				L	T	P		
THEORY								
1.		Professional Elective II		3	0	0	3	3
2.		Professional Elective III		3	0	0	3	3
3.		Open Elective		3	0	0	3	3
PRACTICALS								
4.		Summer Internship		---	---	---	4 weeks	2
5.		Project Work I		0	0	12	12	6
			TOTAL	**9**	**0**	**12**	**21**	**17**

SEMESTER IV

S. No.	Course Code	Course Title	Category	Periods Per Week			Total Contact Periods	Credits
				L	T	P		
PRACTICALS								
1.		Project Work II		0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL CREDITS: 71

PROFESSIONAL ELECTIVE COURSES (PEC)

S. No.	Course Code	Course Title	Periods			Total Contact Periods	Credits
			L	T	P		
1.		Automotive Embedded Systems	3	0	0	3	3
2.		Autonomous Vehicle Technologies and Control Systems	3	0	0	3	3
3.		AI and Machine Learning for Intelligent Vehicles	3	0	0	3	3
4.		Special Electrical Machines	3	0	0	3	3
5.		Automotive Technology	3	0	0	3	3
6.		Engine Electronic Management Systems	3	0	0	3	3
7.		Advanced Combustion Technologies	3	0	0	3	3
8.		Hydrogen Production and Utilisation	3	0	0	3	3
9.		Low and Zero Carbon Fuels	3	0	0	3	3
10.		Energy Storage Technologies	3	0	0	3	3

MA3155	ADVANCED NUMERICAL METHODS	L	T	P	C
		4	0	0	4

COURSE OBJECTIVES:

- To impart knowledge in understanding the advantages of various solution procedures of solving the system of linear and nonlinear equations.
- To give a clear picture about the solution methods for solving the BVPs and the system of IVPs.
- To acquire knowledge in solving time dependent one and two dimensional parabolic PDEs by using various methodologies.
- To strengthen the knowledge of finite difference methods for solving elliptic equations.
- To get exposed to the ideas of solving PDEs by finite element method.

UNIT I	ALGEBRAIC EQUATIONS	12

Systems of linear equations: Gauss Elimination method, pivoting techniques, Thomas algorithm for tridiagonal system – Jacobi, Gauss Seidel, SOR iteration methods - Systems of nonlinear equations: Fixed point iterations, Newton Method, Eigenvalue problems: power method, Faddeev – Leverrier Method.

UNIT II	ORDINARY DIFFERENTIAL EQUATIONS	12

Runge-Kutta Methods for system of IVPs, numerical stability, Adams-Bashforth multistep method, solution of stiff ODEs, shooting method, BVP: Finite difference method, collocation method, orthogonal collocation method, Galerkin infinite element method.

UNIT III	FINITE DIFFERENCE METHOD FOR TIME DEPENDENT PARTIAL DIFFERENTIAL EQUATION	12

Parabolic equations: explicit and implicit finite difference methods, weighted average approximation - Dirichlet and Neumann conditions – Two dimensional parabolic equations – ADI method; First order hyperbolic equations – method of characteristics, Lax - Wendroff explicit and implicit methods; numerical stability analysis, method of lines – Wave equation: Explicit Scheme-Stability of above schemes.

UNIT IV	FINITE DIFFERENCE METHODS FOR ELLIPTIC EQUATIONS	12

Laplace and Poisson’s equations in a rectangular region: Five-point finite difference schemes, Leibmann’s iterative methods, Dirichlet and Neumann conditions – Laplace equation in polar coordinates: finite difference schemes – approximation of derivatives near a curved boundary while using a square mesh.

UNIT V	FINITE ELEMENT METHOD	12

Partial differential equations – Finite element method - collocation method, orthogonal collocation method, Galerkin finite element method.

Total : 60 Periods

COURSE OUTCOMES:

At the end of the course, students will be able to

CO1 Get familiarized with the methods which are required for solving system of linear, nonlinear equations and eigenvalue problems.

CO2 Solve the BVPs and the system of IVPs by appropriate methods discussed.

CO3 Solve time dependent parabolic PDEs by using various methodologies up to dimension two.

CO4 Solve elliptic equations by finite difference methods.

CO5 Use the ideas of solving PDEs by finite element method.

REFERENCES:

1. Burden, R.L., and Faires, J.D., “Numerical Analysis – Theory and Applications”, Cengage Learning, India Edition, New Delhi, 2010.

2.	Gupta S.K., “Numerical Methods for Engineers”, New Age Publishers, 3rd Edition, New Delhi, 2015.
3.	Jain M. K., Iyengar S. R. K., Jain R.K., “Computational Methods for Partial Differential Equations”, New Age Publishers, 2nd Edition, New Delhi, 2016.
4.	Morton K.W. and Mayers D.F., “Numerical solution of partial differential equations”, Cambridge University press, Cambridge, 2005.
5.	Sastry S.S., "Introductory Methods of Numerical Analysis", Prentice - Hall of India Pvt. Limited, 5th Edition, New Delhi, 2012.
6.	SaumyenGuha and Rajesh Srivastava, “Numerical methods for Engineering and Science”, Oxford Higher Education, New Delhi, 2010

CO-PO Mapping:

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

EH3151 ADVANCED THERMODYNAMICS

L	T	P	C
4	0	0	4

COURSE OBJECTIVES:

1. To impart a comprehensive understanding of classical thermodynamics including laws of thermodynamics, system properties, and energy interactions.
2. To develop analytical skills to evaluate the performance of thermodynamic systems using concepts of entropy, exergy, and availability.
3. To enable students to apply thermodynamic principles to real gases, multi-component systems, and combustion analysis of hydrocarbon fuels.

UNIT I FIRST LAW OF THERMODYNAMICS 12

Laws of Thermodynamics, Thermodynamic system and types, properties and processes, PV and TS diagrams, Heat and Work, Application of First law of thermodynamics – Open and Closed systems.

UNIT II SECOND LAW OF THERMODYNAMICS 12

Heat Engine, refrigerator and heat pump, Carnot cycle, First and Second law corollaries. Principle of entropy increase, Clausius inequality and its Applications, Thermodynamic Relations.

UNIT III EXERGY 12

High and low grade energy, Reversible work, Availability and Irreversibility for open and closed systems, Exergy and Energy, First and Second Law Efficiency for various systems, Availability of hydrocarbon fuels.

UNIT IV REALGASBEHAVIOURANDMULTI-COMPONENTSYSTEMS 12

Equations of State, Fugacity and its coefficient, Principle of Corresponding States, enthalpy and entropy departure, Lee-Kesler generalized three parameter tables. Fundamental property relations for systems of variable composition, partial molar properties, Gibb's phase rule for non-reactive components.

UNIT V CHEMICAL THERMODYNAMICS AND COMBUSTION 12

First and Second law analysis of reacting systems - Adiabatic flame temperature - entropy change of reacting systems. Criterion for reaction equilibrium. Combustion of Hydrocarbon Fuels-Proximate and Ultimate Analysis. Heat of reaction, combustion and formation. Stoichiometric, fuel rich and oxygen rich reactions. Heating value of fuels. Explosion limits, flames and flammability limits. Diffusion and premixed flames.

Total : 60 Periods

COURSE OUTCOMES:

On successful completion of this course, the student will be able to

- **CO1** Explain the laws of thermodynamics, system properties, and energy interactions in closec and open systems.
- **CO2** Apply the second law of thermodynamics, entropy relations, and thermodynamic property relations to analyze thermal systems.
- **CO3** Evaluate exergy, availability, irreversibility, and efficiencies for different thermodynamic systems including hydrocarbon fuels.
- **CO4** Analyse real gas behavior, multi-component systems, fugacity, partial molar properties, and Gibbs phase rule to solve engineering problems.
- **CO5** Assess chemical thermodynamic properties, combustion characteristics, adiabatic flame temperature, and reaction equilibrium for hydrocarbon fuels.

REFERENCES:

1. Adrian Bejan, Advanced Engineering Thermodynamics, John Wiley & Sons, 4th Edition, 2016

2. Moran and Shapiro, "Principles of Engineering Thermodynamics", 8th Edition, Wiley Eastern.

3. Kenneth Wark J.R, Advanced Thermodynamics for Engineers, McGraw-Hill Inc., 1995.

4. Sonntag R.E. and Van Wylen, G., Introduction to Thermodynamics, Classical and Statistical Themodynamics, Third Edition, John Wiley and Sons, 1991.
5. Cengel, Y and M. Boles, Thermodynamics - An Engineering Approach, Tata McGraw Hill,8th Edition, 2015.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	1	1	2
CO2	3	3	2	2	2	2
CO3	3	3	2	3	2	2
CO4	3	3	2	3	2	2
CO5	2	3	2	3	2	2
Avg.	**2.8**	**2.8**	**1.8**	**2.4**	**1.8**	**2**

EH3152 ADVANCED HEAT TRANSFER

L	T	P	C
3	0	2	4

COURSE OBJECTIVES:

1. To teach the fundamentals and advancements of heat transfer and its applications with emphasis on numerical solutions to the students and prepare them for research.
2. To offer hands-on training on measurement, analysis of heat transfer phenomena Kwith emphasis on data analysis and report preparation.

UNIT I CONDUCTION 9L, 6P

Fourier law of conduction, Thermal Conductivity,3D-conduction equation, Fin Design, analytical solutions — multi-dimensional steady state heat conduction, Transient Heat conduction — Lumped Capacitance Method, Semi-Infinite Media Method, Boundary Conditions.

PRACTICALS:
Thermal conductivity of solids and liquids and effect of temperature, Thermal analysis of fins, Lumped heat method for analysis of different geometries.

UNIT II CONVECTION 9L, 6P

Energy and Momentum equations, Laminar and Turbulent Boundary Layers, Entry length, Reynolds-Colburn Analogy, Heat transfer coefficient for flow over a flat surface, circular and non-circular ducts.

PRACTICALS:
Thermal and hydraulic boundary layer development through fluid, Free and Forced convective heat transfer coefficient studies.

UNIT III TWO-PHASE HEAT TRANSFER 9L, 6P

Boiling, critical heat flux, Drop wise and film wise condensation, Melting and Solidification, Heat transfer enhancement methods.

PRACTICALS:
Plotting of boiling & condensation curves, T-t plots during melting & solidification.

UNIT IV RADIATION 9L, 6P

Black body radiation, View factor – Algebra. Radiation in an enclosure and in Participating and non-participating medium.

PRACTICALS:
Monte Carlo Ray Tracing (MCRT) simulation – View factor calculation.

UNIT V THRUSTAREAS 9L, 6P

Heat exchanger, Battery thermal management, Heat pipes, Thermal energy storage, Solar desalination, Solar refrigeration, Hybrid electric vehicles. Machine Learning in Heat Transfer — Linear regression and Neural networks, Practical considerations & Applications.

PRACTICALS:
Application of machine learning in heat transfer.

Total : 45L + 30P = 75 Periods

REFERENCES

1. John H. Lienhard IV and John H. Lienhard V, A Heat Transfer Textbook, Phlogiston Press, 2020.
2. Adrian Bejan, Convection Heat Transfer,Wiley,2013.
3. Holman. J. P, Heat Transfer, Tata McGraw Hill,2002.
4. Yunus Cengel, Heat and Mass Transfer: Fundamentals and Applications, McGrawHill, 2020.
5. Brennen, C. E., Fundamentals of Multiphase Flow, Cambridge UniversityPress,2005.

6. Collier, J. G. and Thome, J. R., Convective Boiling and Condensation, 3rd ed., Oxford University Press.
7. Incropera F.P. and DeWitt. D.P., Fundamentals of Heat & Mass Transfer, John Wiley &Sons ,2002.
8. Ashley J. Welch, Martin J.C.Gemert, Optical-Thermal Response of Laser-Irradiated Tissue, Springer Dordrecht, 2011.
9. Punit Prakash, Govindarajan Srimathveeravalli, Principles and Technologies for Electromagnetic Energy Based Therapies, Academic Press, 2021.

COURSE OUTCOMES:

On successful completion of this course the student will be able to

CO1	Explain the fundamentals and advanced concepts of conduction, convection, radiation, and phase-change heat transfer.
CO2	Apply analytical, numerical, and experimental methods to solve steady and transient heat conduction, convection, boiling/condensation, and radiation problems.
CO3	Analyze experimental data from conduction, convection, radiation, and two-phase heat transfer systems, including error estimation and uncertainty analysis.
CO4	Evaluate the performance of heat exchangers, heat pipes, thermal storage, and advanced thermal systems using theoretical and computational approaches.
CO5	Design and develop innovative heat transfer solutions for advanced applications such as battery thermal management, solar desalination, hybrid electric vehicles, and machine-learning-assisted thermal analysis.

CO-PO Mapping:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	1	1	2	2
CO2	3	3	2	2	2	2
CO3	2	3	2	3	2	2
CO4	2	3	3	2	2	2
CO5	2	2	3	3	2	2
Avg.	**2.4**	**2.6**	**2.2**	**2.6**	**2**	**2**

EH3101 MEASUREMENTS AND CONTROLS FOR THERMAL SYSTEMS

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

1. To expose students to basic characteristics of measurement parameters, and enable the students use appropriate measurement system for various applications
2. To elaborate the students on the need, types of control systems and architecture of a control system
3. To equip students with the skills required to design appropriate control unit for a range of thermal systems

UNIT I BASICS OF MEASUREMENTS 9

Introduction, general measurement system, Signal flow diagram of measurement system, Inputs and their methods of correction, Presentation of experimental data, Errors in measurement, Propagation of errors, Uncertainty analysis, Regression analysis, Transient response – zeroth, first and second order measurement systems.

UNIT II MEASUREMENTS IN THERMAL SYSTEMS 9

Basic Electrical measurements, Transducers and its types, Signal conditioning and processing - Measurement of temperature, pressure, velocity, flow – basic and advanced techniques.

UNIT III MEASUREMENT OF FUEL PROPERTIES AND POLLUTANTS 9

Thermo / Physical / Chemical and transport properties of solids, liquids and gaseous fuels, Analysers – Flame Ionisation Detector, Non-Dispersive Infrared Analyser, Chemiluminescent detector, Smoke meters, and Gas chromatography.

UNIT IV CONTROL SYSTEMS AND COMPONENTS 9

Introduction, Open and closed loop control systems, Transfer function. Types of feedback and feedback control system characteristics – Control system parameters – DC and AC servomotors, servo amplifier, potentiometer, synchro transmitters, synchro receivers, synchro control transformer, stepper motors - Continuous, Discontinuous and Composite control modes – Analog and Digital controllers.

UNIT V DATA ACQUISITION AND SIGNAL CONDITIONING 9

Data logging and acquisition - Integration of industrial instrumentation systems and monitoring, sensors for error reduction, elements of computer interfacing, timers and counters, designing measurement and control systems for specific applications, fault finding, and computer-based controls.

Total : 45 Periods

COURSE OUTCOMES:

On successful completion of this course the student will be able to

CO1 Understand the concepts of errors in measurements, statistical analysis of data, regression analysis, correlation, and estimation of uncertainty.
CO2 Select appropriate sensors for measurement of specific parameters/properties with required accuracy.
CO3 Carry out calibration and evaluate measurement systems using uncertainty analysis
CO4 Distinguish between measurement and control systems, and use appropriate control system for an application
CO5 Construct a complete control system for a thermal application.

REFERENCES:

1. Holman J.P, “Experimental methods for Engineers”, Tata McGraw-Hill, 8th Edition, 2018.
2. Venkateshan S.P, “Mechanical Measurements”, Springer, 2nd Edition, 2022.
3. Ernest O Doebelin and Dhanesh N. Manik, “Measurement systems: Application and design”, Tata McGraw Hill publications, 7th Edition, 2019.

4. Thomas G Beckwith, Roy D. Marangoni, and John H. Lienhard, "Mechanical Measurements" Pearson publications, 6th Edition, 2006.

5. A. Morris, "Measurement and Instrumentation Principles," Oxford, UK, 3rd Edition, 2015.

6. Nakra, B.C., Choudhry K.K., "Instrumentation, Measurements and Analysis", Tata McGraw Hill, New Delhi, 4th Edition, 2016.

7. William Bolton, "Industrial Control & Instrumentation", Longman Scientific & Technical, 1991.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	3	2	2
CO2	3	3	3	2	3	2
CO3	3	3	3	3	3	2
CO4	2	3	3	2	2	2
CO5	3	3	3	2	3	2
Avg.	**2.8**	**3**	**2.8**	**2.4**	**2.6**	**2**

EH3102	ELECTRIC VEHICLE TECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

The objective of this course is to introduce the basic concepts of electric vehicle and their characteristics and their architecture, various energy storage systems, different types of motors and their characteristics and to design an electric vehicle

UNIT I NEED FOR ELECTRIC VEHICLES 9

History and need for electric and hybrid vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies, comparison of diesel, petrol, electric and hybrid vehicles, limitations, technical challenges

UNIT II ELECTRIC VEHICLE ARCHITECTURE 9

Electric vehicle types, layout and power delivery, performance – traction motor characteristics, tractive effort, transmission requirements, vehicle performance, energy consumption, Concepts of hybrid electric drive train, architecture of series and parallel hybrid electric drive train, merits and demerits, mild and full hybrids, plug-in hybrid electric vehicles and range extended hybrid electric vehicles, Fuel cell vehicles.

UNIT III ENERGY STORAGE 9

Batteries – types – lead acid batteries, nickel-based batteries, and lithium based batteries, electrochemical reactions, thermodynamic voltage, specific energy, specific power, energy efficiency, Battery modeling and equivalent circuit, battery charging and types, battery cooling, Ultra-capacitors, Flywheel technology, Hydrogen fuel cell, Thermal Management of the PEM fuel cell

UNIT IV ELECTRIC DRIVES AND CONTROL 9

Types of electric motors – working principle of AC and DC motors, advantages and limitations, DC motor drives and control, Induction motor drives and control, PMSM and brushless DC motor -drives and control, AC and Switch reluctance motor drives and control – Drive system efficiency – Inverters – DC and AC motor speed controllers

UNIT V DESIGN OF HYBRID ELECTRIC VEHICLES 9

Motor sizing, power pack sizing, component matching, Ideal gear box – Gear ratio, torque–speed characteristics, Dynamic equation of vehicle motion, Maximum tractive effort – Power train tractive effort Acceleration performance, rated vehicle velocity – maximum gradability, Brake performance, electronic control system, safety and challenges in electric vehicles. Case study of NISSAN LEAF, TOYOTA PRIUS, TESLA model 3, and RENAULT ZOE cars

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On successful completion of this course the student will be able to

CO1 Understand the advantages and challenges of electric vehicles
CO2 Understand and select appropriate electric vehicle architecture
CO3 Adopt a suitable energy storage system for a vehicle
CO4 Choose an appropriate electric motor and drive system for a vehicle
CO5 Design a suitable electric vehicle for various applications

REFERENCES:

1. John G Hayes and G AbaasGoodarzi, Electric Powertrain -, 1st Edition, John Wiley & Sons Ltd., 2018.
2. Iqbal Husain, “Electric and Hybrid Vehicles – Design Fundamentals”, Second Edition, CRC Press,2019
3. Alfred Rufer, “Energy Storage systems and components”, CRC Press,2017

4 Hong Cheng, —Autonomous Intelligent Vehicles: Theory, Algorithms & Implementation‖, Springer, 2011
5 Berker B., James W. J. & A. Emadi, “Switched Reluctance Motor Drives”, CRC Press 2017
6 Ehsani, Mehrdad, et al. Modern electric, hybrid electric, and fuel cell vehicles. CRC press, 2017.

CO – PO MAPPING:

CO	PO					
	1	2	3	4	5	6
1	3	2	-	-	3	1
2	3	1	-	-	3	-
3	3	1	-	-	3	-
4	3	1	-	-	3	-
5	3	2	-	-	3	2
Avg	**3**	**2**	**-**	**-**	**3**	**1.5**

RM3151 RESEARCH METHODOLOGY AND IPR

L	T	P	C
2	1	0	3

COURSE OBJECTIVES:

To impart knowledge on

- Formulation of research problems, design of experiment, collection of data, interpretation and presentation of result
- Intellectual property rights, patenting and licensing

UNIT I RESEARCH PROBLEM FORMULATION 9

Objectives of research, types of research, research process, approaches to research; conducting literature review- information sources, information retrieval, tools for identifying literature, Indexing and abstracting services, Citation indexes, summarizing the review, critical review, identifying research gap, conceptualizing and hypothesizing the research gap

UNIT II RESEARCH DESIGN AND DATA COLLECTION 9

Statistical design of experiments- types and principles; data types & classification; data collection - methods and tools.

UNIT III DATA ANALYSIS, INTERPRETATION AND REPORTING 9

Sampling, sampling error, measures of central tendency and variation; test of hypothesis- concepts; data presentation-types of tables and illustrations (evaluated by suitable software); guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript; guidelines for writing thesis, research proposal; References – Styles and methods (Reference manager), Citation and listing system of documents; plagiarism, ethical considerations in research

UNIT IV INTELLECTUAL PROPERTY RIGHTS 9

Concept of IPR, types of IPR – Patent, Designs, Trademarks and Trade secrets, Geographical indications, copy rights, applicability of these IPR; IPR & biodiversity; IPR development process, role of WIPO and WTO in IPR establishments, common rules of IPR practices, types and features of IPR agreement, functions of UNESCO in IPR maintenance.

UNIT V PATENTS 9

Patents – objectives and benefits of patent, concept, features of patent, inventive steps, specifications, types of patent application; patenting process - patent filling, examination of patent, grant of patent, revocation; equitable assignments; Licenses, licensing of patents; patent agents, registration of patent agents.

Total : 45 Periods

COURSE OUTCOMES: **At the end of the course, students will be able to**

CO1 Identify and formulate research problems by reviewing literature, recognizing research gaps, and framing appropriate hypotheses

CO2 Design suitable methodologies and apply statistical tools for data collection, classification, and experimentation.

CO3 Analyze data using statistical methods, interpret results, and construct structured technical reports, manuscripts, and research proposals.

CO4 Explain the concepts, types, and significance of Intellectual Property Rights (IPR) in research and innovation.

CO5 Demonstrate knowledge of patents and apply the patenting process including filing, examination, and licensing in real-world research contexts.

REFERENCES:

1. Cooper Donald R, Schindler Pamela S and Sharma JK, "Business Research Methods", Tata McGraw Hill Education, 11e (2012).
2. Soumitro Banerjee, "Research methodology for natural sciences", IISc Press, Kolkata, 2022,
3. Catherine J. Holland, "Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets", Entrepreneur Press, 2007.
4. David Hunt, Long Nguyen, Matthew Rodgers, "Patent searching: tools & techniques", Wiley, 2007.
5. The Institute of Company Secretaries of India, Statutory body under an Act of parliament, "Professional Programme Intellectual Property Rights, Law and practice", September 2013.

CO-PO Mapping:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	2	2	1	2
CO2	3	3	3	2	2	2
CO3	2	3	2	3	2	2
CO4	2	2	2	2	3	2
CO5	2	2	2	2	3	2
Avg.	**2.4**	**2.6**	**2.2**	**2.2**	**2.2**	**2**

EH3111	TECHNICAL SEMINAR	L	T	P	C
		0	0	2	1

COURSE OBJECTIVE:

The main learning objective of this course is to prepare the students for acquiring skills of oral presentation in seminars and conferences and technical writing abilities for journal publications.

The students will work for two hours per week guided by a group of staff members. They will be asked to talk on any topic of their choice related to Thermal Engineering with specialisation in Engines and hybrid technologies topics and to engage in dialogue with the audience. A brief copy of their talk also should be submitted. Similarly, the students will have to present a seminar of not less than fifteen minutes and not more than thirty minutes on the technical topic. They will also answer the queries on the topic. The students as audience also should interact. The evaluation will be based on the technical presentation and the report and on the interaction during the seminar.

Seminar Exercises:

1. Battery modelling and Simulink
2. Cool prop – Thermodynamic property data base
3. Control logic in Simulink
4. Design of Experiments
5. Communication protocols related to autonomous vehicle
6. EV modelling and simulations
7. Data analytics and management
8. Digital twin related vehicle
9. Performance bench marking
10. Net-zero carbon emissions
11. Hybrid vehicle safety and standards

TOTAL: 30 PERIODS

COURSE OUTCOMES:

On successful completion of this course the student will be able to

CO1 Identify and select advanced technical topics in engineering design and related domains through literature survey and recent developments.

CO2 Analyze and synthesize technical information, organizing it into a structured seminar presentation and technical report.

CO3 Demonstrate effective oral presentation skills by communicating technical ideas clearly and engaging in professional dialogue.

CO4 Critically evaluate and respond to questions, feedback, and peer interactions, showcasing depth of knowledge and confidence

CO5 Develop technical writing skills for seminar reports, abstracts, and journal-style documentation.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	3	2	3
CO2	3	3	2	3	2	3
CO3	2	2	2	3	3	2
CO4	2	3	2	3	3	2
CO5	3	2	2	3	2	3
Avg.	**2.6**	**2.6**	**2**	**3**	**2.4**	**2.6**