ANNA UNIVERSITY: : CHENNAI 600 025

UNIVERSITY DEPARTMENTS

M.E. INTERNAL COMBUSTION ENGINEERING

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.

Attested

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PROGRAMME EDUCATIONAL OBJECTIVES (PEO)

The Internal Combustion Engineering program seeks to prepare PG students for productive and rewarding careers in the engines and propulsion field. The PEOs are listed below:

I. Excelling as an engine expert for providing solutions towards improving the efficacy of engine package

II. Inclination towards advanced research for developing solutions for green mobility

III. Uphold professional ethics in the field of work for societal upliftment.

PROGRAMME OUTCOMES (POs):

PO	Programme Outcome
1	An ability to independently carry out research/investigation and development work to solve practical problems.
2	An ability to write and present a substantial technical report/document.
3	Students should be able to demonstrate a degree of mastery in the area of mechatronics.
4	Technically sound and competent to work in a challenging automotive industry
5	Ability to transfer acquired knowledge through innovative and modern teaching methodologies
6	Capability to excel in core engine 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	PSO4	PSO5	PSO6
YEAR I	SEMESTER I	Advanced Numerical Methods	3	2	-	-	3	2
		Advanced Thermodynamics	2	2	3	2	2	2
		Advanced Heat transfer	3	2	2	-	3	2
		Emission Formation and Control	3	2	2	-	3	2
		Combustion in IC Engines	3	2	2	-	3	2
		Research Methodology and IPR	3	3	2	-	-	-
		Fuel Synthesis and Characterisation Laboratory	3	3	3	3	-	-
		Internal Combustion Engines Laboratory	3	1	2	-	3	1
	SEMESTER II	Electronic Engine Management Systems	3	2	2	2	3	1
		Design of Engine Components and Testing	2	3	2	2	2	2
		Instrumentation for Thermal Systems	3	2	2	-	2	2
		Computational Fluid Dynamics for Mobility Systems	3	2	2	2	3	2
		Professional Elective - I	-	-	-	-	-	-
		Professional Elective - II	-	-	-	-	-	-
		Technical Seminar	2	3	2	-	3	2
		Computational Laboratory	2	3	2	-	3	2
YEAR II	SEMESTER III	Low and Zero Carbon Fuels	3	2	2	2	3	2
		Professional Elective - III	-	-	-	-	-	-
		Professional Elective - IV	-	-	-	-	-	-
		Research Data Analysis Laboratory	2	3	2	-	3	2
		Project Work I	3	2	2	-	3	2
	SEMESTER IV	Project Work II	3	3	3	-	3	3

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M.E. INTERNAL COMBUSTION ENGINEERING

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CURRICULUM AND SYLLABI FOR SEMESTERS I TO IV

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	FC	4	0	0	4	4
2.	IC3151	Advanced Thermodynamics	FC	3	1	0	4	4
3.	RA3151	Advanced Heat Transfer	FC	3	0	2	5	4
4.	IC3101	Emission Formation and Control	PCC	2	0	2	4	3
5.	IC3152	Combustion in IC Engines	PCC	3	0	0	3	3
6.	RM3151	Research Methodology and IPR	RMC	2	1	0	3	3
PRACTICALS								
7.	IC3111	Fuel Synthesis and Characterisation Laboratory	PCC	0	0	4	4	2
8.	IC3112	Internal Combustion Engines Laboratory	PCC	0	0	4	4	2
			TOTAL	**17**	**2**	**12**	**31**	**25**

SEMESTER-II

S. No.	Course Code	Course Title	Category	Periods Per Week			Total Contact Periods	Credits
				L	T	P		
THEORY								
1.	IC3251	Electronic Engine Management Systems	PCC	3	0	0	3	3
2.	IC3252	Design of Engine Components and Testing	PCC	3	0	0	3	3
3.	IC3201	Instrumentation for Thermal Systems	PCC	3	0	0	3	3
4.	IC3253	Computational Fluid Dynamics for Mobility systems	PCC	2	0	2	4	3
5.		Professional Elective - I	PEC	3	0	0	3	3
6.		Professional Elective - II	PEC	3	0	0	3	3
PRACTICALS								
7.	IC3211	Technical Seminar	EEC	0	0	2	2	1
8.	IC3212	Computational Laboratory	PCC	0	0	4	4	2
			TOTAL	**17**	**0**	**8**	**25**	**21**

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SEMESTER-III

S.No.	Course code	Course Title	Category	Periods Per Week			Total Contact Periods	Credits
				L	T	P		
THEORY								
1.	IC3301	Low and Zero Carbon Fuels	PCC	3	0	0	3	3
2.		Professional Elective - III	PEC	3	0	0	3	3
3.		Professional Elective - IV	PEC	3	0	0	3	3
PRACTICALS								
4.	IC3361	Research Data Analysis Laboratory	EEC	0	0	2	2	1
5.	IC3311	Project Work - I	EEC	0	0	12	12	6
			TOTAL	**9**	**0**	**14**	**23**	**16**

SEMESTER-IV

S. No.	Course Code	Course Title	Category	Periods Per Week			Total Contact Periods	Credits
				L	T	P		
PRACTICALS								
1	IC3411	Project Work - II	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL CREDITS : 74

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FOUNDATION COURSES (FC)

S.No	Course Code	Course Title	Periods Per Week			Credits	Semester
			L	T	P		
1.	MA3155	Advanced Numerical Methods	4	0	0	4	I
2.	IC3151	Advanced Thermodynamics	3	1	0	4	I
3.	RA3151	Advanced Heat Transfer	3	0	2	4	I

PROFESSIONAL CORE COURSES (PCC)

S. No	Course Code	Course Title	Periods Per Week			Credits	Semester
			Lecture	Tutorial	Practical		
1.	IC3101	Emission Formation and Control	2	0	2	3	I
2.	IC3152	Combustion in IC Engines	3	0	0	3	I
3.	IC3111	Fuel Synthesis and Characterisation Laboratory	0	0	4	2	I
4.	IC3112	Internal Combustion Engines Laboratory	0	0	4	2	I
5.	IC3251	Electronic Engine Management Systems	3	0	0	3	II
6.	IC3252	Design of Engine Components and Testing	0	0	3	3	II
7.	IC3201	Instrumentation for Thermal Systems	0	0	3	3	II
8.	IC3253	Computational Fluid Dynamics for Mobility Systems	2	0	2	3	II
9.	IC3212	Computational Laboratory	0	0	4	2	II
10.	IC3301	Low and Zero Carbon Fuels	3	0	0	3	III

PROFESSIONAL ELECTIVE COURSES (PEC)

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	PW3052	Electric Vehicles and Power Management	PEC	3	3	0	0	3
2.	EY3052	Fuel Cell Technology	PEC	3	3	0	0	3
3.	IC3051	Advanced Combustion Technologies	PEC	3	3	0	0	3
4.	IC3004	Electric Vehicle Systems	PEC	3	3	0	0	3
5.	IC3052	Hydrogen – Production and Utilization	PEC	3	3	0	0	3
6.	IC3001	Automotive Systems	PEC	3	3	0	0	3
7.	ET3251	Automotive Embedded System	PEC	3	3	0	0	3
8.	IC3053	Machine Learning in IC Engines	PEC	3	3	0	0	3
9.	IC3002	Green Energy Production Technologies	PEC	3	3	0	0	3
10.	PW3059	Electrical Drives and Control	PEC	3	3	0	0	3
11.	IC3054	Autonomous and Connected Vehicle Systems	PEC	3	3	0	0	3
12.	IC3003	Aerospace Propulsion	PEC	3	3	0	0	3

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			L	T	P		
1.	IC3211	Technical Seminar	0	0	2	1	II
2.	IC3361	Research Data Analysis Laboratory	0	0	2	1	III
3.	IC3311	Project Work - I	0	0	12	6	III
4.	IC3411	Project Work - II	0	0	24	12	IV

S.NO	ME INTERNAL COMBUSTION ENGINEERING (FULL TIME)					
	SUBJECT AREA	CREDITS PER SEMESTER				CREDITS TOTAL
		I	II	III	IV	
1.	FC	12	0	0	0	12
2.	PCC	10	14	3	0	27
3.	PEC	0	6	6	0	12
4.	RMC	3	0	0	0	3
5.	EEC	0	1	7	12	20
	TOTAL CREDIT	**25**	**21**	**16**	**12**	**74**

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

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 finite 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

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. Saumyen Guha 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

IC3151 ADVANCED THERMODYNAMICS

L	T	P	C
3	1	0	4

COURSE OBJECTIVES:

1. To achieve an understanding of basic principle and scope of thermodynamics
2. To predict the availability and irreversibility associated with the thermodynamic processes and Chemical availability of reactive systems
3. To arrive at the adiabatic flame temperature during combustion of air-fuel mixture

UNIT I THERMODYNAMIC PROPERTY RELATIONS 12

Thermodynamic Potentials, Maxwell relations, Generalised relations for changes in Entropy, Internal Energy and Enthalpy, Generalised Relations for Cp and Cv, Clausius Clapeyron Equation, Joule Thomson Coefficient, Bridgeman Tables for Thermodynamic Relations.

UNIT II REAL GAS BEHAVIOUR AND MULTI-COMPONENT SYSTEMS 12

Equations of State (mention three equations), Fugacity, Compressibility, Principle of Corresponding States, use of generalised charts for enthalpy and entropy departure, fugacity coefficient, Lee-Kesler generalised three parameter tables. Fundamental property relations for systems of variable composition, partial molar properties, Real gas mixtures, Ideal solution of real gases and liquids, Equilibrium in multi-phase systems, Gibb's phase rule for non-reactive components.

UNIT III AVAILABILITY OF MIXTURES 12

Introduction, Reversible work, Availability, Irreversibility and Second - Law Efficiency for a closed System and Steady-State Control Volume. Availability Analysis of Simple Cycles. Chemical availability of closed and control volume. Fuel Chemical availability, Evaluation of the availability of hydrocarbon fuels.

UNIT IV PHASE EQUILIBRIUM OF MIXTURES 12

Phase equilibrium – Two phase system – Multiphase systems, Gibbs phase rule. Simplified criteria for phase equilibrium – General criteria of any solution, Ideal solution and Raoult's law, Vapour as Ideal gas mixture, Pressure and Temperature diagrams. Completely miscible mixtures – Liquid-vapour mixtures

UNIT V THERMO CHEMISTRY 12

Ideal gas laws and properties of Mixtures, Combustion Stoichiometry, Application of First Law of Thermodynamics – Heat of Reaction – Enthalpy of Formation – Adiabatic flame temperature. Second law of Thermodynamics applied to combustion – entropy, maximum work and efficiency Chemical equilibrium: - Equilibrium constant evaluation Kp & Kf, Equilibrium composition evaluation of ideal gas and real gas mixtures.

TOTAL 60 PERIODS

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1 Find thermodynamic properties using various thermodynamic relations.
CO2 Apply the law of thermodynamics to thermal systems.
CO3 Perform second law analysis to thermal systems
CO4 Design and analyse a multi component thermodynamic system
CO5 Understand and analyse the combustion of different fuels

REFERENCES:

1. Kenneth Wark., J.R, Advanced Thermodynamics for Engineers, McGraw-Hill Inc., 1995.
2. K.Annamalai, I.K.Puri, M.A.Jog, Advanced Thermodynamics Engineering, Second Edition, CRC Press, 2011.
3. Sonntag R.E. and Van Wylen, G., Introduction to Thermodynamics, Classical and Statistical Themodynamics, Third Edition, John Wiley and Sons, 1991.
4. S.S. Thipse, Advanced Thermodynamics, Narosa Publishing Home Pvt. Ltd., 2013
5. Yunus A. Cengel and Michael A. Boles, Thermodynamics, McGraw-Hill Inc., 2006.
6. Adrian Bejan, Advanced Engineering Thermodynamics, John Wiley & Sons, 4th Edition, 2016
7. Holman,J.P., Thermodynamics, Fourth Edition, McGraw-Hill Inc., 1988.

CO – PO Mapping:

CO	PO					
	1	2	3	4	5	6
1	1	1	2	1	2	2
2	2	2	2	2	1	2
3	3	2	3	2	3	3
4	3	3	3	3	3	3
5	3	3	3	3	3	3
Avg.	2.4	2.2	2.6	2.2	2.4	2

RA3151 **ADVANCED HEAT TRANSFER**

L	T	P	C
3	0	2	4

COURSE OBJECTIVES:

- 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.
- To offer hands-on training on measurement, analysis of heat transfer phenomena with emphasis on data analysis and report preparation.

UNIT – I CONDUCTION 9L, 6P

Boundary Conditions, Thermal Conductivity, Conduction equation, Fin Design, analytical solutions – Multi-dimensional steady state heat conduction, Transient Heat conduction – Lumped Capacitance Method, Semi-Infinite Media Method

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

UNIT – II CONVECTION 9L, 6P
Energy & Momentum equations, Laminar & Turbulent Boundary Layers, Entry length, Reynolds-Colburn Analogy, Heat transfer coefficient for flow over a flat surface, circular & non-circular ducts

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

UNIT – III TWO-PHASE FLOW 9L, 6P

Flow patterns, Void fraction, critical flow, Dispersed, slug, annular & stratified flow, Homogeneous, Drift & Separated flow model

PRACTICALS:
Temperature & Flow field visualisation

UNIT – IV TWO-PHASE HEAT TRANSFER 9L, 6P

Pool & Convective boiling, critical heat flux, Dropwise & filmwise condensation, Melting & Solidification, Heat transfer enhancement methods.

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

UNIT – V THRUST AREAS 9L, 6P

Thermoregulation, Laser Generated Heat Transfer, Tissue Thermal Properties and Perfusion, Thermal Damage and Rate Processes in Biologic Tissues, Thermal Injury, Mathematical models of bio-heat transfer
Machine Learning in Heat Transfer – Linear regression and Neural networks, Practical considerations & Applications.

PRACTICALS:
Irradiation studies & heat generation from lasers

TOTAL: 45L + 30P = 75 PERIODS

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

1. Demonstrate the concepts of conduction and experimentation in the thermal systems.
2. Illustrate the concept of conservation of energy, solve problems and conduct experiments in convection heat transfer.
3. Categorise & examine the different two-phase flow models and evaluate the parameters of flow fields through experimentation.
4. Analyse the phase change heat transfer and formulate practical problems and interpret data of experimentation.
5. Use engineering tools and appraise the heat transfer in biological systems.

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, McGraw Hill, 2020.
5. Brennen, C.E., Fundamentals of Multiphase Flow, Cambridge University Press, 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.

Mapping of CO with PO

CO	PO					
	1	2	3	4	5	6
1	2	1	2	2	1	-
2	2	1	2	3	2	1
3	3	1	2	3	2	1
4	2	1	2	2	2	1
5	2	2	2	2	3	2
Avg.	2.2	1.2	2	2.4	2	1.25

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IC3101 **EMISSION FORMATION AND CONTROL**

L	T	P	C
2	0	2	3

COURSE OBJECTIVES

1. To provide an insight about effect of engine out emissions on human health and environment, emission formation and techniques to measure and mitigate them

UNIT I INTRODUCTION 3

Atmospheric pollution from automotive, stationary engines and gas turbines, Global warming – Green-house effect, Effects of engine pollution on human health and environment

UNIT II POLLUTANT FORMATION 6

Formation of Oxides of Nitrogen, Carbon monoxide, Hydrocarbon, Aldehydes, Smoke and Particulate matter emissions. Effect of Engine design and operating variables on emission formation.

UNIT III EMISSION MEASUREMENT TECHNIQUES 6L + 6P

CO, CO2 - Non dispersive infrared gas analyser, NOx - Chemiluminescent analyser, HC - Flame ionization detector, Smoke – Opacity and filter paper measurements, Particulate Matter – Full flow and Partial flow dilution tunnel, Gas chromatography, Noise measurement.

UNIT IV EMISSION CONTROL TECHNIQUES 9L + 3P

Engine design modifications, Fuel modification, Evaporative emission control, EGR, Air injection, Water injection, Common rail direct injection, and Gasoline direct injection system, After treatment systems - Catalytic converters, Diesel oxidation catalyst, Particulate traps, De-NOx catalysts, SCR systems.

UNIT V DRIVING CYCLES AND EMISSION STANDARDS 6L + 6P

Transient dynamometer, Test cells, Driving cycles for emission measurement, chassis dynamometer, CVS system, National and International emission standards, RDE

TOTAL: 60 PERIODS

COURSE OUTCOMES:

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

CO1 Understand about atmospheric pollution from engines and its impact on human health and environment.

CO2 Understand the formation of emissions in both SI and CI engines

CO3 Understand the various measurement techniques used globally for the measurement of automotive and stationary engine out emissions.

CO4 Learn the various control methods/techniques used in IC engine to control the engine out emissions

CO5 Learn the transient and steady state driving cycles performed on automotive and stationary engines and emission standards that are followed in the national and international level

REFERENCES:

1. Ganesan V., “Internal Combustion Engines”, 5th Edition, Tata McGraw Hill, 2012.
2. Pundir B. P., Engine Emissions” , 2nd Edition, Narosa publishing house, 2017.
3. John. B. Heywood, “Internal Combustion Engine fundamentals” McGraw – Hill, 1988.
4. Ernest, S., Starkman, Combustion Generated Air Pollutions, Plenum Press, 1980.
5. Crouse William, Automotive Emission Control, Gregg Division /McGraw-Hill,1980

CO – PO MAPPING:

CO	PSO					
	1	**2**	**3**	**4**	**5**	**6**
1	3	2	2	-	3	2
2	3	1	2	-	3	-
3	3	1	2	-	3	-
4	3	1	1	-	3	-
5	3	2	3	-	3	2
Avg	3	2	2	-	3	2

IC3152	COMBUSTION IN IC ENGINES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVE

1. To familiarize with the principles of combustion in engines and modern concepts of combustion

UNIT I THERMODYNAMICS OF COMBUSTION 9

Properties of Mixtures, Combustion Stoichiometry - Methods of Quantifying Fuel and Air Content of Combustible Mixtures, Heating Values - Determination of HHV for Combustion Processes at Constant Pressure - Determination of HHV for Combustion Processes from a Constant-Volume Reactor - Representative HHV Values, Adiabatic Flame Temperature, Constant-Pressure Combustion Processes, Comparison of Adiabatic Flame Temperature Calculation Method

UNIT II COMBUSTION PRINCIPLES 9

Combustion – Combustion equations, chemical equilibrium, and Dissociation -Theories of Combustion - Flammability Limits - Reaction rates - Laminar and Turbulent Flame Propagation in Engines, Flame structure and speed - Chemical kinetics.

UNIT III COMBUSTION IN S.I. ENGINES 9

Stages of combustion, Cylinder pressure measurement and heat release analysis normal and abnormal combustion, knocking, Variables affecting Knock, Features and design consideration of combustion chambers, Types of combustion chambers., Cyclic variations, Lean burn combustion, Stratified charge combustion systems. Heat release correlations.

UNIT IV COMBUSTION IN C.I. ENGINES 9

Stages of combustion, and spray formation and characterization, air motion, swirl measurement, knock and engine variables, Features and design considerations of combustion chambers, delay period correlations, heat release correlations, Influence of the injection system on combustion, Direct and indirect injection systems.

UNIT V LOW TEMPERATURE COMBUSTION CONCEPTS 9

Homogeneous charge compression ignition (HCCI) engine – Premixed charge compression ignition (PCCI) engine, Gasoline Direct Injection Compression Ignition (GDCI) engine, Reactivity controlled compression ignition (RCCI) engine – An introduction.

TOTAL:45 PERIODS

COURSE OUTCOMES:

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

CO1 Knowledge to apply laws of thermodynamics to combustion processes

CO2 Understanding and Analysing ability on theories of combustion, flame, and flame structure

CO3 Acquired knowledge on SI normal and abnormal combustion

CO4 Acquired knowledge on CI stages of combustion and various factors influencing CI combustion

CO5 Gained brief knowledge about various low temperature combustion schemes and its benefits.

REFERENCES:

1. McAllister, Sara; Chen, Jyh-Yuan; Fernandez-Pello, A. Carlos (2011). [Mechanical Engineering Series] Fundamentals of Combustion Processes, 10.1007/978-1-4419-7943-8,–doi:10.1007/978-1-4419-7943-8.
2. Ganesan, V, Internal Combustion Engines, Tata McGraw Hill Book Co., 2003.
3. John B. Heywood, Internal Combustion Engine Fundamentals, McGraw Hill Book, 1998.
4. Pundir B P, I.C. Engines Combustion and Emission, 2010, Narosa Publishing House.
5. Gupta H.N. Fundamentals of Internal Combustion Engines, Prentice Hall of India, Ltd, 2nd Edition, 2006.
6. Williard W Pulkrabek, Engineering Fundamentals of IC Engines, Prentice Hall of India, 2004.

CO – PO MAPPING:

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

RM3151 RESEARCH METHODOLOGY AND IPR

		L	T	P	C
RM3151	RESEARCH METHODOLOGY AND IPR	2	1	0	3

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; 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, 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

Upon completion of the course, the student can

CO1: Describe different types of research; identify, review and define the research problem

CO2: Select suitable design of experiment s; describe types of data and the tools for collection of data

CO3: Explain the process of data analysis; interpret and present the result in suitable form

CO4: Explain about Intellectual property rights, types and procedures

CO5: Execute patent filing and licensing

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.

IC3111 FUEL SYNTHESIS AND CHARACTERISATION LABORATORY

L	T	P	C
0	0	4	2

COURSE OBJECTIVES:

1. To acquire a knowledge on selection of feedstock for biodiesel, bioethanol production and testing interpreting and analysing fuel properties through various testing methods

LIST OF EXPERIMENTS

1. Selection of feedstock and catalyst for biodiesel, bioethanol production
2. Biodiesel production through conventional technique using different feedstock
3. Liquid fuel production through pyrolysis process
4. Determination of calorific value for liquid and gaseous fuels.
5. Determination of oxidation stability of biodiesel and diesel fuel
6. Determination of copper strip corrosion of biodiesel and diesel
7. Study the elemental composition of fuel using ultimate analyzer
8. Categorize the organic compounds of fuel using proximate analysis

TOTAL: 60 PERIODS

COURSE OUTCOMES:

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

CO1 Understand the importance of selection of feedstock on biodiesel and bioethanol production

CO2 Understand the catalyst production on biodiesel production

CO3 Determine the property of fuels

CO4 Determine the elemental composition of liquid fuels using ultimate analyzer

CO5 Determine the organic compounds of fuels using proximate analysis

CO – PO MAPPING:

COs	PO					
	1	2	3	4	5	6
1	3	3	3	3	-	-
2	3	3	3	3	-	-
3	3	3	3	3	-	-
Avg	3	3	3	3	-	-

IC3112 **INTERNAL COMBUSTION ENGINES LABORATORY**

L	T	P	C
0	0	4	2

COURSE OBJECTIVES:

1. To impart hands on experience in dismantling and assembling of engines
2. To impart practical exposure to the advanced engine technologies
3. To provide practical experience in fuel property measurements, engine combustion, performance, and emission testing

LIST OF EXPERIMENTS

1. Disassembly and Assembly of single and multi-cylinder engines
2. Study of advanced diesel and gasoline engine technology engines.
3. Experimental investigation of combustion, performance, and emission characteristics of spark ignition engine.
4. Experimental study on the effect of fuel injection pressure on CI engine performance, combustion, and emission characteristics.
5. Experimental study on the effect of fuel injection timing on CI engine performance, combustion, and emission characteristics.
6. Determination of Flash and Fire point of various fuel blends.
7. Determination of Viscosity of various fuel blends

LABORATORY REQUIREMENTS

1. Single and Multi-Cylinder SI or CI Engine for disassembly and assembly
2. Engine Components for drawing and dimensioning
3. Single/ Multi-Cylinder S.I. Engine Test Rig with combustion, performance, and emission measurement facility
4. Single/ Multi-Cylinder C.I. Engines Test Rig with combustion, performance, and emission measurement facility
5. Exhaust Gas Analyser
6. Smoke Meter
7. In cylinder Pressure Transducers, Charge Amplifiers, and crank angle encoders with high speed data acquisition system
8. Open cup or Closed cup Flash and Fire Point Apparatus
9. Viscometer

TOTAL: 60 PERIODS

COURSE OUTCOMES:

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

CO1 Understand the various components of engine, its function, assembling of engine parts and working of advanced engine technologies

CO2 Understand the procedures of conducting performance, combustion and emission test on engines and its significance

CO3 Understand the method of calculating the volumetric efficiency and fuel-air ratio of an engine

CO4 Understand the effect of various operating parameters of the engine on combustion, performance, and emissions

CO5 Understand the methods of calculating flash point, fire point and viscosity of the various oil samples

CO – PO MAPPING:

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

IC3251	ELECTRONIC ENGINE MANAGEMENT SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. To provide basic grounding on electronics used in engine management, and how engine is managed electronically using these electronic devices for reduced emissions and performance

UNIT I ELECTRICAL AND ELECTRONICS PRINCIPLES 7

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 10

Sensors - Camshaft Position, Crank Position, Throttle Position, Valve position, Air flow, Pressure, Temperature, Speed, Exhaust gas Oxygen, Knock, NH_3, RF, DP, 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 8

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 10

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 10

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 PERIODS

COURSE OUTCOMES:

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

CO1 Learn the application of electronics in engine management systems
CO2 Able to choose the types of sensors
CO3 Decide on the type of ignition systems to be employed for different applications
CO4 Able to design gasoline injection systems
CO5 Demonstrate the capabilities of diesel fuel injection systems

REFERENCES:

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, Sxith Edition, Elsevier Inc, 2002

CO – PO MAPPING:

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

IC3252 DESIGN OF ENGINE COMPONENTS AND TESTING

L	T	P	C
3	0	0	3

COURSE OBJECTIVES

1. To introduce the concepts for designing engine components and testing

UNIT I DESIGN OF CYLINDER, CYLINDER HEAD AND PISTON 9

Introduction - Stress, fatigue, material selection, Determination of required displacement, Determination of number of cylinders and arrangement of cylinders, Determination of bore diameter & stroke length, Design of cylinder – cylinder head – piston – piston rings

UNIT II DESIGN OF CONNECTING ROD AND CRANK SHAFT 9

Design of connecting rod, Design of overhang and center crank shaft – for maximum bending – for maximum torsion.

UNIT III DESIGN OF VALVE TRAIN AND SUBSYSTEMS 9

Design of valve train components, Design of cooling system, Design of lubrication system, Manifold tuning, Selection of bearings and gaskets.

UNIT IV ENGINE TESTING 9

During engine development: Performance Testing - Emission Testing (Steady state, Transient and Real driving emissions) - Durability testing (Individual components, Complete engine) - Emission and performance tuning. During engine production: Hot test - Cold test.

UNIT V MODELING AND ANALYSIS 9

Modelling and analysis of designed components using computer aided design and analysis software, Generation of production drawings.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1 Design cylinder, cylinder head and piston.
CO2 Design connecting rod and crank shaft.
CO3 Design of valve train components and sub systems.
CO4 Demonstrate understanding about engine testing.
CO5 Model and analyze engine components.

REFERENCES:

1. Kevin Hoag, Brian Dondlinger, "Vehicular Engine Design", 2nd Edition, 2015, Springer Vienna.
2. Editors: Richard van Basshuysen and Fred Schaefer, "Internal Combustion Engine Handbook: Basics, Components, Systems and Perpectives", 2nd Edition, 2016, SAE International, USA.
3. R. S. Khurmi, J. K. Gupta, "A Textbook of Machine Design", 25th Edition, 2020, S. Chand.
4. A. Kolchin and V. Demidov, "Internal Combustion Engine Design", 1984, MIR Publishers, Moscow.
5. Editors: Bernard Challen and Rodica Baranescu, "Diesel Engine Reference Book", Second Edition, 1999, Butterworth-Heinemann, UK.

CO – PO MAPPING:

COs	PO					
	1	**2**	**3**	**4**	**5**	**6**
1	2	3	3	3	2	1
2	2	3	3	1	2	3
3	2	3	2	1	2	3
4	2	2	2	3	2	1
5	2	3	3	3	2	3
Avg.	2	3	2	2	2	2

IC3201 INSTRUMENTATION 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

UNIT I MEASUREMENT CHARACTERISTICS 9

Introduction to measurements, Errors in measurements, Statistical analysis of data, Regression analysis, correlation, estimation of uncertainty and presentation of data, design of experiments – Experimental design factors and protocols

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, COMPONENTS AND CONTROLLERS 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 DESIGN OF MEASUREMENT AND CONTROL SYSTEMS 9

Data logging and acquisition - Sensors for error reduction, elements of computer interfacing, Timers, and Counters, Designing of measurement and control systems for specific applications - Fault finding – Computer based controls

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1 Understand the fundamental concepts of measurement parameters
CO2 Select the suitable type of sensor for a measuring a fundamental parameter
CO3 Use appropriate devices to measure different properties of solids and fuels

REFERENCES:

1. Bolton. W, Industrial Control & Instrumentation, Universities Press, Second Edition, 2001.
2. Doblin E.O, Measurement System Application and Design, Second Edition, McGraw Hill, 1978.
3. Holman, J.P., Experimental methods for Engineers, Tata McGraw-Hill, 7th Ed.2001.
4. Nakra, B.C., Choudhry K.K., Instrumentation, Measurements and Analysis Tata McGraw Hill, NewDelhi, Second Edition 2003
5. Norman A. Anderson, Instrumentation for Process Measurement and Control, Third Edition, CRC Press,1997
6. Venkatesan S.P, Mechanical Measurements, Ane Publications, Second edition, 2015

CO – PO MAPPING:

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

IC3253	COMPUTATIONAL FLUID DYNAMICS FOR MOBILITY SYSTEMS	L	T	P	C
		2	0	2	3

COURSE OBJECTIVES

1. To make the students to understand the basic principles of fluid flow, heat transfer, computational fluid dynamics (CFD) and its applications
2. To enlighten the students on the fundamental governing equations and turbulence models used in CFD solvers
3. To enable the students to understand grid generation techniques and post processing techniques.

UNIT I INTRODUCTION 6

Introduction to fluid flow and heat transfer – Mathematical description of fluid flow and heat transfer, incompressible and compressible flows, turbulent flows, boundary layer theory. Introduction to Computational Fluid Dynamics (CFD) – Objectives, modelling process, 2D and 3D simulations, advantages, limitations, application domains, software tools.

UNIT II GOVERNING EQUATIONS 6

Mass and momentum conservation equations, Energy conservation equation, Equation of state, Species transport equations, Scalar transport equations. Turbulence models – RANS, LES and DNS models.

UNIT III GRID GENERATION AND POST PROCESSING TECHNIQUES 6

Surface preparation, Volume meshing – cell types, structured, unstructured and hybrid meshing. Considerations for accurate and fast solutions. Mesh generation techniques, dynamic meshing, overset meshing, mesh size control, y+ and wall layer, adaptive mesh refinement, grid independence study. Post processing techniques – Vector plot, scalar plot, streamline plot, flow animation, x-y plot, surface area and mass flow integrated reports

UNIT IV NUMERICAL METHODS 6

Finite volume method, Discretization schemes – First order, higher order and hybrid schemes, stability of schemes. Steady and unsteady flow solvers – CG and AMG solvers, SIMPLE, SIMPLER & PISO solution algorithms. Initial and boundary conditions, material properties, solver control, convergence criteria, parallel processing.

UNIT V ADVANCED CFD SIMULATIONS 6

Compressible flow, conjugate heat transfer, VOF, MRF, porous media, radiation, combustion and emission simulations. Fluid flow and heat transfer modelling of IC engine, thermal systems, power generation and storage systems, turbomachinery etc. Introduction to fluid-structure interaction modelling

TOTAL: 30 PERIODS

LABORATORY EXPERIMENTS (30 PERIODS):

1. Prepare a closed surface geometry for a given application as per given dimensions
2. Clean-up a raw geometry for the given flow domain and mark different boundaries
3. Prepare surface mesh and volume mesh as per given size and quality criteria
4. Prepare volume meshing with different grid controls like wall layering, boundary refinement, etc.
5. Perform a simple fluid flow analysis as per given problem description
6. Perform a simple heat transfer analysis as per given problem description
7. Perform an advanced CFD analysis as per given problem description

TOTAL : 60 PERIODS

COURSE OUTCOMES:

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

CO1 Understand the basic principles of fluid flow, heat transfer, computational fluid dynamics (CFD) and its applications

CO2 Analyse the governing equations and boundary conditions

CO3 Create grid for any simulation domain and post process various simulations

CO4 Setup solvers and perform all common simulations

CO5 Perform advance fluid flow and heat transfer simulations

REFERENCES:

1. Versteeg and Malalasekera, N, "An Introduction to computational Fluid Dynamics The Finite Volume Method," Pearson Education, Ltd., Second Edition, 2014.
2. Ghoshdastidar, P.S., "Computer Simulation of Flow and Heat Transfer", Tata McGraw-Hill Publishing Company Limited, New Delhi, 1998.
3. Muralidhar, K., and Sundararajan, T., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, New Delhi, 2003.
4. Subas and V.Patankar "Numerical heat transfer fluid flow", Hemisphere Publishing Corporation,1980.
5. Jiyuan Tu, Guan Heng Yeoh, Chaogun Liu, "Computational Fluid Dynamics A Practical Approach" Butterworth – Heinemann An Imprint of Elsevier, Madison, U.S.A., 2008
6. John D. Anderson . JR. "Computational Fluid Dynamics The Basics with Applications" McGraw-Hill International Editions, 1995.

CO – PO MAPPING:

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

IC3211 **TECHNICAL SEMINAR** **L T P C**
0 0 2 1

COURSE OBJECTIVES

1. This course will prepare you to prepare and deliver instructive, informational, and persuasive presentations based on well-defined and achievable outcomes
2. This course will improve the communication and lecture delivering skills

Selection of topics, Abstract writing for review articles, literature collection and critical review of articles, Writing conclusion and future research directions, Case studies on published review articles.

Selection of problem, Experimental design of the article, Checking the scientific originality and novelty of the designed experiment

Selection of template, Background, Planning of number of slides, Planning of content structure, Selection of font, font size, and color, Readability of the presentation, Animation, clarity on pictures, and videos

TOTAL: 30 PERIODS

COURSE OUTCOMES:

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

CO1 Demonstrate theoretical knowledge to create and present effective technical presentation

CO2 Apply and adapt flexible process strategies to produce clear, high-quality deliverables in a multitude of technical writing genres

CO3 Gather and apply researched information that is appropriate to your field, as demonstrated by reading and analyzing documents, and citing sources correctly.

CO – PO MAPPING:

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

IC3212 COMPUTATIONAL LABORATORY

L	T	P	C
0	0	4	2

COURSE OBJECTIVES

1. The objective of this course is to make the student familiarize with simulation softwares for IC engine and hybrid vehicle applications

LIST OF EXPERIMENTS

1. Modelling of a hybrid vehicle using appropriate software
2. Performance matching for a hybrid vehicle
3. Simulation of Heating / Cooling requirement of battery and control system
4. Aerodynamic performance study of electric vehicle
2. Engine intake flow analysis using different port shapes
3. Engine exhaust flow analysis
4. Engine in-cylinder cold flow analysis for the given engine sector model
5. Fuel spray studies
6. Combustion analysis – arriving at p- theta and heat release rate

NOTE: The above exercises are only guidelines to maintain the standard for teaching and conduct of examination

TOTAL: 30 PERIODS

SIMULATION LAB – REQUIREMENT:

1. Software – For preprocessing – Any 3D Modelling software compatible for the geometry, along with meshing software(s) capable of meshing different type of geometry
2. Solving and post-processing Open-FOAM / Any commercially available CFD codes and mathematical equation solving softwares.
3. Every student in a batch must be provided with a hardware terminal with atleast 16 GB RAM , SSD HDD 512 GB capacity, and with dedicated Graphics card of atleast 4 GB

COURSE OUTCOMES:

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

CO1 Model and analyse any engine related study using CFD software

CO2 Simulate the temperature distribution of an EV power pack / control system

CO3 Carryout simulation studies on fuel -air mixing inside the combustion chamber of IC engine

CO – PO MAPPING:

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

IC3301 **LOW AND ZERO CARBON FUELS** **L T P C**
3 0 0 3

COURSE OBJECTIVES

1. To impart knowledge about the low carbon and zero carbon fuels production and utilization in IC engines.

UNIT I INTRODUCTION 9

Desirable properties of IC engine fuels, Petroleum fuel standards – ASTM & EN, Need for low carbon and zero carbon fuels, flexi fuel systems, Dual fuel system, Bi fuel system.

UNIT II LOW CARBON FUELS – LNG, LPG, BIOGAS 9

Properties – Merits – Demerits - Fuel production technologies – Strategies for using the fuel in IC engines – Fuel supply system - Performance, combustion, and emission characteristics

UNIT III LOW CARBON FUELS – METHANOL, ETHANOL, DME 9

Properties – Merits – Demerits - Fuel production technologies – Strategies for using the fuel in IC engines - Fuel supply system - Performance, combustion, and emission characteristics.

UNIT IV ZERO CARBON FUEL – HYDROGEN 9

Properties – Merits – Demerits - Fuel production technologies – Storage and safety aspects - Strategies for using the fuel in IC engines - Fuel supply system - Performance, combustion, and emission characteristics.

UNIT V ZERO CARBON FUEL – AMMONIA 9

Properties – Merits – Demerits - Fuel production technologies – Storage and safety aspects - Strategies for using the fuel in IC engines - Fuel supply system - Performance, combustion, and emission characteristics

TOTAL:45 PERIODS

COURSE OUTCOMES:

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

CO1 Evaluate the suitability of a particular fuel for IC engines.
CO2 Devise strategies for utilising LNG, LPG, and Biogas in IC engines
CO3 Devise strategies for utilising Methanol, Ethanol, and DME in IC engines
CO4 Devise strategies for utilising Hydrogen in IC engines.
CO5 Devise strategies for utilising Ammonia in IC engines.

REFERENCES

1. Frano Barbir, Angelo Basile, T. Nejat Veziroglu, “Compendium of Hydrogen Energy”, 1st Edition, 2015, Woodhead Publishing.
2. Richard Folkson, "Alternative Fuels and Advanced Vehicle Technologies for Improved Environmental Performance, Towards Zero Carbon Transportation", 1st Edition, 2014, Woodhead Publishing.
3. Avinash Kumar Agarwal, Hardikk Valera, "Potential and Challenges of Low Carbon Fuels for Sustainable Transport", 1st Edition, 2022, Springer Singapore.
4. Richard L. Bechtold, “Automotive Fuels Guide Book”, 3rd Edition, 2015, SAE Publications.

CO – PO MAPPING:

COs	PO					
	1	**2**	**3**	**4**	**5**	**6**
1	2	1	3	3	2	1
2	2	1	3	3	2	1
3	2	1	3	3	2	1
4	2	1	3	2	2	1
5	2	1	3	2	2	1
Avg.	2	1	3	2	2	1

IC3361	RESEARCH DATA ANALYSIS LABORATORY	L	T	P	C
		0	0	2	1

COURSE OBJECTIVES

1. The objective of the course is to acquire knowledge on the various aspects of data presentation, data collection, documentation and interpretation of research data

LIST OF EXPERIMENTS

1. Interpretation and analysis of diesel engine performance data using any analytical tool
2. Plot and analysis of given engine combustion data using graphical tool
3. Uncertainty analysis of given engine emission data using graphical tool
4. Visualize the velocity, temperature, HRR using the 3D post processing file using Tec plot software
5. Optimization of biodiesel production parameters using RSM technique for given data
6. Optimization of bioethanol production parameters using RSM technique for given data
7. Prediction of pyrolysis oil yield with experimental data by using ANN technique
8. Prediction of biofuel yield with experimental data by using Genetic Algorithm
9. Optimization and prediction of engine performance, and emission characteristics using ANN and RSM technique

TOTAL: 30 PERIODS

COURSE OUTCOMES:

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

CO1 Use different plotting tools such as MS Excel and Origin for data visualization and analysis

CO2 Familiar in uncertainty analysis of experimental data in Matlab/Minitab

CO3 Post process the experimental data for 3D visualization using Tecplot software

CO4 Develop non-parametric model for prediction of unknown data using experimental data with techniques such as RSM, ANN and GA

CO5 Optimize the experimental parameters using different techniques such as RSM and GA

CO – PO MAPPING:

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

IC3311 **PROJECT WORK – I**

L	T	P	C
0	0	12	6

COURSE OBJECTIVES

1. The main learning objective of this course is to prepare the students for identifying a specific problem for the current need of the society and or industry, through detailed review of relevant literature, developing an efficient methodology to solve the identified specific problem.

   Note: A project topic must be selected by the students in consultation with their guides. The progress of the project is evaluated based on a minimum of three reviews. The review committee may be constituted by the Head of the Department. A project report is required at the end of the semester. The project work is evaluated jointly by external and internal examiners constituted by the Head of the Department based on oral presentation and the project report.

COURSE OUTCOMES:

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

CO1 Identify a suitable industrial problem with regard to engines..
CO2 Develop the required setup for testing

CO – PO MAPPING:

CO	PO					
	1	2	3	4	5	6
1	3	3	3	3	3	3
2	3	3	3	3	3	3
Avg	3	3	3	3	3	3

IC3411	PROJECT WORK – II	L	T	P	C
		0	0	24	12

COURSE OBJECTIVES

1. The main learning objective of this course is to prepare the students for solving the specific problem for the current need of the society and or industry, through the formulated efficient methodology, and to develop necessary skills to critically analyse and discuss in detail regarding the project results and making relevant conclusions.

   Note: A project topic must be selected by the students in consultation with their guides. The progress of the project is evaluated based on a minimum of three reviews. The review committee may be constituted by the Head of the Department. A project report is required at the end of the semester. The project work is evaluated jointly by external and internal examiners constituted by the Head of the Department based on oral presentation and the project report.

COURSE OUTCOMES:

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

CO1 Conduct the experiments, interpret and analyse the data

CO2 Validate, present and publish the findings

CO – PO MAPPING:

CO	PO					
	1	2	3	4	5	6
1	3	3	3	3	3	3
2	3	3	3	3	3	3
Avg	3	3	3	3	3	3

PW3052 ELECTRIC VEHICLES AND POWER MANAGEMENT **L T P C**

3 0 0 3

UNIT I HYBRID ELECTRIC VEHICLE ARCHITECTURE AND POWER TRAIN COMPONENTS 9

History of Evolution of Electric Vehicles (EV) - Comparison of Electric Vehicles with Internal Combustion Engines - Architecture of Electric Vehicles (EV) and Hybrid Electric Vehicles (HEV) – Plug-in Hybrid Electric Vehicles (PHEV)- Power Train Components and Sizing, Gears, Clutches, Transmission and Brakes

UNIT II MECHANICS OF HYBRID ELECTRIC VEHICLES 9

Fundamentals of Vehicle Mechanics - Tractive Force, Power and Energy Requirements for Standard Drive Cycles of HEV's - Motor Torque - Power Rating and Battery Capacity

UNIT III CONTROL OF DC AND AC MOTOR DRIVES 9

Speed control for Constant Torque, Constant HP operation of all Electric Motors - DC/DC chopper based Four Quadrant Operation of DC Motor Drives, Inverter-based V/f Operation (motoring and braking) of Induction Motor Drives, Vector Control Operation of Induction Motor and PMSM, Brushless DC Motor Drives, Switched Reluctance Motor (SRM) Drives

UNIT IV ENERGY STORAGE SYSTEMS 9

Battery: Principle of operation, Types, Estimation Of Parameters, Battery Modeling, SOC of Battery, Traction Batteries and their capacity for Standard Drive Cycles, Vehicle to Grid operation of EV's -Alternate sources: Fuel cells, Ultra capacitors, Fly wheels

UNIT V HYBRID VEHICLE CONTROL STRATEGY AND ENERGY MANAGEMENT 9

HEV Supervisory Control - Selection of modes - Power Spilt Mode - Parallel Mode - Engine Brake Mode - Regeneration Mode - Series Parallel Mode - Energy Management of HEV's

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, students will be able to:

CO1: Learn the electric vehicle architecture and power train components.

CO2: Acquire the concepts of dynamics of Electrical Vehicles.

CO3: Understand the vehicle control for Standard Drive Cycles of Hybrid Electrical Vehicles (HEVs).

CO4: Ability to model and understand the Energy Storage Systems for EV.

CO5: Acquire the knowledge of different modes and Energy Management in HEVs.

REFERENCES:

1. Iqbal Husain, “Electric and Hybrid Electric Vehicles”, First Edition, CRC Press, 2011
2. Wei Liu, “Hybrid Electric Vehicle System Modeling and Control”, Second Edition, Wiley, 2017
3. James Larminie and John Lowry, “Electric Vehicle Technology Explained”, Second Edition, 2012
4. Mehredad Ehsani, Yimi Gao, Stefano Longo and Kambiz Ebrahimi,” Modern Electric, Hybrid Electric and Fuel cell Vehicles”, Third edition, CRC Press, 2019
5. Jingsheng Yu and Vladimir V. Vantsevich, “Control Application of Vehicle Dynamics”, First Edition, CRC Press, 2021

MAPPING OF COs WITH POs AND PSOs

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

EY3052 **FUEL CELL TECHNOLOGY**

L	T	P	C
3	0	0	3

OBJECTIVE:

The major objective of this course is to enhance the knowledge of the students about classifications, construction, working, analysis and applications of fuel cells. This course will also enable students to understand various production and storage techniques of Hydrogen.

UNIT – I OVERVIEW 9

Basics of Fuel Cell Technology - History of Fuel Cells - Fundamentals - Components - Working Principle - Advantages and Limitations - Comparison of Fuel Cell and Battery.

UNIT – II CLASSIFICATION 9

Classification of Fuel Cells - Based on Temperature and Electrolyte - Description and working principles of various types of fuel cells - Components used - Fabrication - Applications - Merits and Demerits of PEMFC, DMFC, PAFC, AMFC, SOFC, MCFC and MFC - Recent Developments and Achievements.

UNIT – III THERMODYNAMIC AND KINETIC ASPECTS OF FUEL CELL 9

Theory - Thermodynamics - Electrochemistry - Energy Conversion Efficiency - Factors that influence Fuel Cell Efficiency - Reaction Kinetics - Electrode Kinetics - Characterization methods - Polarization and Power Density Curves - Fuel Cell Losses - Methods to improve Fuel Cell Performance.

UNIT – IV HYDROGEN PRODUCTION, STORAGE AND SAFETY 9

Hydrogen Salient Characteristics - Physical and Chemical Properties - Hydrogen Economy - Hydrogen Production Methods - Steam Reforming, Electrolysis, Coal Gasification, Biomass Conversion - Biological Methods - Photo dissociation and Photo catalytic Methods - Thermal Methods - Hydrogen Storage - Physical and Chemical Methods - Hydrogen Safety and Risk - Challenges and Management – Codes and Standards.

UNIT – V APPLICATIONS AND CHALLENGES OF FUEL CELL 9

Fuel Cell Applications - Domestic - Industrial - Commercial - Transportation and Stationary Applications - Economics and Environment Analysis - Cost and Safety - Life Cycle Analysis - Future Trends.

TOTAL: 45 PERIODS

OUTCOMES:

Upon completion of this course, the students will be able to:

CO1 Get introduced to the concepts of fuel cell technology.

CO2 Recognize the need for development of various types of fuel cells and their scopes.

CO3 Understand and apply the principles of thermodynamics and reaction kinetics of fuel cell to increase the fuel cell efficiency.

CO4 Gain knowledge on the use of hydrogen as a source of green energy and understand the challenges associated.

CO5 Analyse the cost effectiveness and eco-friendliness of fuel cell technology and understand the impact on the application aspects.

REFERENCES:

1. Aulice Scibioh M. and Viswanathan B, “Fuel Cells – principles and applications’, University Press (India), 2006.

2. Ryan O. H., Suk Won C. and Whiteny C., “Fuel Cell Fundamentals”, John Wiley & Sons, 2016.
3. O’Hayre, R., Cha S. W., Colella W. and Prinz, B., “Fuel Cell Fundamentals”, John Wiley and Sons, 2005.
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.
6. Barbir F “PEM fuel cells: theory and practice” Elsevier, Burlington, MA 2005.
7. Christopher M A Brett, “Electrochemistry – Principles, Methods and Applications”, Oxford University, 2004.
8. Basu, S., “Fuel Cell Science and Technology”, Springer, 2007.

CO – PO MAPPING:

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

IC3051 ADVANCED COMBUSTION TECHNOLOGIES

L	T	P	C
3	0	0	3

COURSE OBJECTIVES

1. To provide fundamental knowledge about low temperature combustion concepts
2. To impart in-depth knowledge about various advanced LTC methods
3. To impart knowledge on fuel requirements for LTC combustion and its effect

UNIT I FUNDAMENTALS OF LOW TEMPERATURE COMBUSTION 9

Introduction, low temperature combustion (LTC) Fundamentals – Background of LTC, Principle, Benefits, Challenges, Need for control.

UNIT II GASOLINE AND DIESEL LOW TEMPERATURE COMBUSTION 9

Conventional Gasoline and Diesel Combustion, Effects of EGR, Techniques to HCCI operation in gasoline engines, Overview of diesel HCCI engines, Techniques–Early Injection, Multiple injections, Narrow angle direct injection (NADI™) concept, Modulated kinetics (MK)combustion – First and Second generation of MK combustion, RCCI combustion, Gasoline Direct Injection Compression Ignition (GDCI) combustion.

UNIT III LOW TEMPERATURE COMBUSTION CONTROL 9

Control Methods, Combustion timing sensors, HCCI/SI switching, Transition between operating modes (HCCI-SI-HCCI), Fuel effects in HCCI - gasoline, diesel, auto-ignition requirement, combustion phasing, Influence of equivalence ratio, auto-ignition timing, combustion duration, auto-ignition temperature and auto-ignition pressure, Combustion limits, IMEP and indicated efficiency, other approaches to characterizing fuel performance in HCCI engines.

UNIT IV FUEL REQUIREMENTS FOR ADVANCED COMBUSTION 9

Introduction, Background, Diesel fuel HCCI, HCCI fuel ignition quality, Gasoline HCCI, HCCI fuel specification, Fundamental fuel factors

UNIT V LTC COMBUSTION WITH ALTERNATIVE FUELS 9

Natural gas HCCI engines, CNG HCCI engines, methane/n- butane/air mixtures. DME HCCI engine - chemical reaction model, Combustion completeness, Combustion control system, Methodof combining DME and other fuels, Unmixed-ness of DME/air mixture

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1 Understand the fundamentals of HCCI combustion, benefits and challenges

CO2 Learn the methods followed to achieve HCCI in Gasoline and Diesel engines

CO3 Learn the HCCI combustion control methods and its significance

CO4 Understand the fuel requirements for HCCI operation and its role on complete load range operation

CO5 Learn the HCCI operation with alternative fuels and its comparison over conventional fuels

REFERENCES:

1. Hua Zhao “HCCI and CAI Engines for automotive industry” Wood Head Publishing in Mechanical Engineering, 2007.
2. Pundir B.P., Engine Combustion and Emission, 2011, Narosa Publishing House.
3. Ganesan V., “Internal Combustion Engines”, 5th Edition, Tata McGraw Hill, 2012.
4. Pundir B. P., Engine Emissions” , 2nd Edition, Narosa publishing house, 2017.
5. John. B. Heywood, “Internal Combustion Engine fundamentals” McGraw – Hill, 1988.
6. HCCI Diesel Engines - NPTEL - https://nptel.ac.in/courses/112104033/34
7. HCCI and CAI Engines – NPTEL - https://nptel.ac.in/courses/112104033/33

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

IC3004 **ELECTRIC VEHICLE SYSTEMS**

	L	T	P	C
	3	0	0	3

COURSE OBJECTIVE

1. 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 ELECTRIC VEHICLE FUNDAMENTALS 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, hybrid vehicles, and Fuel cell vehicles, limitations, technical challenges.

UNIT II 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.

UNIT III ENERGY STORAGE SYSTEMS 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.

UNIT IV ELECTRIC DRIVES 9

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

UNIT V DESIGN OF ELECTRIC VEHICLES 9

Materials and types of production, Chassis skate board design, 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 gradeability, Electronic control system, safety and challenges in electric vehicles.

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 Abaas Goodarzi, 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

IC3052 HYDROGEN – PRODUCTION AND UTILIZATION

L	T	P	C
3	0	0	3

COURSE OBJECTIVES

1. To impart knowledge about hydrogen production from different sources
2. To impart knowledge about utilization of hydrogen in fuel cells.
3. To impart knowledge about utilization of hydrogen in IC engines.

UNIT I INTRODUCTION 9

Properties of hydrogen, safety and storage aspects of hydrogen, hydrogen leakage detection, regulation - codes – standards.

UNIT II HYDROGEN PRODUCTION FROM FOSSIL FUELS AND BIOMASS 9

Gasification, Pyrolysis, reforming - steam reforming - partial oxidation – autothermal reforming.

UNIT III HYDROGEN PRODUCTION FROM WATER 9

Fundamentals of electrolysis of water, Types of electrolyzers, sizing of electrolyzers, electrolysis parameters – current density, pressure, operating temperature, hydrogen purity

UNIT IV UTILIZATION OF HYDROGEN IN FUEL CELL 9

Introduction to fuel cells, thermodynamics and electrochemical kinetics of fuel cells, Fuels cells for automotive applications – Sizing - Performance evaluation - Parameters affecting the efficiency

UNIT V UTILIZATION OF HYDROGEN IN IC ENGINES 9

Merits and demerits of hydrogen as a fuel for IC engines, Strategies for using hydrogen as fuel in IC engines, hydrogen fuel supply system, Performance – combustion - emission characteristics

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1 Demonstrate understanding of properties of hydrogen

CO2 Demonstrate understanding of technologies to produce hydrogen from fossil fuel and biomass.

CO3 Demonstrate understanding of technologies to produce hydrogen by electrolysis of water

CO4 Carry out performance analysis and sizing of fuel cell for automotive application.

CO5 Devise strategies for utilizing hydrogen as fuel in IC engines.

REFERENCES:

1. Agata Godula -Jopek, “Hydrogen production: by electrolysis”, 2015, Wiley.
2. Angelo Basile and Adolfo Iulianelli, “Advances in hydrogen production, storage and distribution”, 2014, Woodhead Publishing.
3. Detlef Stolten, “Hydrogen and Fuel Cells: Fundamentals, Technologies and Applications”, 2010, Wiley
4. Manfred Klell, Helmut Eichlseder, Alexander Trattner, “Hydrogen in Automotive Engineering”, 1st Edition, 2022, Springer Wiesbaden.
5. Efstathios-Al. Tingas, “Hydrogen for Future Thermal Engines”, 1st Edition, 2023, Springer Cham.

CO – PO MAPPING:

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

IC3001 **AUTOMOTIVE SYSTEMS**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES

1. To distinguish different types of chassis, frames and body and its component design.
2. To introduce the automobile subsystems
3. To introduce the concept of aerodynamics in automobiles
4. To introduce the concept of vehicle dynamics
5. To introduce different automobile safety technologies

UNIT I CHASSIS & LAYOUT 9

Basic construction of Chassis, types of Chassis layout, types of Body, types of frames, Loads acting on vehicle frame, materials for frames, testing of frames, Bharat New Vehicle Safety Assessment Program (BNVSAP) - Protocols.

UNIT II AUTOMOBILE POWERTRAIN 9

Clutch – principle – construction – type, transmission – principle – construction – type, torque converters, drive shaft, axle, differential

UNIT III AUXILIARY SYSTEMS 9

Braking system - types, steering geometry - steering system - types, suspension system – types, cooling and lubrication system

UNIT IV ENGINE & VEHICLE TESTING 9

Engine testing - related standards – test cycles, dynamometers – transient dynamometer – chassis dynamometers, safety & crash testing – NCAP – Injury criteria, central motor vehicle rules – homologation, vehicle service and maintenance, on board diagnostics.

UNIT V SAFETY SYSTEMS 9

Antilock Braking System, Electronic Brake Force Distribution, Dual stage Airbag, Seatbelt Pretensioner, Dynamic Radar Cruise Control, Traction control system, Pre-Collision System, Automatic High Beam, Adaptive Headlights, Daytime Running Lamp, Active headrests, Crumple Zone

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1 Differentiate different types of automobiles based on body features.
CO2 Identify automotive power train components
CO3 Identify auxiliary systems
CO4 Carryout engine and vehicle testing
CO5 Demonstrate understanding of automobile safety technologies

REFERENCES:

1. Robert Bosch GmbH, “Automotive Handbook”, 11th Edition, 2022, Willey.
2. Joseph Heitner, “Automotive Mechanics,” 2nd Edition, 2006, CBS.
3. William H. Crouse, Donald L. Anglin, “Automotive Mechanics”, 10th Edition, 2017, McGraw Hill Education.
4. Heinz Heisler, “Advanced Vehicle Technology,” 2nd Edition, 2002, Butterworth-Heinemann.
5. Hans B Pacejka, “Tyre and Vehicle Dynamics”, 3rd edition, 2012, SAE International.
6. William B. Ribbens,“Understanding Automotive Electronics”,8th edition,2017, Butterworth Heinemann.
7. Hucho, W.H., “Aerodynamics of Road vehicles”, 4th Edition, SAE,1998,

CO – PO MAPPING:

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

ET3251 AUTOMOTIVE EMBEDDED SYSTEMS L T P C
3 0 0 3

UNIT I ELECTRONIC ENGINE CONTROL SYSTEMS 9

Overview of Automotive systems, fuel economy, air-fuel ratio, emission limits and vehicle performance; Automotive microcontrollers - Electronic control Unit - Hardware & software selection and requirements for Automotive applications – open source ECU - RTOS - Concept for Engine management-Standards; Introduction to AUTOSAR and Introduction to Society SAE - Functional safety ISO 26262 - Simulation and modeling of automotive system components.

UNIT II SENSORS AND ACTUATORS FOR AUTOMOTIVES 9

Review of sensors- sensors interface to the ECU, conventional sensors and actuators, Modern sensor and actuators - LIDAR sensor- smart sensors- MEMS/NEMS sensors and actuators for automotive applications.

UNIT III VEHICLE MANAGEMENT SYSTEMS 9

Electronic Engine Control - engine mapping, air/fuel ratio spark timing control strategy, fuel control, electronic ignition - Adaptive cruise control - speed control - anti-locking braking system - electronic suspension - electronic steering, Automatic wiper control - body control system; Vehicle system schematic for interfacing with EMS, ECU. Energy Management system for electric vehicles - Battery management system, power management system-electrically assisted power steering system - Adaptive lighting system - Safety and Collision Avoidance.

UNIT IV ONBOARD DIAGONSTICS AND TELEMATICS 9

On board diagnosis of vehicles - System diagnostic standards and regulation requirements Vehicle communication protocols Bluetooth, CAN, LIN, FLEXRAY, MOST, KWP2000 and recent trends in vehicle communications - Navigation - Connected Cars technology - Tracking - Security for data communication - dashboard display and Virtual Instrumentation, multimedia electronics - Role of IOT in Automotive systems

UNIT V ELECTRIC VEHICLES 9

Electric vehicles – Components - Plug in Electrical vehicle - V2G - Charging station – Aggregators - Fuel cells/Solar powered vehicles - Autonomous vehicles.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of this course, the students will have the ability in

CO1: Insight into the significance of the role of embedded system for automotive applications.
CO2: Illustrate the need, selection of sensors and actuators and interfacing with ECU
CO3: Develop the Embedded concepts for vehicle management and control systems.
CO4: Demonstrate the need of Electrical vehicle and able to apply the embedded system technology for various aspects of EVs
CO5: Improved Employability and entrepreneurship capacity due to knowledge up gradation on recent trends in embedded systems design and its application in automotive systems.

REFERENCES:

1. William B. Ribbens, “Understanding Automotive Electronics”, Elseiver,2012
2. Ali Emedi, Mehrdedehsani, John M Miller, “Vehicular Electric power system- land, Sea, Air and Space Vehicles” Marcel Decker, 2004.
3. L.Vlacic, M.Parent, F.Harahima,” Intelligent Vehicle Technologies”, SAE International,2001.
4. Jack Erjavec,JeffArias, “Alternate Fuel Technology-Electric, Hybrid& Fuel Cell Vehicles”, Cengage , 2012.

5. Electronic Engine Control technology - Ronald K Jurgen Chilton's guide to Fuel Injection - Ford.
6. Automotive Electricals/Electronics System and Components, Tom Denton, 3rd. Edition, 2004.
7. Uwe Kiencke, Lars Nielsen, "Automotive Control Systems: For Engine, Driveline, and Vehicle", Springer; 1 edition, March 30, 2000.
8. Automotive Electricals Electronics System and Components, Robert Bosch Gmbh, 4th Edition, 2004.
9. Automotive Hand Book, Robert Bosch, Bently Publishers, 1997.
10. Jurgen, R., Automotive Electronics Hand Book.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	2	1	1	-	2
CO2	2	3	2	2	2	3
CO3	3	3	3	3	3	2
CO4	3	3	3	3	3	2
CO5	3	3	3	3	3	2
Average	**2.75**	**2.8**	**2.4**	**2.4**	**2.75**	**2.2**

IC3053 MACHINE LEARNING IN IC ENGINES

L	T	P	C
3	0	0	3

COURSE OBJECTIVES

1. The objective of the course is to impart knowledge on the various machine learning aspects of IC engines

UNIT I INTRODUCTION AND MATHEMATICAL FOUNDATIONS 9

Machine Learning Need –History – Definitions – Applications - Advantages, Disadvantages & Challenges of Machine learning -Types of Machine Learning Problems – Mathematical Foundations - Linear Algebra & Analytical Geometry -Probability and Statistics- Bayesian Conditional Probability.

UNIT II SUPERVISED LEARNING 9

Introduction-Discriminative and Generative Models -Linear Regression - Least Squares - Under-fitting / Overfitting -Cross-Validation – Lasso Regression- Classification - Logistic Regression- Gradient Linear Models -Support Vector Machines –Kernel Methods -Instance based Methods - K-Nearest Neighbours - Tree based Methods –Decision Trees –ID3 – CART - Ensemble Methods –Random Forest.

UNIT III UNSUPERVISED LEARNING AND REINFORCEMENT LEARNING 9

Introduction - Clustering Algorithms -K – Means – Hierarchical Clustering - Cluster Validity - Dimensionality Reduction –Principal Component Analysis – Recommendation Systems - EM algorithm. Reinforcement Learning – Elements -Model based Learning – Temporal Difference Learning

UNIT IV PROBABILISITIC METHODS FOR LEARNING 9

Introduction -Naïve Bayes Algorithm -Maximum Likelihood -Maximum Apriori -Bayesian Belief Networks -Probabilistic Modeling of Problems -Inference in Bayesian Belief Networks – Probability Density Estimation - Sequence Models – Markov Models – Hidden Markov Models

UNIT V MODELING, DIAGNOSTICS AND OPTIMIZATION OF IC ENGINE 9

Conventional modeling approaches for ICE, Limitations of conventional ICE modeling, ICE modeling challenges, ML to address ICE optimization and calibration challenges, ML to address ICE control challenges, Combining ML-based control with conventional ICE calibration methods, ML For combustion stability control, ML to address ICE diagnostics challenges, Systematic decision tree for use of ML in ICEs, Optimum data required for ML-based ICE applications, ML for ICE component fault diagnostics

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1 Understand and outline problems for each type of machine learning

CO2 Implement Discriminative and Generative algorithms for an application and analyze the results.

CO3 Understand the Clustering Algorithms, EM Algorithm and Reinforcement Learning

CO4 Use a tool to implement different algorithms for different types of applications

CO5 Understand the modeling, diagnostic and optimization of IC engine using Machine learning Techniques

REFERENCES:

1. Stephen Marsland, “Machine Learning: An Algorithmic Perspective”, Chapman & Hall/CRC, 2nd Edition, 2014.
2. Kevin Murphy, “Machine Learning: A Probabilistic Perspective”, MIT Press, 2012
3. Tom M Mitchell, “Machine Learning”, McGraw Hill Education, 2013.
4. Hal Daumé III, “A Course in Machine Learning”, 2017 (freely Downloadable online)

CO – PO MAPPING:

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

IC3002 GREEN ENERGY PRODUCTION TECHNOLOGIES

L	T	P	C
3	0	0	3

COURSE OBJECTIVES

1. To introduce the technologies for producing power from solar, wind, hydro, ocean, and geothermal energy.

UNIT I INTRODUCTION 9

Global and Indian energy scenario**,** National & State Energy Policy, Greenhouse effect and the carbon cycle, United Nations Framework Convention on Climate Change (UNFCC) - Conference of Parties (COP) - Kyoto Protocol - Emissions trading (ET) - Joint implementation (JI) - Clean Development Mechanism (CDM), Need for green energy technologies.

UNIT II SOLAR THERMAL TECHNOLOGIES 9

Solar radiation – Measurements of solar radiation, Solar thermal collectors – evacuated tubular collector - Flat plate collectors - concentrating collectors, Design of solar thermal applications – Solar heating and cooling systems – Solar desalination, Solar thermal energy storage.

UNIT III SOLAR PHOTOVOLTAIC TECHNOLOGIES 9

Solar PV fundamentals, Solar cell array design, PV system design, voltage regulation, maximum tracking, Solar PV systems – standalone – hybrid – grid connected

UNIT IV WIND ENERGY TECHNOLOGIES 9

Wind data and energy estimation – Betz limit - Site selection for windfarms – characteristics - Wind resource assessment - Horizontal axis wind turbine – components - Vertical axis wind turbine – Wind turbine generators and its performance – Hybrid systems – Environmental issues - Applications.

UNIT V HYDRO, OCEAN, AND GEOTHERMAL ENERGY TECHNOLOGIES 9

Small hydro - Tidal energy – Wave energy – Open and closed OTEC Cycles – Limitations – Geothermal energy – Geothermal energy sources - Types of geothermal power plants – Applications - Environmental impact

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1 Suggest projects for reducing greenhouse gas emission
CO2 Design solar thermal systems.
CO3 Design solar PV systems.
CO4 Demonstrate understanding of wind energy technologies.
CO5 Demonstrate understanding of hydro, ocean, and geothermal technologies

REFERENCES:

1. Godfrey Boyle, “Renewable Energy, Power for a Sustainable Future”, 2012, UK, Oxford University Press.
2. Rai.G.D., “Non-Conventional Energy Sources”, 2014, New Delhi, Khanna Publishers.
3. Sukhatme.S.P., “Solar Energy: Principles of Thermal Collection and Storage”, 2009, New Delhi, Tata McGraw Hill Publishing Company Ltd.
4. Tiwari G.N., “Solar Energy – Fundamentals Design, Modelling and applications”, 2015, Alpha Science Intl Ltd, 2015.
5. Twidell, J.W. & Weir A., “Renewable Energy Resources”, 2015, UK, EFNSpon Ltd.
6. Chetan Singh Solanki, "Solar Photovoltatics – Fundamentals, Technologies and Applications", 2011, PHI Learning Private limited.
7. Solar Energy International, Photovoltaic, “Design and Installation Manual”, 2006, New Society Publishers.

CO – PO MAPPING:

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

PW3059 **ELECTRICAL DRIVES AND CONTROL**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES

1. To expose the students to the fundamentals of electric drives systems and their components
2. To understand AC and DC drives, and to model and control them

UNIT I **INTRODUCTION** **9**

Concepts, and classification of Electric drives - Selection of motors - Dynamics of Electric drives: Types of loads, Multi quadrant operations, motor dynamics steady state stability and transient stability - Rating and Heating of motors: Heating effects, heating and cooling curves - classes of duty - load equalization.

UNIT II **POWER SEMICONDUCTOR DEVICES** **9**

Construction and Characteristics of Power Diodes, BJT, SCR, TRIAC, MOSFETs, and IGBT- Half wave rectifier – mid-point secondary transformer based full wave rectifier – bridge rectifier- distortion factor – capacitor filter for low power rectifiers – LC filters – Concern for power quality – three phase Diode Bridge.

UNIT III **DYNAMIC MODELING OF ELECTRIC MACHINES** **9**

Construction and types of Electric motors - Development of dynamic equations of DC motor - derivation of dynamic equations of three phase AC machine (only cylindrical rotor), SRIM and PMSM - development of steady state machine models (equivalent circuit) from the dynamic equations

UNIT IV **DC MOTOR DRIVES** **9**

Basic characteristics - Single phase and three phase controlled rectifier fed DC drives -Dual converters drives - Chopper drives - Rheostat and regenerative braking - effects of changes in supply voltage and load torque - closed loop control schemes.

UNIT V **AC MOTOR DRIVES** **9**

Induction motor drives - Voltage Source Inverter and its PWM strategies - stator voltage control - stator impedance control, rotor voltage control - Slip power recovery, FOC, DTC, Sensorless control - Dynamic, plugging, and regenerative breaking - Need for harmonic filter.
Control of Synchronous motors, Brushless DC motor, Permanent Magnet Synchronous motor, and Synchronous Reluctance Motor.

TOTAL: 45 PERIODS

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

CO1	Gain fundamental knowledge on electric motors and power electronics
CO2	Acquire and develop knowledge on control systems
CO3	Gain knowledge on drive system architecture and components
CO4	Explore real-world applications of electrical drives and control systems across various industries
CO5	Develop and design controlled electrical drives & control systems to ensure system stability and reliable operations

REFERENCES:

1. G.K. Dubey, Fundamentals of Electric Drives, , 2nd Edition, Narosa publishing House, 2010
2. V Subrahmanyam, Electric Drives, 2nd Edition, McGrawhill Education, 2010
3. R. Krishnan, “Electric Motor Drives-Modeling, Analysis, and Control”, Prentice Hall India, 2001
4. Rashid M.H., Power Electronics Circuits, Devices and Applications, Prentice Hall India, 3 rd Edition, New Delhi, 2004.
5. Ned Mohan, T.M.Undeland, W.P.Robbins,”Power Electronics: Converters, applications and design”, John Wiley and Sons, 3rd Edition (reprint), 2009.
6. PhilipT.Krein, Elements of Power Electronics, Oxford University Press, 2013. 4. P.C.Sen, Power Electronics, Tata McGraw-Hill, 30th reprint, 2008.

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

IC3054 **AUTONOMOUS AND CONNECTED VEHICLE SYSTEMS**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES

1. The objective of the course is to impart knowledge on the various machine learning aspects of IC engines

UNIT I INTRODUCTION TO AUTOMOUS VEHICLE TECHNOLOGY 9

Introduction- SAE autonomous level classification-Examples-Application of Autonomous vehicle, Advantages and disadvantages of autonomous vehicles

UNIT II PATH PLANNING AND DECISION MAKING 9

Principles of decision making and path planning for autonomous vehicles-Decision making approaches-Approximation-Heuristic-Graph based-Point guidance. Verification and validation of decision making and path planning-Application examples of task allocation and path planning algorithm

UNIT III SENSORS, PERCEPTION AND VISUALIZATION 9

Introduction to sensors, perception and visualization for autonomous vehicles-Sensor integration architectures and multiple sensor fusion- AI algorithm for sensor and imaging-neural networks.

UNIT IV NETWORKING AND CONNECTING VEHICLES 9

Current and future vehicle networking technologies-CAN, LIN,MOST and Flex-ray. The use of modern validation and verification methods-software-in the-loop, and hardware-in-the-loop technologies. The role of functional safety and ISO 26262 within the overall control system. Interdependency between software engineering and control system-advanced test methods for validation of safety-critical systems. Connected vehicle control (CACC). Vehicle to vehicle (v2v), vehicle to infrastructure and vehicle to cloud (v2c). Applications such as intelligent traffic signals, collaborative adaptive cruise and vehicle platooning.

UNIT V HUMAN FACTORS AND ETHICAL DECISION MAKING 9

Introduction to human factors-Human performance: perception and attention-situation awareness and error-human reliability: driver workloads and fatigue-emotion and motivation in design-Trust in autonomous vehicles and assistive technology-designing ADAS systems-Driverless vehicles and ethical dilemmas: Human factors and decision making software-Application of human factors in autonomous vehicles. International and national regulatory frameworks for CAV and their safe operation

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

- **CO1** Gain fundamental knowledge on electric motors Estimate vehicle state based on available data.
- **CO2** facilitate various computer vision features and techniques
- **CO3** Develop motion plan for the vehicle based on the environment, behavior and interaction of objects
- **CO4** Describe the applications of AL in autonomous and connected vehicles.
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- **CO5** Incorporate the human related factors in decision making of ADAS

REFERENCES:

1. Autonomous Driving: How the Driverless Revolution will Change the World, by Andreas Herrmann, Walter Brenner, Rupert Stadler, ISBN-10 1787148343, ISBN-13 978-1787148345, Emerald Publishing Limited, 26 March 2018.
2. Autonomous Vehicles: Technologies, Regulations, and Societal Impacts, George Dimitrakopoulos, Aggelos Tsakanikas, Elias Panagiotopoulos, Paperback ISBN: 9780323901376, eBook ISBN: 9780323901383, 1st Edition – April 14, 2021, Elsevier.
3. Driverless: Intelligent Cars and the Road Ahead (MIT Press) 1St Edition, by Hod Lipson , Melba Kurmanr), ISBN-13: 978-0262035224, ISBN-10: 0262035227, September 23, 2016.

CO – PO MAPPING:

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

IC3003	AEROSPACE PROPULSION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. To familiarize with the concept of compressible flow and effect of shock waves
2. To gain insight on the working principle of aircraft engines, rocket engines, different feed systems, propellants and their properties and dynamics of rocket

UNIT I WAVE MOTION AND SHOCK WAVES 9

Wave motion, Mach waves and Mach cone, sound waves, Shock waves – Normal and Oblique, Relation of physical properties across a shock, Deflection Relations, Method of Characteristics– Applications, Problems, Expansion Waves – Introduction

UNIT II AIR – BREATHING ENGINES 9

Theory of Aircraft propulsion – Different propulsion systems – Turboprop – Turbojet, Turbojet with after burner, Turbo fan and Turbo shaft, Ramjet, Scramjet. Methods of Thrust augmentation - Thrust vector control, Fuels for jet engines

UNIT III THERMODYNAMICS OF AIRCRAFT ENGINES, PERCEPTION AND VISUALIZATION 9

Engine - Aircraft matching – Design of inlets and nozzles – Performance characteristics of Ramjet, Turbojet, Scramjet and Turbofan engines, Problems

UNIT IV ROCKET PROPULSION 9

History of rocket propulsion, Deflagration & Detonation, Combustion in solid and liquid propellants rockets, classification of propellants and Propellant Injection systems – Non equilibrium expansion and supersonic combustion – Propellant feed systems – Reaction Control Systems - Rocket heat transfer. Electric propulsion – classification- electro thermal – electro static – electromagnetic thrusters- geometries of Ion thrusters- beam/plume characteristics – hall thrusters.

UNIT V ROCKET STAGING AND PERFORMANCE 9

Rocket equations – Escape and Orbital velocity – Multi-staging of Rockets – Space missions – Performance characteristics of rockets – Losses and efficiencies, Design of Rockets

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1 Use concepts of compressible flow to design variable area ducts for the given conditions.

CO2 Identify various aircraft engines and know its inner workings with emphasis on its limitations and applications

CO3 Mix and match various components of an aircraft engine for its design conditions

CO4 Classify various rocket engines based on its type and design it for requirements

CO5 Use orbital mechanics principles to design payload for rockets

REFERENCES:

1. Philip G. Hill and Carl R. Peterson, Mechanics and Thermodynamics of Propulsion, Second Edition, Addition – Wesley Publishing Company, New York, 2009.
2. Cohen,H. Rogers, G.F.C. and Saravanamuttoo, H.I.H, Gas Turbine Theory Longman,1989
3. S.M.Yahya, Gas Dynamics & Jet Propulsion,3rd Edition, New Age International, 2010
4. George P. Sutton, Oscar Biblarz. Rocket Propulsion Elements, John Wiley & Sons, 8th Edition, 2010.
5. Ramamurthy, Rocket Propulsion, Pan Macmillan (India) Ltd, 2010
6. W.P.Gill, H.J.Smith& J.E. Ziurys, "Fundamentals of Internal Combustion Engines as applied to Reciprocating, Gas turbine & Jet Propulsion Power Plants", Oxford & IBH Publishing Co., 1980

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