ANNA UNIVERSITY, CHENNAI

AFFILIATED INSTITUTIONS

REGULATIONS 2013

M.E. INTERNAL COMBUSTION ENGINEERING

I TO IV SEMESTERS (FULL TIME) CURRICULUM AND SYLLABUS

SEMESTER I

SL. No	COURSE CODE	COURSE TITLE	L	T	P	C
1	MA7169	Advanced Numerical Methods	3	1	0	4
2	TE7101	Advanced Heat Transfer	3	1	0	4
3	IC7101	Thermodynamics for IC Engineering	3	1	0	4
4	IC7102	Alternative Fuels for IC Engines	3	0	0	3
5	IC7103	Combustion and Emission in Engines	3	0	0	3
6		Elective I	3	0	0	3
PRACTICALS						
7	IC7111	I.C. Engineering Practices Laboratory	0	0	3	2
		TOTAL	**18**	**3**	**3**	**23**

SEMESTER II

SL. No	COURSE CODE	COURSE TITLE	L	T	P	C
1	IC7201	Electronic Engine Management Systems	3	0	0	3
2	IC7202	Internal Combustion Engine Design	3	1	0	4
3	IC7203	Instrumentation for Thermal Systems	3	0	0	3
4		Elective II	3	0	0	3
5		Elective III	3	0	0	3
6		Elective IV	3	0	0	3
PRACTICALS						
7	IC7211	Seminar Presentation	0	0	2	1
8	IC7212	Simulation Laboratory	0	0	3	2
		TOTAL	**18**	**1**	**5**	**22**

SEMESTER III

SL. No	COURSE CODE	COURSE TITLE	L	T	P	C
1		Elective V	3	0	0	3
2		Elective VI	3	0	0	3
3		Elective VII	3	0	0	3
		PRACTICALS				
4.	IC7311	Project Work (Phase I)	0	0	12	6
		TOTAL	**9**	**0**	**12**	**15**

SEMESTER IV

SL. No	COURSE CODE	COURSE TITLE	L	T	P	C
1.	IC7411	Project Work (Phase II)	0	0	24	12
		TOTAL	**0**	**0**	**24**	**12**

TOTAL NUMBER OF CREDITS TO BE EARNED FOR AWARD OF THE DEGREE = 72

ELECTIVES FOR M.E. INTERNAL COMBUSTION ENGINEERING

SEMESTER I (Elective I)

SL. No	COURSE CODE	COURSE TITLE	L	T	P	C
1	IC7001	Engine Pollution and Control	3	0	0	3
2	IC7002	Engine Auxiliary Systems	3	0	0	3
3	IC7003	Aircraft and Space Propulsion	3	0	0	3
4	IC7004	Manufacturing and Testing of Engine Components	3	0	0	3
5	IC7005	Marine Diesel Engines	3	0	0	3

SEMESTER II (Elective II, III & IV)

SL. No	COURSE CODE	COURSE TITLE	L	T	P	C
1	IC7006	Simulation of I.C. Engine Processes	3	0	0	3
2	IC7007	Supercharging and Scavenging	3	0	0	3
3	IC7008	Fluid Flow and Heat Transfer in Engines	3	0	0	3
4	IC7009	Computational Fluid Dynamics for Thermal Systems	3	0	0	3
5	IC7010	Flow Visualisation Techniques for I.C. Engines	3	0	0	3

SEMESTER III (Elective V, VI & VII)

SL. No	COURSE CODE	COURSE TITLE	L	T	P	C
1	TE7009	Boundary Layer Theory and Turbulence	3	0	0	3
2	IC7011	Combustion and Reaction Kinetics in I.C. Engines	3	0	0	3
3	IC7012	Homogeneous Charge Compression Ignition Combustion in Engines	3	0	0	3
4	EY7202	Design and Analysis of Turbomachines	3	0	0	3
5	IC7013	Automobile Engineering	3	.0	0	3

MA7169 ADVANCED NUMERICAL METHODS L T P C
3 1 0 4

OBJECTIVES:

- To impart knowledge on numerical methods that will come in handy to solve numerically the problems that arise in engineering and technology. This will also serve as a precursor for future research.

UNIT I ALGEBRAIC EQUATIONS (9+3)

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, inverse power method, Faddeev – Leverrier Method.

UNIT II ORDINARY DIFFERENTIAL EQUATIONS (9+3)

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

UNIT III FINITE DIFFERENCE METHOD FOR TIME DEPENDENT PARTIAL DIFFERENTIAL EQUATION (9+3)

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, different 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 (9+3)

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 (9+3)

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

TOTAL : 60 PERIODS

OUTCOME:

It helps the students to get familiarized with the numerical methods which are necessary to solve numerically the problems that arise in engineering.

REFERENCES

1. Saumyen Guha and Rajesh Srivastava, "Numerical methods for Engineering and Science", Oxford Higher Education, New Delhi, 2010.
2. Gupta S.K., "Numerical Methods for Engineers", New Age Publishers, 1995
3. Burden, R.L., and Faires, J.D., "Numerical Analysis – Theory and Applications", Cengage Learning, India Edition, New Delhi, 2009.
4. Jain M. K., Iyengar S. R., Kanchi M. B., Jain , "Computational Methods for Partial Differential Equations", New Age Publishers,1993.
5. Morton K.W. and Mayers D.F., "Numerical solution of partial differential equations", Cambridge University press, Cambridge, 2002.

TE7101 **ADVANCED HEAT TRANSFER** **L T P C**
3 1 0 4

AIM:
The course is intended to build up necessary fundamentals for the understanding of the physical behavior of conduction and convection.

OBJECTIVES:
- To develop the ability to use the heat transfer concepts for various applications like finned systems, turbulence flows, high speed flows.
- To analyse the thermal analysis and sizing of heat exchangers and to learn the heat transfer coefficient for compact heat exchanges.
- To achieve an understanding of the basic concepts of phase change processes and mass transfer.

UNIT I CONDUCTION AND RADIATION HEAT TRANSFER 10
One dimensional energy equations and boundary condition - three-dimensional heat conduction equations - extended surface heat transfer - conduction with moving boundaries - radiation in gases and vapour Gas radiation and radiation heat transfer in enclosures containing absorbing and emitting media – interaction of radiation with conduction and convection.

UNIT II TURBULENT FORCED CONVECTIVE HEAT TRANSFER 10
Momentum and energy equations - turbulent boundary layer heat transfer - mixing length concept - turbulence model – k Є model - analogy between heat and momentum transfer – Reynolds, Colburn, Prandtl turbulent flow in a tube - high speed flows.

UNIT III PHASE CHANGE HEAT TRANSFER AND HEAT EXCHANGER 8
Condensation with shears edge on bank of tubes - boiling – pool and flow boiling - heat exchanger -Є – NTU approach and design procedure - compact heat exchangers.

UNIT IV NUMERICAL METHODS IN HEAT TRANSFER 9
Finite difference formulation of steady and transient heat conduction problems – discretization schemes – explicit - Crank Nicolson and fully implicit schemes - control volume formulation -steady one-dimensional convection and diffusion problems - calculation of the flow field – SIMPLER Algorithm.

UNIT V MASS TRANSFER AND ENGINE HEAT TRANSFER CORRELATION 8
Mass transfer - vaporization of droplets - combined heat and mass transfers - heat transfer correlations in various applications like I.C. engines - compressors and turbines.

T=15, TOTAL: 60 PERIODS

OUTCOME:
- On successful completion of this course the student will be able to apply the law of thermodynamics to engines.

REFERENCES

1. Yunus A.Cengal, Heat and Mass Transfer – A practical Approach, 3rd edition, Tata McGraw - Hill, 2007.
2. Holman.J.P, Heat Transfer, Tata Mc Graw Hill, 2002.
3. Ozisik. M.N., Heat Transfer – A Basic Approach, McGraw-Hill Co., 1985
4. Incropera F.P. and DeWitt. D.P., Fundamentals of Heat & Mass Transfer, John Wiley & Sons, 2002.
5. Nag.P.K, Heat Transfer, Tata McGraw-Hill, 2002
6. Ghoshdastidar. P.S., Heat Transfer, Oxford University Press, 2004
7. Yadav, R., Heat and Mass Transfer, Central Publishing House, 1995.

IC7101 THERMODYNAMICS FOR IC ENGINEERING

L	T	P	C
3	1	0	4

AIM:

To enrich the knowledge of students in thermodynamics

OBJECTIVES:

- To achieve an understanding of basic principle and scope of thermodynamics.
- To predict the availability and irreversibility associated with the thermodynamic processes.
- To analyse the properties of ideal and real gas mixtures and to understand the basic concepts of thermal systems

UNIT I THERMODYNAMIC PROPERTY RELATIONS 9

Thermodynamic Potentials, Maxwell relations, Generalised relations for changes in Entropy, Internal Energy and Enthalpy, Generalised Relations for C_p and C_v, Clausius Clayperon Equation, Joule-Thomson Coefficient, Bridgeman Tables for Thermodynamic Relations.

UNIT II REAL GAS BEHAVIOUR AND MULTI-COMPONENT SYSTEMS 9

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, Gibbs phase rule for non-reactive components.

UNIT III CHEMICAL AVAILABILITY 9

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, Environmental state, Air-conditioning processes. Fuel Chemical availability, availability analysis of chemical processes – steam power plant, combustion and heat transfer losses, preheated inlet air, problems.

UNIT IV FUEL – AIR CYCLES AND THEIR ANALYSIS 9

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

UNIT V THERMO CHEMISTRY 9

Chemical equilibrium: - Equilibrium combustion products. Dynamic properties of working fluids: - Unburned mixture – Low temperature combustion products – High temperature combustion products, problems.

T=15, TOTAL: 60 PERIODS

OUTCOME:

- On successful completion of this course the student will be able to apply the law of thermodynamics to thermal systems.

REFERENCES

1. Kenneth Wark., J. R, Advanced Thermodynamics For Engineers, McGraw-Hill Inc., 1995.
2. Yunus A. Cengel and Michael A . Boles, Thermodynamics, McGraw-Hill Inc., 2006.
3. B.P. Pundir, I.C. engine combustion and emissions.
4. Bejan, A., Advanced Engineering Thermodynamics, John Wiley and Sons, 1988.
5. Holman,J.P., Thermodynamics, Fourth Edition, McGraw-Hill Inc., 1988
6. Smith, J.M. and Van Ness., H.C., Introduction to Chemical Engineering Thermodynamics, Fourth Edition, McGraw-Hill Inc., 1987.

7. Sonntag, R.E., and Van Wylen, G, Introduction to Thermodynamics, Classical and Statistical Third Edition, , John Wiley and Sons, 1991
8. Sears, F.W. and Salinger G.I., Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Third Edition, Narosa Publishing House, New Delhi, 1993.
9. DeHotf, R.T., Thermodynamics in Materials Science, McGraw-Hill Inc., 1993.
10. Rao, Y.V.C., Postulational and Statistical Thermodynamics, Allied Publisher Limited, New Delhi, 1994.

IC7102 ALTERNATIVE FUELS FOR IC ENGINES **L T P C**
3 0 0 3

AIM:
To impart knowledge on various alternative fuels for I.C. Engines

OBJECTIVES:
- Gain a working understanding of the engineering issues and perspectives affecting fuel and engine development
- Examine future trends and development, including hydrogen as an internal combustion engine fuel.
- Explore further fuel specification and performance requirements for advanced combustion systems.

UNIT I INTRODUCTION 12
Availability, Suitability, Properties, Merits and Demerits of Potential Alternative Fuels – Ethanol, Methanol, Diethyl ether, Dimethyl ether, Hydrogen, Liquefied Petroleum Gas, Natural Gas, Bio-gas and Bio-diesel.

UNIT II LIQUID FUELS FOR S.I. ENGINES 9
Requirements, Utilisation techniques – Blends, Neat form, Reformed Fuels, Storage and Safety, Performance and Emission Characteristics

UNIT III LIQUID FUELS FOR C.I. ENGINES 8
Requirements, Utilisation techniques - Blends, Neat fuels, Reformed fuels, Emulsions, Dual fuelling, Ignition accelerators and Additives, Performance and emission characteristics.

UNIT IV GASEOUS FUELS FOR S.I. ENGINES 8
Hydrogen, Compressed Natural gas, Liquefied Petroleum gas, and Bio gas in SI engines – Safety Precautions – Engine performance and emissions.

UNIT V GASEOUS FUELS FOR C.I. ENGINES 8
Hydrogen, Biogas, Liquefied Petroleum gas, Compressed Natural gas in CI engines. Dual fuelling, Performance and emission characteristics.

TOTAL: 45 PERIODS

OUTCOME:
- On successful completion of this course the student will be able to understand the various alternative fuel options available for conventional fuels and their performance and emission characteristics.

REFERENCES
1. Osamu Hirao and Richard K Pefley, Present and Future Automotive Fuels, John Wiley and Sons, 1988.
2. Keith Owen and Trevor Eoley, Automotive Fuels Handbook, SAE Publications,1990.
3. Automotive Lubricants Reference Book, Second Edition, Roger F. Haycock and John E. Hillier, SAE International Publications, 2004.

IC7103 COMBUSTION AND EMISSION IN ENGINES **L T P C**
3 0 0 3

AIM:
To Demonstrate extensive mastery of the fundamental principles which govern the design and operation of internal combustion engines as well as a sound technical framework for understanding real world problems.

OBJECTIVES:
- Understand combustion in spark ignition and diesel engines.
- To identify the nature and extent of the problem of pollutant formation and control in internal combustion engines.

UNIT I COMBUSTION PRINCIPLES 9
Combustion – Combustion equations, heat of combustion - Theoretical flame temperature – chemical equilibrium and Dissociation -Theories of Combustion - Flammability Limits - Reaction rates - Laminar and Turbulent Flame Propagation in Engines. Introduction to spray formation and characterization.

UNIT II COMBUSTION IN S.I. ENGINES 10
Stages of combustion, normal and abnormal combustion, knocking, Variables affecting Knock, Features and design consideration of combustion chambers. Flame structure and speed, Cyclic variations, Lean burn combustion, Stratified charge combustion systems. Heat release correlations.

UNIT III COMBUSTION IN C.I. ENGINES 10
Stages of combustion, vapourisation of fuel droplets and spray formation, 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 IV COMBUSTION IN GAS TURBINES 9
Flame stability, Re-circulation zone and requirements - Combustion chamber configurations, Cooling, Materials.

UNIT V EMISSIONS 7
Carbon Monoxide, Unburnt Hydrocarbons, Oxides of Nitrogen, Particulate matter and smoke – sources. Emission control measures for SI and CI engines. Effect of emissions on environment and human beings.

TOTAL: 45 PERIODS

OUTCOME:
- On successful completion of this course the student will be able to understand the concept of the combustion in engines.

REFERENCES:

1. Ramalingam, K.K., Internal Combustion Engines, SciTech Publications (India) Pvt. Ltd., 2004.
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. B.P. Pundir I.C. Engines Combustion and Emission, 2010, Narosa Publishing House.
5. B.P. Pundir Engine Combustion and Emission, 2011, Narosa Publishing House.
6. Mathur, M.L., and Sharma, R.P., A Course in Internal Combustion Engines, Dhanpat Rai Publications Pvt.New Delhi-2, 1993.
7. Obert, E.F., Internal Combustion Engine and Air Pollution, International Text Book Publishers, 1983.
8. Cohen, H, Rogers, G, E.C, and Saravanamuttoo, H.I.H., Gas Turbine Theory, Longman Group Ltd., 1980.
9. Domkundwar V, A course in Internal Combustion Engines, Dhanpat Rai & Co. (P) Ltd, 2002.
10. Rajput R.K. Internal Combustion Engines, Laxmi Publications (P) Ltd, 2006.
11. Willard W. Pulkrabek, Engineering Fundamentals of the Internal Combustion Engines, 2007, Second Edition, Pearson Prentice Hall.

IC7111	**I.C. ENGINEERING PRACTICES LABORATORY**	**L T P C**
		0 0 3 2

AIM:

To impart knowledge on the practical aspects of Internal Combustion Engine Systems.

OBJECTIVES:

- To understand the behaviour of system at different operating conditions
- To understand the influence of individual components on the Overall performance of the system

LIST OF EXPERIMENTS

1. Disassembly and Assembly of Engines
2. Study and drawing of engine components with dimensions.
3. Experimental Study of S.I. Engine with alternative fuels.
4. Experimental Study on C.I. Engines with alternative fuels.
5. Experimental Study on the effect of fuel injection pressure on the Engine Performance, Heat Transfer and Emission Characteristics.
6. Experimental Study on the effect of preheating air and fuel on Engine Performance, Heat Transfer and Emission Characteristics.
7. Determination of Volumetric efficiency and Equivalence ratio in a single cylinder D.I. Diesel engine.
8. Determination of Flash and Fire point of various fuel blends.
9. Determination of viscosity of various fuel blends

LABORATORY REQUIREMENTS

1. S.I Engine Components
2. C.I Engine Components
3. Single/ Multi-cylinder S.I. Engines
4. Single/ Multi-cylinder C.I. Engines
5. Exhaust Gas Analyser (To measure HC,CO,NO_x,O_2,CO_2)
6. Smoke Meter

7. Pressure Transducer
8. Charge Amplifier
9. Data Acquisition System
10. Flash and Fire Point Apparatus
11. Redwood Viscometer

TOTAL: 45 PERIODS

OUTCOME:

- On successful completion of this course the student will be able to have hands on experience in Operation, testing and maintenance of engines.

IC7201 ELECTRONIC ENGINE MANAGEMENT SYSTEMS **L T P C 3 0 0 3**

AIM:
To learn the various sensors and engine management systems used in petrol and diesel engines

OBJECTIVES:

- To give an in-depth knowledge of various sensors used in engine management
- To give an overview of different types of fuel injection and ignition systems
- To know the latest technological advancements in vehicle power plant

UNIT I BASICS OF ELECTRONICS 5
Semiconductors, Transistors, Amplifiers, Integrated circuits – Analog and Digital, Logic Gates, Microcontrollers, Analog to Digital and Digital to Analog Converters.

UNIT II SENSORS 8
Sensors - Air flow, Pressure, Temperature, Speed, Exhaust gas Oxygen, Knock and Position, Principle of operation, construction and characteristics.

UNIT III IGNITION SYSTEMS 10
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.

UNIT IV GASOLINE INJECTION SYSTEMS 12
Open loop and closed loop systems, Mono-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.

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 and unit injector systems – Construction and principle of operation.

TOTAL: 45 PERIODS

OUTCOME:

- On successful completion of this course the student will be able to understand about Electronic Engine Management Systems

REFERENCES
1. Robert N. Brady, Automotive Computers and Digital Instrumentation, Prentice Hall, 1988.
2. Bosch Technical Instruction Booklets.
3. Tom Denton, Automotive Electrical and Electronic Systems, 4th Edition, Taylor and Francis Group, 2004.
4. Duffy Smith, Auto Fuel Systems, The GoodHeart-Wilcox Company Inc., Publishers, 1992.
5. Gasoline Engine Management, Third Edition, Robert Bosch, Bentley Publications, 2004.
6. Diesel Engine Management, Fourth Edition, Robert Bosch, Newness Publications, 2005.
7. Eric Chowanietz, Automobile Electronics, SAE Publications 1995.
8. William B. Ribbens, Understanding Automotive Electronics, Sxith Edition, Elsevier Inc, 2002.

IC7202 INTERNAL COMBUSTION ENGINE DESIGN **L T P C**
3 1 0 4

AIM:
To impart the basic engine design skills to the learners such that there is seamless transition to advanced design concepts.

OBJECTIVES:
- To provide the basic grounding on the piston engine design philosophy.

UNIT I GENERALIA 10
Principle of similitude, Choice of material, Stress, Fatigue and Noise, Vibration and Harshness considerations (NVH)

UNIT II DESIGN OF MAJOR COMPONENTS 15
Piston system, Power Cylinder System, Connecting rod assembly, Crankshaft system, Valve Gearing, Stress analyses.

UNIT III DESIGN OF OTHER COMPONENTS / SUBSYSTEMS 15
Inlet and exhaust manifolds, cylinder block, cylinder-head, crankcase, engine mountings, gaskets, bearings, flywheel, turbocharger, supercharger, computer controlled fuel injection system, Basics of ignition, lubrication and cooling system design.
Introduction to design of catalytic converters, particulate traps and EGR systems.

UNIT IV DESIGN SPECIFICS OF TWO-STROKE ENGINE SYSTEMS 10
Arrangement and sizing of ports, piston assembly, intake and exhaust system, scavenging, application to automotive gasoline and marine diesel engines.

UNIT V CONCEPTS OF COMPUTER AIDED DESIGN 10
Preparation of working drawings of designed components using CAD system.

TOTAL:60 PERIODS

OUTCOME:
The pupils would have gained an insight /understanding on the rudiments of piston engine design philosophy as a prelude to higher level design activities for varied applications.

REFERENCES
1. Vehicular Engine Design, Kevin L. Hoag, SAE International USA /
2. Springer – Verlag, Wien, Austria, 2006.

3. Internal Combustion Engine Handbook: Basics, Components, Systems and Perpectives, Richard Van Basshuysen and Fred Schafer (Editors) SAE International USA and Siemes VDO Automotive, Germany, 2002.
4. Engineering Design, A Systematic Approach, G. Pahl, W. Beltz J. Fieldhusen and K.H. Grote, Springer
5. Internal Combustion Engine Fundamentals, John B. Heywood, McGraw – Hill Book Company, 1988.
6. Modern Engine Technology from A to Z, Richard Van Basshuysen and Fred Schafer, SAE International, USA and Siemens VDO, Germany, 2007.
7. Introduction to Engine Valvetrains, Yushu Wang, SAE International, USA, 2007.
8. Introduction to Internal Combustion Engines, Richard Stone, Fourth Edition SAE International, USA and Macmillan Press, 2012.
9. Engineering Fundamentals of the Internal Combustion Engine, Willard W. Pulkrabek, Second Edition, Prentice – Hall of India Pvt. Ltd., New Delhi, 2006.
10. An Introduction to Engine Testing and Development, Richard D. Atkids, SAE International, USA, 2009.
11. Diesel Engine Reference Book, Second Edition, Rodica Baranescu and Bernard Challen (Editors), Society of Automotive Engineers, Inc., USA, 1999.
12. Internal Combustion Engine Design, A. Kolchin and V. Demidov, MIR Publishers, Moscow, 1984.
13. Design and Simulation of Four-Stroke Engines, Gordon P. Blair, Society of Automotive Engineers, Inc., USA, 1999.

IC7203	INSTRUMENTATION FOR THERMAL SYSTEMS	L	T	P	C
		3	0	0	3

AIM:

To enhance the knowledge of the students about various measuring instruments, importance of error and uncertainty analysis, and advanced measurement

OBJECTIVES:

- To understand the working of measuring instruments and errors associated with them
- To carry out error analysis and uncertainty of measurements
- To measure pressure and heat release from an IC engine, understand use of flow visualisation techniques

UNIT I MEASUREMENT CHARACTERISTICS 9

Instruments - Classification and Characteristics – Static and dynamic, Systematic and random errors, Statistical analysis, Uncertainity, Experimental planning and selection of measuring instruments.

UNIT II MEASUREMENT OF PHYSICAL QUANTITIES 12

Measurement of Temperature- Thermistor, Resistance Temperature Detector, Thermocouples, Pressure – Manometer, Bourdon gauge, Diaphragm gauge, electrical methods, In cylinder pressure transducer, Flow – Venturimeter, Rotameter, Ultrasonic flow meter, Vortex flow meter, Thermal mass flow meter, Turbine flow meter.

UNIT III ADVANCED MEASUREMENTS 9

Interferometer, Laser Doppler Anemometer, Hot wire Anemometer, Particle Image Velocimetry. Gas Analysers – Flame Ionisation Detector, Non-Dispersive Infrared Analyser, Chemiluminescent detector, Smoke meters, and Gas chromatography.

UNIT IV CONTROL SYSTEMS 10

Open & closed loop control systems, Response, Transfer function, Types of feedback, feedback Control system characteristics, Control system parameters, Servo motors, Stepper motors, Servo Amplifiers, Continuous control modes.

UNIT V DATA ACQUISITION SYSTEM 5

Data logging and acquisition - Sensors for error reduction, elements of computer interfacing, Timers and Counters, Analog to Digital & Digital to Analog conversion.

TOTAL: 45 PERIODS

OUTCOME:

On successful completion of this course the student will be able to plan their experiments and understand the suitability, accuracy and uncertainty associated with the instrument used for measuring thermal system parameters**.**

REFERENCES:

1. Holman, J.P., Experimental methods for Engineers, Tata McGraw-Hill, 7th Ed.2001.
2. Barney G.C, Intelligent Instrumentation, Second Edition, Prentice Hall of India, 1988.
3. Bolton.W, Industrial Control & Instrumentation, Universities Press, Second Edition, 2001.
4. Doblin E.O, Measurement System Application and Design, Second Edition, McGraw Hill, 1978.
5. Nakra, B.C., Choudhry K.K., Instrumentation, Measurements and Analysis Tata McGraw Hill, New Delhi, 2nd Edition 2003.
6. Morris.A.S, Principles of Measurements and Instrumentation, Prentice Hall of India, 1998.

IC7211 SEMINAR PRESENTATION L T P C
0 0 2 1

OBJECTIVES:

- During the seminar session each student is expected to prepare and present a topic on Energy related issues / technology, for a duration of about 30 minutes.
- In a session of three periods per week, 4 students are expected to present the seminar.
- A faculty guide is to be allotted and he / she will guide and monitor the progress of the student and maintain attendance also.
- Students are encouraged to use various teaching aids such as over head projectors, power point presentation and demonstrative models.

TOTAL: 30 PERIODS

IC7212 SIMULATION LABORATORY L T P C
0 0 3 2

FOCUS: USE OF STANDARD APPLICATION SOFTWARE FOR SOLVING HEAT TRANSFER PROBLEMS

1. Heat exchanger analysis – NTU method
2. Heat exchanger analysis – LMTD method
3. Convection heat transfer analysis – Velocity boundary layer
4. Convection heat transfer analysis – Internal flow
5. Radiation heat transfer analysis – Emissivity
6. Critical radius of insulation
7. Lumped heat transfer analysis

8. Conduction heat transfer analysis
9. Condensation heat transfer analysis

DYNAMIC LINKING OF MAT LAB AND REF PROP SOFTWARE
SIMPLE CFD PROBLEMS FOR PRACTICE

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

SIMULATION LAB – REQUIREMENT:

1. Software - Modeling software like ProE, Gambit, Ansys etc
   Analysis software like Ansys, fluent, CFX, etc
   Equation solving software like Matlab, Engg equation solver

1. Every students in a batch must be provided with a terminal
2. Hardware are compatible with the requirement of the above software.

TOTAL: 45 PERIODS

IC7001 ENGINE POLLUTION AND CONTROL

L	T	P	C
3	0	0	3

AIM:

- To educate the students about pollution formation in engines, and importance of its control.
- To educate the ways and means to protect the environment from various types of engine Pollution.

OBJECTIVES:

- To create an awareness on the various environmental pollution aspects and issues.
- To give a comprehensive insight into the pollution in engine and gas turbines.
- To impart knowledge on pollutant formation and control.
- To impart knowledge on various emission instruments and techniques.

UNIT I AIR POLLUTION - ENGINES AND TURBINES 6

Atmospheric pollution from Automotive and Stationary engines and gas turbines, Global warming – Green-house effect and effects of engine pollution on environment.

UNIT II POLLUTANT FORMATION 10

Formation of oxides of nitrogen, carbon monoxide, hydrocarbon, aldehydes and Smoke, Particulate emission. Effects of Engine Design - operating variables on Emission formation – Noise pollution.

UNIT III EMISSION MEASUREMENT TECHNIQUES 9

Non dispersive infrared gas analyzer, gas chromatography, Chemiluminescent analyzer and flame ionization detector, smoke meters – Noise measurement and control.

UNIT IV EMISSION CONTROL TECHNIQUES 12

Engine Design modifications, fuel modification, evaporative emission control, EGR, air injection, thermal reactors, Water Injection, catalytic converters, application of microprocessor in emission control. Common rail injection system, Particulate traps, NOx converters, SCR systems. GDI and HCCI concepts.

UNIT V DRIVING CYCLES AND EMISSION STANDARDS 8

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

TOTAL: 45 PERIODS

OUTCOME:

- On successful completion of this course the student will be able to understand about the emission formation and its control in engines.

REFERENCES

1. John. B. Heywood, "Internal Combustion engine fundamentals" McGraw – Hill, 1988.
2. B. P. Pundir, "IC Engines Combustion and Emission" Narosa publishing house, 2010.
3. Crouse William, Automotive Emission Control, Gregg Division /McGraw-Hill,1980
4. Ernest, S., Starkman, Combustion Generated Air Pollutions, Plenum Press, 1980.
5. George Springer and Donald J.Patterson, Engine emissions, Pollutant Formation and Measurement, Plenum press, 1973.
6. Obert, E.F., Internal Combustion Engines and Air Pollution, Intext Educational Publishers, Third Edition, 1973.

IC7002 ENGINE AUXILIARY SYSTEMS

L	T	P	C
3	0	0	3

AIM:

This course aims to impart the knowledge about engine auxiliaries like fuel supply and distribution, ignition, lubrication and cooling systems.

OBJECTIVES:

- To provide an overview of engine auxiliary systems like fuel supply, cooling and lubrication
- To impart knowledge on Gasoline and Diesel fuel injection system, requirement, Components and types of ignition

UNIT I CARBURETION 7

Gasoline - air mixtures. Mixture requirements - Mixture formation - Carburettor, Choke, Carburettor systems for emission control- Secondary Air Injection.

UNIT II GASOLINE INJECTION AND IGNITION SYSTEMS 12

Petrol Injection - Pneumatic and Electronic Fuel Injection Systems, Ignition systems - Requirements, Timing Systems, Energy requirement, Spark plug operation, Electronic & Distributorless Ignition Systems.

UNIT III DIESEL FUEL INJECTION SYSTEMS 9

Atomisation, penetration and dispersion, Rate and duration of injection, Fuel line hydraulics, Fuel pump, Injectors, CRDI Governors.

UNIT IV INTAKE AND EXHAUST MANIFOLDS 7

Intake system components, Air filter, Intake manifold, VGT, VNT, Exhaust manifold and exhaust pipe, Exhaust mufflers & Resonators.

UNIT V LUBRICATION AND COOLING SYSTEMS 10

Lubricating systems- Theory, requirements and types, Lubrication - piston rings, crankshaft bearings, camshaft, Cooling systems – Need, Engine heat transfer, liquid and air cooled engines, Oil cooling, Additives and lubricity improvers.

TOTAL: 45 PERIODS

OUTCOME:

- On successful completion of this course the student will be able to understand the need and working various auxiliaries of engine systems.

REFERENCES

1. Ganesan, V, Internal Combustion Engines, Tata McGraw Hill Book Co., Third Edition, 2010.
2. Eric Chowanietz, Automobile Electronics, SAE International, 1995.
3. Heinz Heisler, Advanced Engine Techology, Butterworth Heinmann Publishers, Second Edition, 2002..
4. Duffy Smith, Auto Fuel Systems, Good Heart Wilcox Company Inc., Publishers, 1987.

IC7003 AIRCRAFT AND SPACE PROPULSION

L	T	P	C
3	0	0	3

AIM:

To enhance the knowledge of the students on aircrafts and space propulsion

OBJECTIVES:

- To gain insight on the working principle of rocket engines, different feed systems, propellants and their properties and dynamics of rockets.

UNIT I GAS DYNAMICS 8

Wave motion - Compressible fluid flow through variable area devices – Stagnation state Mach Number and its influence and properties, Isentropic Flow, Rayleigh and Fanno Flow. Deflagration and Detonation – Normal shock and oblique shock waves.

UNIT II THERMODYNAMICS OF AIRCRAFT ENGINES 9

Theory of Aircraft propulsion – Thrust – Various efficiencies – Different propulsion systems – Turboprop – Ram Jet – Turbojet, Turbojet with after burner, Turbo fan and Turbo shaft.Variable thrust-nozzles – vector control.

UNIT III PERFORMANCE CHARACTERISTICS OF AIRCRAFT ENGINES 9

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

UNIT IV ROCKET PROPULSION 9

Theory of rocket propulsion – Rocket equations – Escape and Orbital velocity – Multi-staging of Rockets – Space missions – Performance characteristics – Losses and efficiencies.

UNIT V ROCKET THRUST CHAMBER 10

Combustion in solid and liquid propellant classification – rockets of propellants and Propellant Injection systems – Non-equilibrium expansion and supersonic combustion – Propellant feed systems – Reaction Control Systems - Rocket heat transfer.

TOTAL: 45 PERIODS

OUTCOME:

- On successful completion of this course the student will be able to understand the working of different types of aircraft and rocket propulsion systems and their performance characteristics.

REFERENCES

1. Philip G. Hill and Carl R. Peterson, Mechanics and Thermodynamics of Propulsion, Second Edition, Addition – Wesley Publishing Company, New York, 2009.
2. Zucrow N.J. Principles of Jet Propulsion and Gas Turbines, John Wiley and Sons New York, 1970.
3. Zucrow N.J. Aircraft and Missile Propulsion, Vol. I and Vol. II, John Wiley and Sons Inc, New York, 1975.
4. S. M.Yahya, Fundamentals of Compressible Flow. Third edition, New Age International Pvt Ltd, 2003.
5. Bonney E.A. Zucrow N.J. Principles of Guided Missile Design, Van Nostranc Co., 1956.

IC7004 MANUFACTURING AND TESTING OF ENGINE COMPONENTS **L T P C**
3 0 0 3

AIM:

To provide a comprehensive module on the aspects of materials, manufacture and testing of piston engine assemblies, components and subsystems.

OBJECTIVES:

- To equip the learners with necessary domain inputs such that they can pursue research, consultancy, academics or other avocation.

UNIT I MATERIALS 7

Selection – types of Materials – Ferrous – Carbon and Low Alloy steels, High Alloy Steels, Cast Irons – Nonferrous – Aluminium, Magnesium, Titanium, Copper and Nickel alloys, composites.

UNIT II ENGINE COMPONENTS 15

Cylinder Block, Cylinder Head, Crankcase and Manifolds, Piston Assembly, Connecting Rod, Crankshaft, Camshaft and Valve Train - Production methods – Casting, Forging, Powder Metallurgy – Machining – Testing Methodologies.

UNIT III ENGINE AUXILIARIES 7

Carburettors, fuel injection system components, radiators, fans, coolant pumps, ignition system, intake and exhaust systems, Catalytic converters

UNIT IV COMPUTER INTEGRATED MANUFACTURING 7

Integration of CAD, CAM and CIM- Networking, CNC programming for machining of Engine Components.

UNIT V QUALITY ASSURANCE AND TESTING 9

TS 16949, ISO and BIS codes for testing. Instrumentation, computer aided engine testing, metrology for manufacture of engine components, engine tribological aspects.

TOTAL: 45 PERIODS

OUTCOME:

- A course work, of this kind would have equipped a graduate student with the requisite skills needed for a practicing engineer.

REFERENCES

1. Richard D. Atkins, An Introduction to Engine Testing and Development, SAE International, USA, 2009.
2. Bosch Automotive Handbook, (8^{th} Edition), Robert Bosch GmbH, Germany, 2011.
3. H.N. Gupta, Fundamentals of Internal Combustion Engines, PHI Learning Private Ltd., 2010.
4. James D. Halderman and Chase D. Mitchell Jr. , Automotive Engines: Theory and Servicing, Pearson Education Inc., 2005.
5. Christopher Hadfield, Automotive Engineering : Engine Repair and Rebuilding, Delmar Learning (Cengage Learning India Private Ltd.), 2010.
6. Judge, A.W., Testing of high speed internal combustion engines, Chapman & Hall., 1960.
7. Heldt, P.M., High speed Internal Combustion Engines, Oxford & IBH Publishing Co., 1960.
8. P. Radhakrishnan and S. Subramaniyan, CAD / CAM/CIM, New Age International (P) Ltd, Publishers, 1997.
9. Richard W. Heine, Carl R. Loper Jr. and Philip, C., Rosenthal, Principles of Metal Casting, McGraw-Hill Book Co., 1980.
10. Bosch Automotive Handbook, (8^{th} Edition) Robert Bosch GmbH, Germany, 2011.

IC7005	**MARINE DIESEL ENGINES**	**L T P C**
		3 0 0 3

AIM:

To provide a first-hand knowledge about the marine diesel and allied engine systems.

OBJECTIVES:

- To give a broad outline about marine diesel and allied piston engine systems

UNIT I ENGINE RUDIMENTS 10

Engine Operation; Operating Cycles; Performance factors; Supercharging and Scavenging Systems for two stroke and four stroke cycle engines, Submarine Engine Systems, Fuels and Lubricants, Engine Pollution and their Controls.

UNIT II MECHANICS 10

Dynamics of crank gear, Engine Vibration, Design, Engine Systems, Speed governors and Accessory equipment's.

UNIT III INSTRUMENTATION AND CONTROL 10

Automatic instruments and remote control of marine engines, Testing - Standard codes - Rating.

UNIT IV AUXILIARY SYSTEMS 10

Starting and reversing gears, Fuel systems, cooling and Lubrication systems.

UNIT V TYPICAL MODERN MARINE PROPULSION ENGINE SYSTEMS 5

Layout of Diesel Electric Engines - LNG Engines Gas turbines - Screws - Nuclear powered steam Turbines.

TOTAL : 45 PERIODS

OUTCOME:

- The aim and objectives would have been realized on completion of a course work on Marine Engine Systems.

REFERENCES

1. John Lamb, The Running and Maintenance of the Marine Diesel Engine, Charles Griffin and Company Ltd., U.K., (Sixth Edition), 1976.
2. N. Petrovsky, Marine Internal Combustion Engines, Translation from Russian by Horace E Isakson, MIR Publishers, Moscow,1974
3. George H.Clark, Industrial and Marine Fuels Reference Book, Butterworth and Company (Publishers) Ltd., U.K., 1998.
4. Doug Woodyard (Editor), Pounder's Marine Diesel Engines, Butterworth-Heinemann, UK (Seventh Edition), 1998.
5. AkberAyub, Marine Diesel Engines, Ane Books Pvt. Ltd., New Delhi, 2010.

IC7006	SIMULATION OF I.C. ENGINE PROCESSES	L T P C
		3 0 0 3

AIM:

To impart knowledge on simulation of various engine processes used in prime movers and power plants.

OBJECTIVES:

- To learn the simulation of engine combustion based on first and second law of thermodynamics**.**

UNIT I SIMULATION PRINCIPLES 9

First and second laws of thermodynamics – Estimation of properties of gas mixtures - Structure of engine models – Open and closed cycle models - Cycle studies. Chemical Reactions, First law application to combustion, Heat of combustion – Adiabatic flame temperature. Hess Law-Lechatlier principle. Heat transfer in engines – Heat transfer models for engines. Simulation models for I.C. Engines. (Ideal and actual cycle simulation) Chemical Equilibrium and calculation of equilibrium composition.

UNIT II SIMULATION OF COMBUSTION IN SI ENGINES 9

Combustion in SI engines, Flame propagation and velocity, Single zone models – Multi zone models – Mass burning rate, Turbulence models – One dimensional models – Chemical kinetics modeling – Multidimensional models, Flow chart preparation.

UNIT III SIMULATION OF COMBUSTION IN CI ENGINES 9

Combustion in CI engines Single zone models – Premixed-Diffusive models – Wiebe' model – Whitehouse way model, Two zone models - Multizone models- Meguerdichian and Watson's model, Hiroyasu's model, Lyn's model – Introduction to Multidimensional and spray modeling, Flow chart preparation.

UNIT IV SIMULATION OF TWO STROKE ENGINES 9

Thermodynamics of the gas exchange process - Flows in engine manifolds – One dimensional and multidimensional models, Flow around valves and through ports Models for scavenging in two stroke engines – Isothermal and non-isothermal models, Heat Transfer and Friction.

UNIT V SIMULATION OF GAS TURBINE COMBUSTORS 9

Gas Turbine Power plants – Flame stability, Combustion models for Steady Flow Simulation – Emission models. Flow chart preparation.

TOTAL: 45 PERIODS

OUTCOME:

- On successful completion of this course the student will be able to simulate the different engine processes.

REFERENCES

1. Ashley S. Campbell, Thermodynamic Analysis of Combustion Engines, Krieger publication co, 1985.
2. V.Ganesan, Computer Simulation of Spark Ignition Engine Processes, Universities Press, 2000.
3. V V. Ganesan, Computer Simulation of C.I. Engine Processes, Universities Press, 2000.
4. Cohen H. Rogers GEC. – Gas Turbine Theory – Pearson Education India Fifth edition, 2001.
5. Bordon P. Blair, The Basic Design of two-Stroke engines, SAE Publications, 1990.
6. Horlock and Winterbone, The Thermodynamics and Gas Dynamics of Internal Combustion Engines, Vol. I & II, Clarendon Press, 1986.
7. J.I.Ramos, Internal Combustion Engine Modeling, Butterworth – Heinemann ltd, 1999.
8. J.N.Mattavi and C.A.Amann, Combustion Modeling in Reciprocating Engines, Plenum Press, 1980.

IC7007	SUPERCHARGING AND SCAVENGING	L T P C
		3 0 0 3

AIM:

To gain knowledge in the field of turbo charging, supercharging and scavenging.

OBJECTIVES:

- To understand the supercharging and turbocharging effect on I.C engine performance and emissions, scavenging of two stroke engines and design aspects of muffler and port design.

UNIT I SUPERCHARGING 8

Engine modifications required. Effects on Engine performance - Thermodynamics Mechanical Supercharging. Types of compressors – Positive displacement blowers – Centrifugal compressors – Performance characteristic curves – Suitability for engine application – Matching of supercharger compressor and Engine.

UNIT II TURBOCHARGING 8

Turbocharging methods - Thermodynamics – Engine exhaust manifolds arrangements. – Waste gate, Variable nozzle turbochargers, Variable Geometry Turbocharging – Surging - Matching of compressor, Turbine and Engine.

UNIT III SCAVENGING OF TWO STROKE ENGINES 12

Features of two stroke cycle engines – Classification of scavenging systems – Charging Processes in two stroke cycle engine – Terminologies – Sankey diagram – Relation between scavenging terms – scavenging modeling – Perfect displacement, Perfect mixing. Mixture control through Reed valve induction

UNIT IV PORTS AND MUFFLER DESIGN 8

Porting – Port flow characteristics-Design considerations – Design of Intake and Exhaust Systems – Tuning- Kadenacy system.

UNIT V EXPERIMENTAL METHODS AND RECENT TRENDS IN TWO STROKE ENGINES 9

Experimental techniques for evaluating scavenging – Firing engine tests – Non firing engine tests – Development in two stroke engines for improving scavenging. Direct injection two stroke concepts.

TOTAL: 45 PERIODS

OUTCOME:

- On successful completion of this course the student will be able to match turbochargers with engines and design two stroke cycle engines.

REFERENCES

1. Schweitzer, P.H., Scavenging of Two Stroke Cycle Diesel Engine, MacMillan Co., 1949.
2. John B. Heywood, Two Stroke Cycle Engine, SAE Publications, 1999.
3. G P Blair, Two stroke Cycle Engines Design and Simulation, SAE Publications, 1997.
4. Heinz Heisler, Advanced Engine Techology, Butterworth Heinmann Publishers, 2002.
5. Obert, E.F., Internal Combustion Engines and Air Pollution, Intext Educational Publishers, 1980.Richard Stone, Internal Combustion Engines, SAE, 2012.
6. Watson, N. and Janota, M.S., Turbocharging the I.C. Engine, MacMillan Co., 1982.

IC7008 FLUID FLOW AND HEAT TRANSFER IN ENGINES L T P C
3 0 0 3

AIM:

To enrich the students' knowledge engines fluid flow and heat transfer

OBJECTIVES:

- To understand the fluid flow in an IC engine, aspects of heat transfer and cooling of components.

UNIT I INTRODUCTION 9

Basics Laws, Newtonian Fluids, Navier – Stokes Equations, Compressible and Incompressible Flows, Stream Functions and velocity Potential, Vorticity Dynamics.

UNIT II LAMINAR AND TURBULENT FLOWS 9

Ideal - flows and Boundary layers, Flows at Moderate Reynolds Numbers, Characteristics of High - Reynolds Number Flow, Ideal Flows in a plane, Axi-symmetric and Three dimensional Ideal Flows and Boundary Layers, Low Reynolds Numbers Flows. Swirl, Squish and Tumble.

UNIT III LUBRICATION,SURFACETENSION EFFECTS, MICROSCALE EFFECTS 5

Lubrication, Surface Tension effects, Micro scale effects.

UNIT IV COMPRESSIBLE FLOW 10

One dimensional compressible Gas flow, Isentropic Gas Relations, Compressible flow in Nozzles, Area – velocity Relations, Converging – Diverging Nozzle effects of viscous friction and Heat Transfer – Introduction to Multi-Dimensional flow.

UNIT V CONVECTIVE HEAT TRANSFER – MASS TRANSFER AND HEAT TRANSFER IN POROUS MEDIA 12

Convective Heat Transfer – Parallel Flow (Hagen – Poiseuille Flow), Couette Flow, Sudden acceleration of a Flat Plate, Creeping flow, Mass transfer Diffusion and Convection, combined Heat and Mass Transfer, Heat transfer in Porous Media.

TOTAL: 45 PERIODS

OUTCOME:

- On successful completion of this course the student will be able to apply the fluid flow and heat transfer concepts in engine system.

REFERENCES

1. Ronald L. Panton, Incompressible flow, 3rd Edition, Wiley, 2005.
2. K. Muralidhar and G. Biswas, Advanced Engg. Fluid Mechanics, Narosa Publishing House, 2005.
3. Frank M. White, Viscous Fluid Flow, 3rd Edition, McGraw Hill, 2011.
4. I.G. Currie, Fundamental Mechanics of fluids, 4th Edition, McGraw Hill 2011.
5. F.P. Incropera and B. Lavine, Fundamentals of Heat and Mass Transfer, 7th Edition, Willey, 2011.
6. Welty, C. Wicks, Fundamentals of Momentum, Heat and Mass Transfer, 4th Edition, Wiley 2009.
7. Warren M Rehsenow and Harry Y Choi, Heat and Mass Momentum Transfer, Prentice Hall, 1980.

IC7009 COMPUTATIONAL FLUID DYNAMICS FOR THERMAL SYSTEMS

L	T	P	C
3	0	0	3

AIM:

This course aims to introduce numerical modeling and its role in the field of heat and fluid flow; it will enable the students to understand the various discretisation methods and solving methodologies and to create confidence to solve complex problems in the field of heat transfer and fluid dynamics.

OBJECTIVES:

- To develop finite difference and finite volume discretized forms of the CFD equations.
- To formulate explicit & implicit algorithms for solving the Euler Equations & Navier Strokes Equations.

UNIT I GOVERNING DIFFERENTIAL EQUATIONS AND FINITE DIFFERENCE METHOD 10

Classification, Initial and Boundary conditions – Initial and Boundary Value problems – Finite difference method, Central, Forward, Backward difference, Uniform and non-uniform Grids, Numerical Errors, Grid Independence Test.

UNIT II CONDUCTION HEAT TRANSFER BY FINITE DIFFERENCE METHOD AND FINITE VOLUME METHOD 10

Steady one-dimensional conduction, Two and three dimensional steady state problems, Transient one-dimensional problem, Two-dimensional Transient Problems.

UNIT III CONVECTION HEAT TRANSFER BY FINITE DIFFERENCE METHOD AND FINITE VOLUME METHOD 10

Steady One-Dimensional and Two-Dimensional Convection – diffusion, Unsteady one-dimensional convection – diffusion, Unsteady two-dimensional convection – Diffusion.

UNIT IV INCOMPRESSIBLE FLUID FLOW BY FINITE DIFFERENCE METHOD AND FINITE VOLUME METHOD 10

Governing Equations, Stream Function – Vorticity method, Determination of pressure for viscous flow, SIMPLE, Computation of Boundary layer flow - Finite difference approach.

UNIT V FINITE ELEMENT METHOD AND TURBULENCE MODELS 5

Introduction to finite element method – solution of steady heat conduction by FEM. Algebraic Models – One equation model, k – ε models - Standard and High and Low Reynolds number models, Prediction of fluid flow and heat transfer using standard codes – Prediction of flow in a sudden pipe contraction and pipe.

TOTAL: 45 PERIODS

OUTCOME:

- On successful completion of this course the student will be able to apply concept of CFD to analyse flow in thermal systems.

REFERENCES

1. Muralidhar, K., and Sundararajan, T., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, New Delhi, 2003.
2. Muralidhar, K., and Sundararajan, T., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, New Delhi, 2003.
3. Subas and V.Patankar "Numerical heat transfer fluid flow", Hemisphere Publishing Corporation, 1980.
4. Versteeg and Malalasekera, N, "An Introduction to computational Fluid Dynamics The Finite volume Method," Pearson Education, Ltd., 2007.
5. Taylor, C and Hughes, J.B. "Finite Element Programming of the Navier-Stokes Equation", Pineridge Press Limited, U.K., 1981.
6. Anderson, D.A., Tannehill, J.I., and Pletcher, R.H., "Computational fluid Mechanics and Heat Transfer " Hemisphere Publishing Corporation, New York, USA, 2012.
7. Fletcher, C.A.J. "Computational Techniques for Fluid Dynamics 1" Fundamental and General Techniques, Springer – Verlag, 1991.
8. Fletcher, C.A.J. "Computational Techniques for fluid Dynamics 2" Specific Techniques for Different Flow Categories, Springer – Verlag, 1988.
9. Bose, T.K., "Numerical Fluid Dynamics" Narosa Publishing House, 1997.

IC7010 FLOW VISUALISATION TECHNIQUES FOR I.C. ENGINES

L	T	P	C
3	0	0	3

AIM:

To enhance students' knowledge on flow visualisation techniques applied to ICE engine flow processes

OBJECTIVES:

- To understand the significance of flow visualisation techniques in IC engine flow processes.

UNIT I INSTRUMENTATION FOR FLOW VISUALISATION 9

Schilieren photography – Laser Velocimeter – Illuminated Particle Visualisation Holography – Particle Image velocitymetry.

UNIT II FLOW VISUALISATION OF INTAKE PROCESS 9
Engine optical access, Design of optical engine, Thermal properties of materials used for optical engine, processing of materials – Optical techniques.

UNIT III IN-CYLINDER FLOW 9
Visual Experiment of In-cylinder flow by Laser sheet method. Intake flow visualization by light colour layer examination of principle and photographic measurement techniques.

UNIT IV COMBUSTION VISUALISATION 9
Endoscopes, Advanced cameras, Fiber Optic Tools, Laser diagnostics of Flames.

UNIT V NUMERICAL FLOW VISUALISATION 9
Direct, Geometric and texture based flow visualization, Dense Geometric Flow visualization – Surface flow visualisation.

TOTAL: 45 PERIODS

OUTCOME:
- On successful completion of this course the student will be able to apply concept of flow visualisation techniques to IC engines.

REFERENCES

1. V. Ganesan, Internal Combustion Engines, Tata McGraw Hill Book Co., 2008.
2. J.P. Holman, Experimental Methods for Engineers, McGraw – Hill Inc., 2001.
3. Wolfgang Merzkirch, Flow Visualisation, 2nd Edition, Academic Press, 1987.
4. Marshall B. Long, Optical Methods in flow and Particle Diagnosis, Society of Photo Optics, 1989.
5. B.H. Lakshmana Gowda, A Kaleidoscopic view of Fluid Flow Phenomena, Wiley Eastern, 1992.
6. Will Schroeder, Ken Martin and Bill Lorensen, An Object – Oriented Approach to 3D Graphics, 2nd Edition, Prentice Hall, 1998.

TE7009 BOUNDARY LAYER THEORY AND TURBULENCE

L	T	P	C
3	0	0	3

AIM:
To enhance the students' knowledge on boundary layer theory and turbulence

OBJECTIVES:
- To understand the theory of turbulent flow and its modeling, structure types and a detailed insight about turbulence.

UNIT I FUNDAMENTALS OF BOUNDARY LAYER THEORY 9
Boundary Layer Concept, Laminar Boundary Layer on a Flat Plate at zero incidence, Turbulent Boundary Layer on a Flat plate at zero incidence, Fully Developed Turbulent Flow in a pipe, Boundary Layer on an airfoil, Boundary Layer separation.

UNIT II TURBULENT BOUNDARY LAYERS 9
Internal Flows – Couette flow – Two-Layer Structure of the velocity Field – Universal Laws of the wall – Friction law – Fully developed Internal flows – Channel Flow, Couettee – Poiseuille flows, Pipe Flow.

UNIT III TURBULENCE AND TURBULENCE MODELS 9

Nature of turbulence – Averaging Procedures – Characteristics of Turbulent Flows – Types of Turbulent Flows – Scales of Turbulence, Prandtl's Mixing length, Two-Equation Models, Low – Reynolds Number Models, Large Eddy Simulation.

UNIT IV STATISTICAL THEORY OF TURBULENCE 9

Ensemble Average – Isotropic Turbulence and Homogeneous Turbulence – Kinematics of Isotropic Turbulence – Taylor's Hypothesis – Dynamics of Isotropic Turbulence -Grid Turbulence and decay – Turbulence in Stirred Tanks.

UNIT V TURBULENT FLOWS 9

Wall Turbulent shear flows – Structure of wall flow – Turbulence characteristics. of Boundary layer – Free Turbulence shear flows – Jets and wakes – Plane and axi-symmetric flows.

TOTAL: 45 PERIODS

OUTCOME:

On successful completion of this course the student will be able to apply the concepts of boundary layer theory and turbulence.

REFERENCES

1. G. Biswas and E. Eswaran, Turbulent Flows, Fundamentals, Experiments and Modelling, Narosa Publishing House, 2002.
2. H. Schlichting and Klaus Gersten, Boundary Layer Theory, Springer 2004.
3. R.J. Garde,Turbulent Flow, New Age International (p) Limited, Publishers, 2006.

IC7011 COMBUSTION AND REACTION KINETICS IN I.C. ENGINES

L	T	P	C
3	0	0	3

AIM:

To develop the knowledge about combustion kinetics in SI and CI engines.

OBJECTIVES:

- To understand the combustion reaction kinetics in SI and CI engines.

UNIT I INTRODUCTION 8

Gaseous, liquid and solid fuels, Application of the first and second laws of thermodynamics to combustion, – Low temperature reactions – Cool Flames – as applied to detonation. High temperature reactions – species concentration and products formation.

UNIT II CHEMICAL KINETICS OF COMBUSTION 9

Elementary reactions, Pre-ignition kinetics, Ignition delay Nitric Oxide Kinetics, Soot Kinetics, Calculations, – Reaction control effect on Engine performance and emissions.

UNIT III MODELLING 10

Calculation of equilibrium composition. Enthalpy and Energy, Coefficients for reactions and adiabatic flame temperature, Modeling of CO, HC NO reactions in SI and CI Engines – Soot Modelling.

UNIT IV GASOLINE ENGINE COMBUSTION 8

Combustion in S.I. Engines, Laminar flame theory, Flame structure, Turbulent premixed flames, Homogeneous Combustion reactions between Gasoline and air – Reaction rate Constants – species determination. Burning rate estimation.

UNIT V DIESEL ENGINE COMBUSTION 10

Combustion in CI Engine, Spray formation, Spray dynamics, Spray models, Introduction to diesel engine combustion, Premixed and diffusion combustion reactions – Lean flame Reactions – Lean flame out reactions - Species determination. Emissions and Combustion, Burning rate estimation.

TOTAL: 45 PERIODS

OUTCOME:

- On successful completion of this course the student will be able to understand the combustion and reaction kinetics in IC Engines

REFERENCES:

1. J.F. Ferguson, Internal Combustion Engines, John Wiley and Sons, 2004.
2. I R.S. Benson & N.D. Whitehouse, Internal Combustion Engines, First edition, Pergamon Press, England 1979.
3. Combustion Engineering, Gary L Bormann, WCB Mc Graw Hill, 1998.
4. John. B. Heywood, "Internal Combustion engine fundamentals" McGraw – Hill, 1988.
5. A.F. Williams, combustion in flames, Oxford Press, Second Edition, 1978.
6. S.P. Sharma, Fuels and Combustion, S.P. Chand and Co., Sixth Edition, 1982.
7. S.W. Benson, The Foundations of Chemical Kinetics, McGraw-Hill, 1960.

IC7012 HOMOGENEOUS CHARGE COMPRESSION IGNITION COMBUSTION IN ENGINES **L T P C 3 0 0 3**

AIM:

This course aims to introduce fundamentals of HCCI and its benefits in IC Engines

OBJECTIVES:

- To develop the knowledge on HCCI combustion and its benefits and applications.

UNIT I HCCI ENGINE FUNDAMENTALS 8

Introduction, HCCI Fundamentals – Background of HCCI, Principle, Benefits, Challenges, Need for control.

UNIT II GASOLINE AND DIESEL HCCI COMBUSTION ENGINES 9

Conventional Gasoline Combustion, Effects of EGR, Techniques to HCCI operation in gasoline engines, Conventional Diesel Combustion, Overview of diesel HCCI engines, Techniques – Early Injection, Multiple injections, Narrow angle direct injection (NADI™) concept.

UNIT III HCCI CONTROL 10

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 characterising fuel performance in HCCI engines.

UNIT IV HCCI FUEL REQUIREMENTS & COMBUSTION WITH ALTERNATIVE FUELS 9

Introduction, Background, Diesel fuel HCCI, HCCI fuel ignition quality, Gasoline HCCI, HCCI fuel Specification, Fundamental fuel factors. Natural gas HCCI engines, CNG HCCI engines, methane/n-butane/air mixtures. DME HCCI engine - chemical reaction model, Combustion completeness, Combustion control system, Method of combining DME and other fuels, 'unmixed-ness' of DME/air mixture.

UNIT V LOW-TEMPERATURE AND PREMIXED COMBUSTION 9

Basic concept, Characteristics of combustion and exhaust emissions, modulated kinetics (MK) combustion – First and Second generation of MK combustion, Emission, performance improvement.

TOTAL: 45 PERIODS

OUTCOME:

- On successful completion of this course the student will be able to understand the concept of HCCI, its benefits and challenges.

REFERENCES

1. Ganesan, V, Internal Combustion Engines, Tata McGraw Hill Book Co., 2003.
2. B.P. Pundir I.C. Engines Combustion and Emission, 2010, Narosa Publishing House.
3. B.P. Pundir, Engine Combustion and Emission, 2011, Narosa Publishing House.
4. Hua Zhao "HCCI and CAI Engines for automotive industry" Wood Head Publishing in Mechanical Engineering, 2007.
5. John B Heywood, " Internal Combustion Engines Fundamentals", McGraw Hill International Edition, 1988.

EY7202 DESIGN AND ANALYSIS OF TURBOMACHINES L T P C
3 0 0 3

AIM:

To design and analyse the performance of Turbo machines for engineering applications

OBJECTIVES:

- To understand the energy transfer process in Turbomachines and governing equations of various forms.
- To understand the structural and functional aspects of major components of Turbomachines.
- To design various Turbomachines for power plant and aircraft applications

UNIT I INTRODUCTION 12

Basics of isentropic flow – static and stagnation properties – diffuser and nozzle configurations - area ratio – mass flow rate – critical properties. Energy transfer between fluid and rotor velocity triangles for a generalized turbomachines - velocity diagrams. Euler's equation for turbomachines and its different forms. Degree of reaction in turbo-machines – various efficiencies – isentropic, mechanical, thermal, overall and polytropic

UNIT II CENTRIFUGAL AND AXIAL FLOW COMPRESSORS 9

Centrifugal compressor - configuration and working – slip factor - work input factor – ideal and actual work - pressure coefficient - pressure ratio. Axial flow compressor – geometry and working – velocity diagrams – ideal and actual work – stage pressure ratio - free vortex theory – performance curves and losses

UNIT III COMBUSTION CHAMBER 9

Basics of combustion. Structure and working of combustion chamber – combustion chamber arrangements - flame stability – fuel injection nozzles. Flame stabilization - cooling of combustion chamber

UNIT IV AXIAL AND RADIAL FLOW TURBINES 9

Elementary theory of axial flow turbines - stage parameters- multi-staging - stage loading and flow coefficients. Degree of reaction - stage temperature and pressure ratios – single and twin spool arrangements – performance. Matching of components. Blade Cooling. Radial flow turbines.

UNIT V GAS TURBINE AND JET ENGINE CYCLES 9

Gas turbine cycle analysis – simple and actual. Reheated, Regenerative and Intercooled cycles for power plants. Working of Turbojet, Turbofan, Turboprop, Ramjet, Scarmjet and Pulsejet Engines and cycle analysis – thrust, specific impulse, specific fuel consumption, thermal and propulsive efficiencies.

TOTAL: 45 PERIODS

OUTCOME:

When a student completes this subject, he / she can

- Understand the design principles of the turbomachines
- Analyse the turbomachines to improve and optimize its performance

REFERENCES:

1. Ganesan, V., Gas Turbines, Tata McGrawHill, 2011.
2. Khajuria P.R and Dubey S.P., Gas Turbines and Propulsive Systems, Dhanpat Rai Publications, 2003
3. Cohen, H., Rogers, G F C and Saravanmotto, H I H, Gas Turbine Theory, John Wiely, 5th Edition 2001.
4. Hill P G and Peterson C R, Mechanics and Thermodynamics of Propulsion, Addition-Wesley, 1970.
5. Mattingly J D, Elements of Gas turbine Propulsion, McGraw Hill, 1st Edition. 1997

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UNIT I VEHICLE STRUCTURE AND ENGINES 10

Layout, Vehicle construction, Chassis, Frame and Body, Engine - types, construction, operation, performance, Air pollution and Pollution standards.

UNIT II ENGINE AUXILIARY SYSTEMS 10

Carburettors, Electronic Fuel Injection Systems – Monopoint, Multipoint and Direct Injection Systems, Electrical Systems – Battery, Generator, Starting Motor, and Ignition (Battery and Electronic Types)

UNIT III TRANSMISSION SYSTEMS 10

Clutch - Types and Construction, Fluid Flywheel and Torque Converter, Gear Boxes, Manual and Automatic - Overdrives – Propeller Shaft - Differential and Rear Axle.

UNIT IV RUNNING SYSTEMS 8

Steering Geometry and Types, Types of front axle, Suspension systems, Braking systems, Wheel and Tyres,

UNIT V ALTERNATIVE POWER PLANT 7

Electric vehicles and Fuel cells – Types, construction, principle of operation and characteristics

TOTAL: 45 PERIODS

TEXT BOOK:

William Crouse, Automobile Engineering ,McGraw Hill, 2012.

REFERENCES:

1. R.B. Gupta, Automobile Engineering, Satya Prakashan, 1993.
2. Newton and Steeds, Motor Vehicles, ELBS, 1985
3. Duffy Smith, Auto Fuel Systems, The Good Heat Willcox Company Inc., 1987