ANNA UNIVERSITY, CHENNAI

UNIVERSITY DEPARTMENTS

REGULATIONS – 2019

CHOICE BASED CREDIT SYSTEM

M.E. INTERNAL COMBUSTION ENGINEERING (FULL – TIME)

THE VISION OF THE DEPARTMENT OF MECHANICAL ENGINEERING

We, at the Department of Mechanical Engineering, Anna University shall strive hard to impart knowledge and state-of-the-art training to our students and expose them to broad areas of Mechanical Engineering, namely Design, Manufacturing, Energy, Thermal Sciences and currently related interdisciplinary areas, so that they can later practice their profession at home or abroad keeping in mind the needs and concern of the society they represent, safeguarding values, ethics and be instrumental in bringing about an overall technological development.

THE MISSION OF THE DEPARTMENT OF MECHANICAL ENGINEERING

1. To deliver knowledge in Mechanical Engineering and Materials Science and Engineering with high educational standards so that the outgoing students are employable and globally competitive.
2. To produce graduate and post graduate engineers with core competency as well as relevant software skills and social responsibility.
3. To be dynamic in imparting knowledge to students depending upon the changing national and International needs

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PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

The Internal Combustion Engineering program seeks to prepare PG students for productive and rewarding careers in the transport and mobility arena. The PEOs are listed below

1. To develop skill and acquire knowledge in modern engine technologies and develop smart future mobility solutions
2. To provide students with a solid foundation in mathematical, scientific and engineering fundamentals required to solve real time problems in engines and mobility science
3. Become a successful entrepreneur and be a part of a supply chain or manufacture engine / mobility solutions for sustainable development.
4. Lead an ethical life by engaging in lifelong learning experiences for developing environmentally benign and economically affordable mobility solutions for a green environment

PROGRAMME OUTCOMES (POs):

On successful completion of the Programme, graduates will possess:

PO #	Graduate Attribute	Programme Outcome
1	Engineering knowledge	Apply knowledge of mathematics, basic science and engineering science.
2	Problem analysis	Identify, formulate and solve engineering problems.
3	Design/development of solutions	Design a system or process to improve its performance, satisfying its constraints.
4	Conduct investigations of complex problems	Conduct experiments & collect, analyze and interpret the data.
5	Modern tool usage	Apply various tools and techniques to improve the efficiency of the system.
6	The Engineer and society	Conduct themselves to uphold the professional and social obligations.
7	Environment and sustainability	Design the system with environment consciousness and sustainable development.
8	Ethics	Interact in industry, business and society in a professional and ethical manner.
9	Individual and team work	Function in a multidisciplinary team.
10	Communication	Proficiency in oral and written Communication.
11	Project management and finance	Implement cost effective and improved system.
12	Life-long learning	Continue professional development and learning as a life-long activity.

MAPPING OF PEOS WITH POS:

PROGRAMME EDUCATIONAL OBJECTIVES	Programme Outcomes											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**P10**	**P11**	**P12**
I	✓	✓		✓						✓	✓	✓
II	✓		✓		✓	✓					✓	✓
III	✓	✓	✓	✓	✓	✓					✓	✓
IV	✓	✓	✓			✓	✓	✓		✓	✓	
V		✓	✓						✓	✓	✓	✓

PROGRAM SPECIFIC OUTCOMES (PSOs):

At the end of the Programme, graduates will have:

1) Knowledge and hands on experience in advanced engine technologies and testing.
2) Upgraded skills to qualify for jobs in the automotive industries, academics and for seeking higher studies.
3) Potential in engine instrumentation and computational flow dynamic studies to qualify for positions in CFD specialized and power train control specialized industries.

MAPPING OF COURSE OUTCOME AND PROGRAMME OUTCOMES

	SUBJECT	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Sem I	Alternate Fuels for IC Engines	√	√	√		√							
	Combustion in Engines	√	√	√		√							
	Advanced Heat Transfer	√	√	√	√	√	√				√		
	Advanced Thermodynamics	√	√	√	√	√							
	Program Elective - I												
	Research Methodology and IPR												
	Audit Course-I												
	Internal Combustion Engines Laboratory	√	√	√	√								
	Applied Thermal Engineering Laboratory	√	√	√	√								
Sem II	Electronic Engine Management Systems	√	√	√	√	√					√		
	Internal Combustion Engine Design	√	√	√	√	√							√
	Instrumentation for Thermal Systems	√		√	√	√	√				√		
	Computational Fluid Dynamics	√	√	√							√		√
	Program Elective-II												
	Program Elective-III												
	Audit Course-II												
	Analysis and Simulation Laboratory for Internal Combustion Engineering	√	√	√	√						√		
	Technical Seminar	√	√	√									
Sem III	Program Elective-IV												
	Program Elective-V												
	Open Elective												
	Technical Seminar	√	√	√					√		√		
	Dissertation-I	√	√	√	√	√			√	√	√	√	√
Sem IV													
	Dissertation-II	√	√	√	√	√			√	√	√	√	√

ELECTIVES	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Automotive Technology	√	√	√		√					√		
Advanced Fluids Engineering	√	√	√	√								√
Simulation of I.C. Engine Processes	√	√	√	√				√		√		√
Solar Energy Technologies	√	√	√		√	√	√	√				√
Aircraft and Space Propulsion	√	√	√	√		√	√	√				
Bio Energy Technologies	√	√	√	√								
Energy Forecasting, Modeling and Project Management												
Hybrid and Electric Vehicles	√			√								√
Combustion and Reaction Kinetics in I.C. Engines	√	√	√	√	√	√		√				
Engine Pollution and Control	√	√	√	√	√							
Hydrogen and Fuel Cell	√	√	√	√	√	√		√		√		√
Boundary Layer Theory and Turbulence	√	√	√	√	√							
Advanced Combustion Concepts in Engines	√	√	√	√	√							
Manufacturing and Testing of Engine Components	√	√	√									
Modelling and Analysis of Energy Systems	√	√	√		√							√
Supercharging and Scavenging	√	√	√	√								
Advanced Energy Storage Technologies	√	√	√	√					√	√		
Environmental Engineering and Pollution Control	√	√	√	√	√	√	√			√	√	√
Electrical Drives and Control	√	√	√	√	√	√	√			√	√	√

ANNA UNIVERSITY, CHENNAI
UNIVERSITY DEPARTMENTS
M.E. INTERNAL COMBUSTION ENGINEERING (FT)
REGULATIONS - 2019
CHOICE BASED CREDIT SYSTEM
CURRICULA AND SYLLABI FOR I TO IV SEMESTERS

SEMESTER I

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	IC5101	Alternate Fuels for IC Engines	PCC	3	0	0	3	3
2.	IC5102	Combustion in Engines	PCC	3	0	0	3	3
3.	IC5151	Advanced Heat Transfer	FC	4	0	0	4	4
4.	IC5152	Advanced Thermodynamics	FC	4	0	0	4	4
5.	RM5151	Research Methodology and IPR	RMC	2	0	0	2	2
6.		Program Elective - I	PEC	3	0	0	3	3
7.		Audit Course – I*	AC	2	0	0	2	0
PRACTICAL								
8.	IC5111	Internal Combustion Engines Laboratory	PCC	0	0	4	4	2
9.	RA5161	Applied Thermal Engineering Laboratory	PCC	0	0	4	4	2
			TOTAL	**21**	**0**	**8**	**29**	**23**

* Audit Course is optional.

SEMESTER II

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	IC5201	Electronic Engine Management Systems	PCC	3	0	0	3	3
2.	IC5202	Internal Combustion Engine Design	PCC	3	0	0	3	3
3.	IC5251	Computational Fluid Dynamics	PCC	3	0	0	3	3
4.	IC5252	Instrumentation for Thermal Systems	PCC	3	0	0	3	3
5.		Program Elective II	PEC	3	0	0	3	3
6.		Program Elective III	PEC	3	0	0	3	3
7.		Audit Course - II*	AC	2	0	0	2	0
PRACTICAL								
8.	IC5211	Analysis and Simulation Laboratory for Internal Combustion Engineering	PCC	0	0	4	4	2
9.	IC5212	Technical Seminar	EEC	0	0	2	2	1
			TOTAL	**20**	**0**	**6**	**26**	**21**

* Audit Course is optional.

SEMESTER III

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.		Program Elective IV	PEC	3	0	0	3	3
2.		Program Elective V	PEC	3	0	0	3	3
3.		Open Elective	OEC	3	0	0	3	3
PRACTICAL								
4.	IC5311	Dissertation - I	EEC	0	0	12	12	6
			TOTAL	**9**	**0**	**12**	**21**	**15**

SEMESTER IV

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
PRACTICAL								
1.	IC5411	Dissertation - II	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL NO. OF CREDITS: 71

FOUNDATION COURSES (FC)

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	IC5152	Advanced Thermodynamics	FC	4	0	0	4	4
2.	IC5151	Advanced Heat Transfer	FC	4	0	0	4	4

PROGRAM CORE COURSE (PCC)

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	IC5101	Alternate Fuels for IC Engines	PCC	3	0	0	3	3
2.	IC5102	Combustion in Engines	PCC	3	0	0	3	3
3.	IC5201	Electronic Engine Management Systems	PCC	3	0	0	3	3
4.	IC5202	Internal Combustion Engine Design	PCC	3	0	0	3	3
5.	IC5252	Instrumentation for Thermal Systems	PCC	3	0	0	3	3
6.	IC5251	Computational Fluid Dynamics	PCC	3	0	0	3	3
7.	IC5111	Internal Combustion Engines Laboratory	PCC	0	0	4	4	2
8.	IC5211	Analysis and Simulation Laboratory for Internal Combustion Engineering	PCC	0	0	4	4	2
9.	RA5161	Applied Thermal Engineering Laboratory	PCC	0	0	4	4	2

PROGRAM ELECTIVE COURSES

SEMESTER I, ELECTIVE I

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	IC5001	Automotive Technology	PEC	3	0	0	3	3
2.	IC5002	Advanced Fluids Engineering	PEC	3	0	0	3	3
3.	IC5003	Simulation of I.C. Engine Processes	PEC	3	0	0	3	3
4.	EY5081	Solar Energy Technologies	PEC	3	0	0	3	3

SEMESTER II, ELECTIVE II

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	IC5004	Aircraft and Space Propulsion	PEC	3	0	0	3	3
2.	EY5072	Bio Energy Technologies	PEC	3	0	0	3	3
3.	EY5075	Energy Forecasting, Modeling and Project Management	PEC	3	0	0	3	3

SEMESTER II, ELECTIVE III

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	IC5005	Hybrid and Electric Vehicles	PEC	3	0	0	3	3
2.	IC5006	Combustion and Reaction Kinetics in I.C. Engines	PEC	3	0	0	3	3
3.	IC5007	Engine Pollution and Control	PEC	3	0	0	3	3
4.	EY5077	Hydrogen and Fuel Cells	PEC	3	0	0	3	3

SEMESTER III, ELECTIVE IV

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	IC5008	Boundary Layer Theory and Turbulence	PEC	3	0	0	3	3
2.	IC5009	Advanced Combustion Concepts in Engines	PEC	3	0	0	3	3
3.	IC5010	Manufacturing and Testing of Engine Components	PEC	3	0	0	3	3
4.	EY5078	Modeling and Analysis of Energy Systems	PEC	3	0	0	3	3

SEMESTER III, ELECTIVE V

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	IC5011	Supercharging and Scavenging	PEC	3	0	0	3	3
2.	EY5071	Advanced Energy Storage Technologies	PEC	3	0	0	3	3
3.	EY5076	Environmental Engineering and Pollution Control	PEC	3	0	0	3	3
4.	EY5073	Electrical Drives and Controls	PEC	3	0	0	3	3

RESEARCH METHODOLOGY AND IPR COURSES (RMC)

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	RM5151	Research Methodology and IPR	RMC	2	0	0	2	2

OPEN ELECTIVE COURSES [OEC]

(Out of 6 Courses one Course must be selected)

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	OE5091	Business Data Analytics	OEC	3	0	0	3	3
2.	OE5092	Industrial Safety	OEC	3	0	0	3	3
3.	OE5093	Operations Research	OEC	3	0	0	3	3
4.	OE5094	Cost Management of Engineering Projects	OEC	3	0	0	3	3
5.	OE5095	Composite Materials	OEC	3	0	0	3	3
6.	OE5096	Waste to Energy	OEC	3	0	0	3	3

AUDIT COURSES (AC)

Registration for any of these courses is optional to students

SL. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS
			L	T	P	
1.	AX5091	English for Research Paper Writing	2	0	0	0
2.	AX5092	Disaster Management	2	0	0	0
3.	AX5093	Sanskrit for Technical Knowledge	2	0	0	0
4.	AX5094	Value Education	2	0	0	0
5.	AX5095	Constitution of India	2	0	0	0
6.	AX5096	Pedagogy Studies	2	0	0	0
7.	AX5097	Stress Management by Yoga	2	0	0	0
8.	AX5098	Personality Development Through Life Enlightenment Skills	2	0	0	0
9.	AX5099	Unnat Bharat Abhiyan	2	0	0	0

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	IC5212	Technical Seminar	EEC	0	0	2	2	1
2.	IC5311	Dissertation - I	EEC	0	0	12	12	6
3.	IC5411	Dissertation - II	EEC	0	0	24	24	12

IC5101	ALTERNATE FUELS FOR IC ENGINES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES :

1 To expose potential alternate fuels and their characteristics
2 To use appropriate synthetic fuels and fuel additives for better combustion characteristics
3 To utilise alcohol fuels effectively for lower emissions
4 To elaborate on the utilisation of Bio-Diesel and its types as a suitable fuel in CI engines
5 To utilise different gaseous fuels and predict their performance and combustion characteristics

UNIT I INTRODUCTION 9

Availability, Suitability, Properties, Merits and Demerits of Potential Alternative Fuels – Alcohols, Bio-Diesel, Hydrogen, Liquefied Petroleum Gas, Natural Gas, Biogas, Fuel standards – ASTM & EN.

UNIT II SPECIAL AND SYNTHETIC FUELS 9

Different synthetic fuels, Merits and demerits, Dual, Bi-fuel and Pilot injected fuel systems, Fuel additives – types and their effect on performance and emission characteristics of engines, Flexi-fuel systems, Ethers - as fuel and fuel additives, properties and characteristics.

UNIT III ALCOHOL FUELS 9

Alcohols – Properties, Production methods and usage in engines. Blending, dual fuel operation, surface ignition, spark ignition and oxygenated additives. Performance, combustion and emission Characteristics in engines. Issues & limitation in alcohols

UNIT IV BIO-DIESEL FUELS 9

Vegetable oils and their important properties. Fuel properties characterization. Methods of using vegetable oils – Blending, preheating, Transesterification and emulsification – Performance, combustion and emission Characteristics in diesel engines. Third generation biofuels, Ternary and Quaternary fuels, Issues & limitation of using vegetable oils in IC engines

UNIT V GASEOUS FUELS 9

Biogas, Natural gas, LPG, Hydrogen – Properties, problems, storage and safety aspects. Methods of utilisation in engines. Performance, combustion and emission Characteristics in engines. Issues & limitation in Gaseous fuels

TOTAL:45 PERIODS

COURSE OUTCOMES :

The students will be able to

1 potential alternate fuels and their characteristics
2 use appropriate synthetic fuels and fuel additives for better combustion characteristics
3 utilise alcohol fuels effectively for lower emissions
4 elaborate on the utilisation of Bio-Diesel and its types as a suitable fuel in CI engines
5 utilise different gaseous fuels and predict their performance and combustion characteristics

REFERENCES:

1. Keith Owen and Trevor Eoley, Automotive Fuels Handbook, SAE Publications,1990.
2. Pundir B.P , I.C. Engines Combustion and Emission, 2010, Narosa Publishing House.
3. Pundir B.P , Engine Combustion and Emission, 2011, Narosa Publishing House Keith
4. Richard L. Bechtold, Automotive Fuels Guide Book, SAE Publications, 1997

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.9						0.6					0.3	0.9	0.6	0.3
2	0.9	0.6	0.6	0.6	0.3	0.3	0.6				0.6	0.6	0.6	0.9	
3	0.3	0.3	0.3	0.3	0.6			0.3	0.6		0.9				0.9
4	0.3	0.3		0.3	0.3			0.3	0.3		0.9	0.6		0.6	
5	0.3					0.6	0.9	0.3			0.6	0.3	0.9		

IC5102 COMBUSTION IN ENGINES L T P C
3 0 0 3

COURSE OBJECTIVES

1. To make familiar with the design and operating characteristics of engines
2. To understand the basic principles of combustion
3. To gain knowledge in the principles of SI engine combustion
4. To understand the concepts of CI engine system
5. To understand the basic concepts of gas turbine combustion and the latest technological advances in low temperature combustion

UNIT I ENGINE BASICS 9

Principles of Engine operation – Torque and Power Characteristics – Intake and Exhaust Flows – Fuel Characteristics – ISO standards (Qualitative treatment only) Balancing, valve trains

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 COMBUSTION IN GAS TURBINES & LOW TEMPERATURE I.C. ENGINE COMBUSTION CONCEPTS 9

Requirements - Combustion process – combustion chamber configurations – Flame stabilization – Design consideration of combustor – Factors affecting combustor performance – Emission and its control, Afterburners.

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.

COURSE OUTCOMES

1. Given an engine design specification, predict performance and fuel economy trends
2. Apply basic concepts in the design of combustion systems
3. Able to design SI engine system
4. Develop an understanding of real world diesel engine design issues
5. Develop an ability to optimize future engine design for better fuel economy, performance and emissions

TOTAL:45 CREDITS

REFERENCES

1. Cohen, H, Rogers, G, E.C, and Saravanamuttoo, H.I.H., Gas Turbine Theory, Longman Group Ltd., 1980.
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. Rajput R.K. Internal Combustion Engines, Laxmi Publications (P) Ltd, 2006.

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.9	0.6	0.9	0.6	0.3	0.6	0.3	0.6	0.9	0.3	0.6	0.9	0.9	0.6	0.6
2	0.6	0.9	0.6	0.9	0.3	0.6	0.6	0.3	0.3	0.6	0.3	0.6	0.6	0.3	0.3
3	0.3	0.6	0.3	0.9	0.9	0.6	0.3	0.3	0.3	0.3	0.3	0.9	0.6	0.3	0.6
4	0.3	0.6	0.6	0.3	0.9	0.3	0.9	0.6	0.3	0.3	0.3	0.3	0.6	0.3	0.3
5	0.3	0.3	0.9	0.3	0.3	0.3	0.3	0.3	0.6	0.3	0.3	0.3	0.3	0.3	0.3

IC5151 ADVANCED HEAT TRANSFER

L	T	P	C
4	0	0	4

COURSE OBJECTIVES:

1. To impart knowledge on conduction heat transfer associated with Radiation.
2. To impart knowledge on the turbulent forced convective heat transfer.
3. To impart knowledge on the significance of Phase Change Heat Transfer and Mass Transfer.
4. To teach the heat exchanger design aspects including compact heat exchangers.
5. To impart knowledge on Mass transfer as an engineering phenomenon.

UNIT – I CONDUCTION AND RADIATION HEAT TRANSFER 12

One dimensional energy equations and boundary condition - three-dimensional heat conduction equations - extended surface heat transfer - 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 12

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 12

Condensation with shears edge on bank of tubes - boiling – pool and flow boiling - heat Transfer Enhancement Techniques.

UNIT – IV HEAT EXCHANGERS **12**

Heat Exchanger – Ɛ- NTU approach and design procedure – compact heat exchangers – Plate heat exchangers – Heat pipes – Mini and Micro Channel heat exchangers, Heat transfer correlations for specific cases.

UNIT – V MASS TRANSFER **12**

Mass transfer - vaporization of droplets - combined heat and mass transfers applications – Cooling Towers, Evaporative condensers, solar pond, Cooling and dehumidification systems.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

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

1. Analyse problems on heat transfer associated with conduction and convection and radiation through vapors and gases**.**
2. Analyse problems on turbulent heat transfer and also solve high speed flow problems.
3. Analyse problems on phase change heat transfer.
4. Estimate the performance of compact heat exchangers and also understand the use of correlations to predict heat transfer from specific devices
5. Understand and analyse the mass transfer associated with heat transfer in engineering systems

REFERENCES:

1. Amir Faghri, Yuwen Zhang and John R. Howell, Advanced Heat and Mass Transfer, Global Digital Press, 2010
2. Ghoshdastidar. P.S., Heat Transfer, Oxford University Press, 2004
3. Holman.J.P, Heat Transfer, Tata McGraw Hill, 2002.
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. Ozisik. M.N., Heat Transfer – A Basic Approach, McGraw-Hill Co., 1985
7. Yadav, R., Heat and Mass Transfer, Central Publishing House, 1995.
8. YunusA.Cengal, Heat and Mass Transfer – A practical Approach, 3rd edition, Tata McGraw - Hill, 2007.

PO & PSO Mapping:

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.9	0.6		0.3									0.9	0.6	0.3
2	0.9	0.6		0.3									0.9	0.6	0.3
3	0.9	0.6		0.3									0.9	0.6	0.3
4	0.9	0.6		0.3									0.9	0.6	0.3
5	0.9	0.6		0.3									0.9	0.6	0.3

IC5152 **ADVANCED THERMODYNAMICS** **L T P C**
4 0 0 4

COURSE OBJECTIVES:

- To demonstrate the use of correlations for the important properties.
- To achieve an understanding of real gas equations and multi component systems.
- To predict the availability and irreversibility associated with the thermodynamic processes and Chemical availability of reactive systems.
- To introduce phase equilibrium concept for pure substance and mixtures.
- To apply the first and second law of thermodynamics to reactive systems.

UNIT I THERMODYNAMIC PROPERTY RELATIONS 12

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 Thermodyanmic 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.

UNIT III CHEMICAL AVAILABILITY 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 system and control volume, Environmental state, Fuel Chemical availability, Evaluation of 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 K_P and K_f, Equilibrium composition evaluation of ideal gas and real gas mixtures

COURSE 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. K.Annamalai, I.K.Puri, M.A.Jog, Advanced Thermodynamics Engineering, Second Edition, CRC Press, 2011.
3. Advanced Thermodynamics, S.S. Thipse, Narosa Publishing Home Pvt. Ltd., 2013
4. Yunus A. Cengel and Michael A. Boles, Thermodynamics, McGraw-Hill Inc., 2006.
5. B.P. Pundir, I.C. engine combustion and emissions. Bejan, A., Advanced Engineering Thermodynamics, John Wiley and Sons, 1988.
6. Holman,J.P., Thermodynamics, Fourth Edition, McGraw-Hill Inc., 1988.

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.9	0.6		0.3									0.9	0.6	0.3
2	0.9	0.6		0.3									0.9	0.6	0.3
3	0.9	0.6		0.3									0.9	0.6	0.3
4	0.9	0.6		0.3									0.9	0.6	0.3
5	0.9	0.6		0.3									0.9	0.6	0.3

RM5151 RESEARCH METHODOLOGY AND IPR L T P C
2 0 0 2

COURSE OBJECTIVES:

To impart knowledge and skills required for research and IPR:

- Problem formulation, analysis and solutions.
- Technical paper writing / presentation without violating professional ethics
- Patent drafting and filing patents.

UNIT I RESEARCH PROBLEM FORMULATION 6

Meaning of research problem- Sources of research problem, criteria characteristics of a good research problem, errors in selecting a research problem, scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, necessary instrumentations

UNIT II LITERATURE REVIEW 6

Effective literature studies approaches, analysis, plagiarism, and research ethics.

UNIT III TECHNICAL WRITING /PRESENTATION 6

Effective technical writing, how to write report, paper, developing a research proposal, format of research proposal, a presentation and assessment by a review committee.

UNIT IV INTRODUCTION TO INTELLECTUAL PROPERTY RIGHTS (IPR) 6

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

UNIT V INTELLECTUAL PROPERTY RIGHTS (IPR) 6

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases.Geographical Indications. New Developments in IPR: Administration of Patent System, IPR of Biological Systems, Computer Software etc.
Traditional knowledge Case Studies, IPR and IITs.

TOTAL: 30 PERIODS

COURCE OUTCOMES:

1. Ability to formulate research problem
2. Ability to carry out research analysis
3. Ability to follow research ethics
4. Ability to understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity
5. Ability to understand about IPR and filing patents in R & D.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓										
CO2	✓											
CO3	✓							✓				
CO4	✓				✓							
CO5	✓					✓						✓

REFERENCES:

1. Asimov, “Introduction to Design”, Prentice Hall, 1962.
2. Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd ,2007.
3. Mayall, “Industrial Design”, McGraw Hill, 1992.
4. Niebel, “Product Design”, McGraw Hill, 1974.
5. Ranjit Kumar, 2nd Edition, “Research Methodology: A Step by Step Guide for beginners” 2010

IC5111 INTERNAL COMBUSTION ENGINES LABORATORY L T P C
0 0 4 2

COURSE OBJECTIVES:

- To impart the knowledge on the practical aspects of Internal Combustion Engine Systems
- To impart the knowledge on the advanced engine technologies
- To understand the combustion, performance and emission behaviour of SI and CI engine system at different load and speed conditions
- To understand the behaviour of engine system at different operating conditions
- To understand the influence of after treatment system on emission reduction form engine systems
- To know the measurement of important fuel properties and its role

LIST OF EXPERIMENTS

1. Disassembly and Assembly of engines
2. Study of advanced diesel and gasoline engine technology engines
3. Study and drawing of engine components with dimensions.
4. Experimental investigation of combustion, performance and emission characteristics of spark ignition engine.
5. Experimental investigation of combustion, performance and emission characteristics of compression ignition engine
6. Determination of volumetric efficiency and equivalence ratio in a single cylinder D.I. Diesel engine.
7. Experimental study on the effect of fuel injection pressure on CI engine performance, combustion and emission characteristics.
8. Experimental study on the effect of fuel injection timing on CI engine performance, combustion and emission characteristics.
9. Experimental study on the effect of preheating air and fuel on engine performance, combustion and emission characteristics.
10. Performance evaluation of After Treatment Systems
11. Determination of Flash and Fire point of various fuel blends.
12. Determination of Viscosity of various fuel blends.

LABORATORY REQUIREMENTS

1. Single or Multi Cylinder SI and CI Engine for disassembly and assembly
2. Engine Components for drawing and dimensioning
3. Single/ Multi-Cylinder S.I. Engine Test Rig with combustion and emission measurement facility
4. Single/ Multi-Cylinder C.I. Engines Test Rig with combustion and emission measurement facility
5. Exhaust Gas Analyser (To measure HC, CO, NOx, O_2, CO_2)
6. Smoke Meter
7. In cylinder Pressure Transducers, Charge Amplifiers, and crank angle encoders/crank sensor module with high speed data acquisition system
8. Open cup or Closed cup Flash and Fire Point Apparatus
9. Viscometer

COURSE OUTCOMES:

- Understand the various components of engine, its function, assembling of engine parts and working of advanced engine technologies
- Understand the procedures of conducting performance, combustion and emission test on engines and its significance
- Understand the method of calculating the volumetric efficiency and fuel-air ratio of an engine
- Understand the effect of various operating parameters of the engine on combustion, performance and emissions
- Understand the methods of calculating flash point, fire point and viscosity of the various oil samples
- Understand the role of after treatment systems on reducing engine out emissions

TOTAL: 60 PERIODS

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	✓	✓	✓	✓			✓		✓			✓			
2	✓	✓	✓	✓		✓									
3	✓	✓	✓	✓	✓	✓		✓				✓			
4	✓	✓	✓	✓	✓		✓								
5	✓	✓	✓	✓	✓					✓	✓				

RA5161 APPLIED THERMAL ENGINEERING LABORATORY

L	T	P	C
0	0	4	2

COURSE OBJECTIVES

1. To educate the students on the realities of thermal engineering.
2. To educate the students about calibration and its essentiality in thermal systems.

LIST OF EXPERIMENTS

1. Experimental Studies on Thermal Boundary Layer for different geometries.
2. Calibration of Temperature Transducers (Thermocouple, RTD & Thermistors).
3. Calibration of Pressure Transducers.
4. Experimental Analysis of Organic Rankine Cycle.
5. Fluid and Thermal Transfer Properties of Liquid Fuels / Heat Transfer Fluids.

6. Experimental Studies on Pool Boiling of Water using Flow Visualization Technique.
7. Flow Characteristic occurrence between Bodies in Wind Tunnel.
8. Experimental Studies on Fluidization of Solid Fuels.
9. Studies on Absorption Refrigeration System.
10. Experimental Studies on Drying of Agro Products.
11. Determining the Actual p-v Diagram of an IC Engine.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

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

1. Plot the error curve and correction curve for different measuring instruments.
2. Analyze the critical/influential properties of thermal systems.

PO & PSO Mapping:

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.9	0.9	0.6	0.6	0.6				0.6			0.6	0.9	0.6	
2	0.9	0.9	0.6	0.6	0.6				0.6			0.6	0.9	0.6	

IC5201 ELECTRONIC ENGINE MANAGEMENT SYSTEMS L T P C
3 0 0 3

COURSE OBJECTIVES

1. To provide basic grounding on electronics
2. To learn the various sensors used in engine management systems
3. Give an overview of different types of ignition systems
4. To understand the significance of gasoline injection systems
5. To know the latest advancements in Diesel injection systems

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 8

Sensors - Camshaft Position, Crank Position, Throttle Position, Air flow, Pressure, Temperature, Speed, Exhaust gas Oxygen, Knock and Oxides of nitrogen, Principle of operation, construction and characteristics. Actuators – Intake throttle valves Pneumatic, EGR Valve, Waste Gate, Brushless DC motor and stepper motor, calibration of Electronic sensors and actuators.

UNIT III IGNITION SYSTEMS 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, 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

1. Learn the application of electronics in engine management systems
2. Able to choose the types of sensors
3. Decide on the type of ignition systems to be employed for different applications
4. Able to design gasoline injection systems
5. 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												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.9						0.6					0.3	0.9	0.6	0.3
2	0.9	0.6	0.6	0.6	0.3	0.3	0.6				0.6	0.6	0.6	0.9	
3	0.3	0.3	0.3	0.3	0.6			0.3	0.6		0.9				0.9
4	0.3	0.3		0.3	0.3			0.3	0.3		0.9	0.6		0.6	
5	0.3					0.6	0.9	0.3			0.6	0.3	0.9		

IC5202 INTERNAL COMBUSTION ENGINE DESIGN L T P C
3 0 0 3

COURSE OBJECTIVES:

To impart the basic engine design skills to the learners such that there is seamless transition to advanced design concepts
To provide the basic grounding on the piston engine design philosophy
To provide knowledge for the design of engine components
To provide the knowledge about design philosophy of engine subsystems
To enable the student to use CAD for preparing production drawings

UNIT I GENERALIA 5

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

UNIT II DESIGN OF MAJOR COMPONENTS 12

Piston system, Power Cylinder System, Connecting rod assembly, Crankshaft system, Valve Gearing, Stress analyses.

UNIT III DESIGN OF OTHER COMPONENTS / SUBSYSTEMS 12

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 6

Preparation of working drawings of designed components using CAD system.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The student will be able to

1. Select appropriate material for the engine components based on the functional requirements
2. Design engine components such as piston, connecting rod, crank shaft, and valves.
3. Design cylinder block, cylinder head, flywheels and subsystems
4. Design the ports and components for two stroke engines
5. Translate the design in to drawings/models.

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.9	0.9	0.6				0.3								
2	0.9	0.9	0.9	0.9											
3	0.9	0.9	0.9	0.9											
4	0.9	0.9	0.9	0.9											
5					0.9					0.9					

REFERENCES:

1. Design and Simulation of Four-Stroke Engines, Gordon P. Blair, Society of Automotive Engineers, Inc., USA, 1999.
2. Diesel Engine Reference Book, Second Edition, Bernard Challen and Rodica Baranescu (Editors), Butterworth-Heinemann, UK, 1999.
3. Internal Combustion Engine Design, A. Kolchin and V. Demidov, MIR Publishers, Moscow, 1984.
4. Internal Combustion Engine Handbook: Basics, Components, Systems and Perpectives, Richard van Basshuysen and Fred Schaefer (Editors), SAE International, USA and Siemes VDO Automotive, Germany, 2002.
5. Introduction to Engine Valve trains, Yushu Wang, SAE International, USA, 2007.
6. Vehicular Engine Design, Kevin L. Hoag, SAE International USA / Springer – Verlag, Wien, Austria, 2006.

IC5251	COMPUTATIONAL FLUID DYNAMICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- This course aims to introduce numerical modeling and its role in the field of heat, fluid flow and combustion 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.
- To develop finite volume discretised forms of the governing equations for diffusion processes.
- To develop finite volume discretised forms of the convection-diffusion processes.
- To develop pressure based algorithms for flow processes.
- To introduce various turbulence models, Large Eddy Simulation and Direct Numerical Simulation.

UNIT – I GOVERNING DIFFERENTIAL EQUATIONS AND DISCRETISATION TECHNIQUES 8

Basics of Heat Transfer, Fluid flow – Mathematical description of fluid flow and heat transfer – Conservation of mass, momentum, energy and chemical species - Classification of partial differential equations – Initial and Boundary Conditions – Discretisation techniques using finite difference methods – Taylor's Series - Uniform and non-uniform Grids, Numerical Errors, Grid Independence Test.

UNIT – II DIFFUSION PROCESSES : FINITE VOLUME METHOD 10

Steady one-dimensional diffusion, Two and three dimensional steady state diffusion problems, Discretisation of unsteady diffusion problems – Explicit, Implicit and Crank-Nicholson's schemes, Stability of schemes.

UNIT – III CONVECTION-DIFFUSION PROCESSES : FINITE VOLUME METHOD 9

One dimensional convection – diffusion problem, Central difference scheme, upwind scheme – Hybrid and power law discretization techniques – QUICK scheme.

UNIT – IV FLOW PROCESSES : FINITE VOLUME METHOD 8

Discretisation of incompressible flow equations – Pressure based algorithms, SIMPLE, SIMPLER & PISO algorithms.

UNIT – V TURBULENCE MODELS 10

Turbulence – RANS equation - Algebraic Models, One equation model, Two equation models – k – □ & standard k – ϵ model, Low Reynold number models of k- ϵ, Large Eddy Simulation (LES), Direct Numerical Simulation (DNS) - Introduction. Solving simple cases using standard CFD codes.

TOTAL:45 PERIODS

COURSE OUTCOMES:

On successful completion of this course the students will be able to:

- Analyse the governing equations and boundary conditions.
- Analyse various discretization techniques for both steady and unsteady diffusion problems.
- Analyse the various convection-diffusion problems by Finite-Volume method.
- Analyse the flow processes by using different pressure bound algorithms.
- Select and use the different turbulence models according to the type of flows.

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.

0.3- Low 0.6- Medium 0.9- High

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.9						0.6					0.3	0.9	0.6	0.3
2	0.9	0.6	0.6	0.6	0.3	0.3	0.6				0.6	0.6	0.6	0.9	
3	0.3	0.3	0.3	0.3	0.6			0.3	0.6		0.9				0.9
4	0.3	0.3		0.3	0.3			0.3	0.3		0.9	0.6		0.6	
5	0.3					0.6	0.9	0.3			0.6	0.3	0.9		

IC5252 INSTRUMENTATION FOR THERMAL SYSTEMS

L	T	P	C
3	0	0	3

COURSE OBJECTIVES :

1 To expose students to basic characteristics of measurement parameters
2 To enable the students use appropriate measurement system for various applications
3 To enable the students to measure thermo physical properties of solids and fuels
4 To elaborate the students on the need, types of control systems and components of a control system
5 To design a suitable control system for various thermal systems

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, and radiation properties of surfaces

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 :

The students will be able to

1 Understand the fundamental concepts of measurement parameters
2 Select the suitable type of sensor for a measuring a fundamental parameter
3 Use appropriate devices to measure different properties of solids and fuels
4 Distinguish between measurement and control systems, and use appropriate control system for an application
5 Construct a complete control system for a thermal application

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) Morris.A.S, Principles of Measurements and Instrumentation, Prentice Hall of India, 1998.
5) Nakra, B.C., Choudhry K.K., Instrumentation, Measurements and Analysis Tata McGraw Hill, NewDelhi, Second Edition 2003
6) Norman A. Anderson, Instrumentation for Process Measurement and Control, Third Edition, CRC Press,1997
7) Venkatesan S.P, Mechanical Measurements, Ane Publications, Second edition, 2015.

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.9						0.6					0.3	0.9	0.6	0.3
2	0.9	0.6	0.6	0.6	0.3	0.3	0.6				0.6	0.6	0.6	0.9	
3	0.3	0.3	0.3	0.3	0.6			0.3	0.6		0.9				0.9
4	0.3	0.3		0.3	0.3			0.3	0.3		0.9	0.6		0.6	
5	0.3					0.6	0.9	0.3			0.6	0.3	0.9		

IC5211 ANALYSIS AND SIMULATION LABORATORY FOR INTERNAL COMBUSTION ENGINEERING

L	T	P	C
0	0	4	2

COURSE OBJECTIVE:

Use of standard application software for solving engine flow and combustion problems

1. Engine intake flow analysis using different Port shapes
2. Engine exhaust flow analysis
3. Engine in-cylinder cold flow analysis for the given engine sector model
4. Fuel spray studies
5. Combustion and emission analysis
6. Engine hood cooling analysis

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 Gambit, Star-CD es-ice, Star-CD enabled CFM, CCM+,DARS BASIC, DARS CFD, STAR-CDEquation solving software like Matlab, Engg equation solver
2. Every students in a batch must be provided with a terminal
3. Hardware is compatible with the requirement of the above software.

TOTAL: 60 PERIODS

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	0.9	0.9	0.6	0.6	0.6				0.6			0.6	0.9	0.6	
2	0.9	0.9	0.6	0.6	0.6				0.6			0.6	0.9	0.6	

IC5212 TECHNICAL SEMINAR

L	T	P	C
0	0	2	1

COURSE 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 overhead projectors, power point presentation and demonstrative models.

TOTAL: 30 PERIODS

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	0.9	0.9	0.6	0.6	0.6				0.6			0.6	0.9	0.6	
2	0.9	0.9	0.6	0.6	0.6				0.6			0.6	0.9	0.6	

IC5311 **DISSERTATION - I** **L T P C**
0 0 12 6

COURSE OBJECTIVES:

- A research project topic may be selected either from published lists or from the creative ideas of the students themselves in consultation with their project supervisor.
- To improve the student research and development activities.

EVALUATION

Project work evaluation is based on Regulations of Credit system University Departments - Post graduate programmes of Anna University

TOTAL : 90 PERIODS

COURSE OUTCOME:

The students' would apply the knowledge gained from theoretical and practical courses in solving problems, so as to give confidence to the students to be creative, well planned, organized, coordinated in their project work phase – II.

IC5411 **DISSERTATION - II** **L T P C**
0 0 24 12

COURSE OBJECTIVES :

- The objective of the research project work is to produce factual results of their applied research idea in the thermal Engineering, from phase – I.
- 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 Division.
- 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 Division based on oral presentation and the project report
- To improve the student research and development activities.

EVALUATION

- Project work evaluation is based on Regulations of Credit system University Departments - Post graduate programmes of Anna University

TOTAL = 180 PERIODS

COURSE OUTCOME :

The students' would apply the knowledge gained from theoretical and practical courses in solving problems, so as to give confidence to the students to be creative, well planned, organized, coordinated project outcome of the aimed work.

IC5001	AUTOMOTIVE TECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To distinguish different types of chassis, frames and body and its component design.
- To introduce the concept of aerodynamics in automobiles.
- To estimate the forces acting on vehicle during turning and acceleration.
- To identify various safety technologies incorporated in automobiles.
- To introduce the need for alternative power plants and its types.

UNIT I VEHICLE STRUCTURE 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 AUTOMOTIVE AERODYNAMICS 9

Automobile drag and types. Types of forces and moments – drag coefficient of automobiles – low drag profiles. Drag reduction techniques in cars and trucks. Wind Tunnel Testing & Measurement of Drag.

UNIT III VEHICLE DYNAMICS 9

Vehicle Dynamics – Steady state handling characteristics, Types of forces acting on a vehicle body, Roll centre, Roll axis, Vehicle under side forces, Calculation of Maximum acceleration, Reaction forces for different drives, Stability Control.

UNIT IV SAFETY TECHNOLOGIES 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

UNIT V ALTERNATIVE POWER PLANT 9

Need for Alternative power plants, Types of Hybrid Electric Vehicles – Series, parallel, split – parallel, series – parallel, Advantages and Disadvantages. Electric Vehicles – Classification and its characteristics. Power split device – Energy management system - Batteries, Fuel cells – Types, construction, principle of operation and characteristics.

TOTAL : 45 PERIODS

COURSE OUTCOMES :

On successful completion of the course, the students will be able to:

1. Categorise various vehicles based on its chassis, body and know how vehicle testing is carried out.
2. Compute drag coefficients and recognise the need for drag reduction in automobiles.
3. Determine the various forces acting on the automobile and its effect while in motion.
4. Recognise the various safety technologies incorporated in automobiles and their pros and cons.
5. Distinguish the working of various alternate power plants for automobiles.

REFERENCES:

1. Joseph Heitner, “Automotive Mechanics”, 2nd Edition, CBS, 2006.
2. William H. Crouse, Donald L. Anglin, Automotive Mechanics, 10th Edition, McGraw Hill Education (India) Private Limited, 2006.
3. Heinz Heisler, “ Advanced Vehicle Technology”, Butterworth-Heinemann, 2002
4. R.B. Gupta, Automobile Engineering, Satya Prakashan, 1993.
5. Hans B Pacejka, Tyre and Vehicle Dynamics, 2nd edition, SAE International, 2005
6. John C. Dixon, Tyres, Suspension, and Handling, 2nd Edition, Society of Automotive Engineers Inc, 1996
7. William B. Ribbens -Understanding Automotive Electronics, 5th edition- Butter worth Heinemann,1998
8. Hucho, W.H., Aerodynamics of Road vehicles, Butterworths Co Ltd., 4th Edition, SAE, 1998.
9. Iqbal Husain, Electric and Hybrid Vehicles, Design Fundamentals, CRC Press,2003.
10. M. Ehsani, Y. Gao, S. Gay and A. Emadi, Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, CRC Press, 2005.

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.9	-	-	-	-	-	0.6	-	-	-	-	0.3	0.9	0.6	0.3
2	0.9	0.6	0.6	0.6	0.3	0.3	0.6	-	-	-	0.6	0.6	0.6	0.9	-
3	0.3	0.3	0.3	0.3	0.6	-	-	0.3	0.6	-	0.9	-	-	-	0.9
4	0.3	0.3	-	0.3	0.3	-	-	0.3	0.3	-	0.9	0.6	-	0.6	-
5	0.3	-	-	-	-	0.6	0.9	0.3	-	-	0.6	0.3	0.9	-	-

IC5002 ADVANCED FLUIDS ENGINEERING

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

1) To introduce the concept of different types of fluid flow and its characteristics.
2) To model flows using analytical techniques.
3) To introduce the effect of boundary layers on a flow and its effect on the flow properties.
4) To distinguish the effects of pressure waves, flame propagation and special types of flow in engine.
5) To introduce different methods of flow visualisation techniques with its instrumentation.

UNIT I INTRODUCTION TO FLUID FLOW 9

Lagrangian and Eulerian approach, Newtonian Fluids, Non-Newtonian fluids, stokes’ law of viscosity, Navier – Stokes Equations, Compressible and Incompressible Flows, Ideal flows and Boundary layer flows – Introduction, Effect of swirl, squish and tumble flows in mixing of fuel and air. Characteristics of Low, Moderate and High Reynold number flows.

UNIT II POTENTIAL FLOW 9

Stream lines, Path lines, streak lines and time lines, Stream function and Velocity Potential function – Source, Sink and Doublet. Combination of flows - Rankine half body, Rankine full body, Vorticity, Rotational and Irrotational flows, Flow past a cylinder.

UNIT III BOUNDARY LAYERS 9

Laminar Boundary Layers – Approximate Integral Methods, Asymptotic Expansions and Triple Deck theory, 3D laminar boundary layer, unsteady boundary layers and Turbulent Boundary Layers. Velocity Profiles, Turbulent boundary layer on a flat plate, Turbulence Modelling – Introduction, Free Turbulence of Jets, wakes and mixing layers.

UNIT IV COMPRESSIBLE FLOW AND SPEICAL FLOWS 9

Compressible flow – Introduction, stagnation state, Finite pressure waves – effect on engine, Hagen – Poiseuille Flow and Couette Flow – applications in engine.

UNIT V FLOW VISUALISATION 9

Instrumentation - Schilieren photography – Laser Velocimetry – Illuminated Particle Visualisation Holography – Particle Image Velocimetry. Other Cold flow and combustion visualisation techniques. Numerical flow visualisation – Introduction.

TOTAL : 45 PERIODS

COURSE OUTCOMES :

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

1) Use different approximations for the flow problem under consideration.
2) Model basic flows and develop codes for numerical flow visualization
3) Apply the concepts of viscous fluid flow for prediction of thickness of boundary layer and to predict overall flow characteristics.
4) Analyse compressible flow in engine like compression, knocking.
5) Select different flow visualisation techniques required for their experiments.

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. J.P. Holman, Experimental Methods for Engineers, McGraw – Hill Inc., 2001.
8. Wolfgang Merzkirch, Flow Visualisation, 2nd Edition, Academic Press, 1987.
9. Marshall B. Long, Optical Methods in flow and Particle Diagnosis, Society of Photo Optics, 1989.
10. B.H. Lakshmana Gowda, A Kaleidoscopic view of Fluid Flow Phenomena, Wiley Eastern, 1992.
11. Will Schroeder, Ken Martin and Bill Lorensen, An Object – Oriented Approach to 3D Graphics, 2ndEdition, Prentice Hall, 1998.

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.6	-	-	-	0.6	-	0.9	-	0.3	-	-	0.6	0.9	-	-
2	0.6	0.6	0.9	-	-	0.6	0.6	-	-	-	0.3	0.6	0.9	-	-
3	0.6	0.6	0.9	0.6	-	-	0.3	-	-	-	0.6	0.6	0.9	0.6	-
4	0.6	0.6	0.9	0.6	-	-	0.3	-	-	-	0.6	0.6	0.9	0.3	-
5	0.6	0.6	0.9	0.6	-	-	0.3	-	-	-	0.6	0.6	0.9	0.3	-

IC5003 SIMULATION OF I.C. ENGINE PROCESSES L T P C
3 0 0 3

COURSE OBJECTIVES:

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

COURSE 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.

EY5081	SOLAR ENERGY TECHNOLOGIES	L	T	P	C
		3	0	0	3

OBJECTIVES:

1. To learn and study the solar radiation and various solar collectors
2. To study the various solar thermal energy technologies and their applications
3. To learn about various solar PV cell materials and conversion techniques
4. To learn various Solar SPV systems designs and their applications
5. To know about various solar passive building techniques for cooling and heating applications

UNIT I SOLAR RADIATION AND COLLECTORS 9

Solar angles – Sun path diagrams – Radiation - extraterrestrial characteristics - measurement and estimation on horizontal and tilted surfaces - flat plate collector thermal analysis - testing methods- evacuated tubular collectors - concentrator collectors – classification - design and performance parameters - tracking systems - compound parabolic concentrators - parabolic trough concentrators - concentrators with point focus - Heliostats – performance of the collectors

UNIT II SOLAR THERMAL TECHNOLOGIES 9

Principle of working, types, design and operation of - Solar heating and cooling systems - Thermal Energy storage systems – Solar Desalination – Solar cooker : domestic, community – Solar pond – Solar drying-solar chimney-solar thermal electricity conversion

UNIT III SOLAR PV FUNDAMENTALS 9

Semiconductor – properties - energy levels - basic equations of semiconductor devices physics. Solar cells - p-n junction: homo and hetro junctions - metal-semiconductor interface - dark and illumination characteristics - figure of merits of solar cell - efficiency limits - variation of efficiency with band-gap and temperature - efficiency measurements - high efficiency cells – Solar thermo-photovoltaics

UNIT IV SPV SYSTEM DESIGN AND APPLICATIONS 9

Solar cell array system analysis and performance prediction- Shadow analysis: reliability - solar cell array design concepts - PV system design - design process and optimization - detailed array design - storage autonomy - voltage regulation - maximum tracking - centralized and decentralized SPV systems - standalone - hybrid and grid connected system - System installation - operation and maintenances - field experience - PV market analysis and economics of SPV systems

UNIT – V SOLAR PASSIVE ARCHITECTURE 9

Thermal comfort - bioclimatic classification – passive heating concepts: direct heat gain - indirect heat gain - isolated gain and sunspaces - passive cooling concepts: evaporative cooling - Radiative cooling- application of wind, water and earth for cooling; shading - paints and cavity walls for cooling – roof radiation traps - earth air-tunnel – energy efficient landscape design - thermal comfort

TOTAL: 45 PERIODS

OUTCOMES:

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

1. Learn and study the solar radiation and various solar collectors
2. Know the various solar thermal energy technologies and their applications
3. Aware about various solar PV cell materials and conversion techniques
4. Learn various Solar SPV systems designs and their applications
5. Know about various solar passive building techniques for cooling and heating applications

REFERENCES:

1. Chetan Singh Solanki, Solar Photovoltatics – Fundamentals, Technologies and Applications, PHI Learning Private limited, 2011
2. John A. Duffie, William A. Beckman, Solar Engineering of Thermal Processes, John Wiley & Sons, 2013
3. Lovegrove K., Stein W., Concentrating Solar Power Technology, Woodhead Publishing Series in Energy, Elsevier, 1st Edition, 2012
4. Solar Energy International, Photovoltaic – Design and Installation Manual, New Society Publishers, 2006
5. Sukhatme S P, Nayak J K, Solar Energy – Principle of Thermal Storage and collection, Tata McGraw Hill, 2008.

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	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
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2	0.9	0.6	0.6		0.6	0.3	0.9	0.6				0.9			0.6
3	0.9	0.6	0.3		0.6		0.9	0.6				0.9		0.3	
4	0.9	0.9	0.6			0.6	0.9	0.6				0.9	0.3		0.6
5	0.6	0.3	0.9		0.6	0.6	0.9	0.9				0.9	0.3	0.3	0.6

IC5004 AIRCRAFT AND SPACE PROPULSION

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To familiarize with the concept of compressible flow and effect of shock waves.
- To recognize and distinguish the working of various aircraft engines.
- To design and match aircraft components and calculate its performance.
- To gain insight on the working principle of rocket engines, different feed systems, propellants and their properties and dynamics of rocket.
- To design rockets for various space applications and calculate rocket performance.

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 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 students will be able to:

1) Use concepts of compressible flow to design variable area ducts for the given conditions.
2) Identify various aircraft engines and know its inner workings with emphasis on its limitations and applications.
3) Mix and match various components of an aircraft engine for its design conditions.
4) Classify various rocket engines based on its type and design it for requirements.
5) 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. G.C. Oates, "Aerothermodynamics of Aircraft Engine Components", AIAA Education Series,1985.
4. S. M. Yahya, Fundamentals of Compressible Flow. Third edition, New Age International Pvt Ltd,2003.
5. George P. Sutton, Oscar Biblarz. Rocket Propulsion Elements, John Wiley & Sons, 8th Edition, 2010.
6. Ramamurthy, Rocket Propulsion, Pan Macmillan (India) Ltd, 2010.
7. 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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1	0.9	-	-	-	-	-	0.6	-	-	-	-	0.3	0.9	0.6	0.3
2	0.9	0.6	0.6	0.6	0.3	0.3	0.6	-	-	-	0.6	0.6	0.6	0.9	-
3	0.3	0.3	0.3	0.3	0.6	-	-	0.3	0.6	-	0.9	-	-	-	0.9
4	0.3	0.3	-	0.3	0.3	-	-	0.3	0.3	-	0.9	0.6	-	0.6	-
5	0.3	-	-	-	-	0.6	0.9	0.3	-	-	0.6	0.3	0.9	-	-

EY5072 BIO ENERGY TECHNOLOGIES L T P C
3 0 0 3

COURSE OBJECTIVES:

1. To detail on the types of biomass, its surplus availability and characteristics.
2. To create awareness on the technologies available for conversion of biomass to energy in terms of its technical competence and economic implications.
3. To impart knowledge on stoichiometry and combustion of bio fuels
4. To elucidate on the influence of equivalence ratio on thermochemical conversion of biomass
5. To provide insight to the possibilities of producing liquid fuels form biomass

UNIT I INTRODUCTION 9

Biomass: types – advantages and drawbacks – Indian scenario – characteristics – carbon neutrality – conversion mechanisms – fuel assessment studies – densification technologies Comparison with coal – Proximate & Ultimate Analysis - Thermo Gravimetric Analysis – Differential Thermal Analysis – Differential Scanning Calorimetry

UNIT II BIOMETHANATION 9

Microbial systems – phases in biogas production – parameters affecting gas production – effect of additives on biogas yield – possible feed stocks. Biogas plants – types – design – constructional details and comparison – biogas appliances – burner, luminaries and power generation – effect on engine performance.

UNIT III COMBUSTION 9

Perfect, complete and incomplete combustion - stoichiometric air requirement for biofuels-equivalence ratio – fixed Bed and fluid Bed combustion – fuel and ash handling systems –steam cost comparison with conventional fuels

UNIT IV GASIFICATION, PYROLYSIS AND CARBONISATION 9

Chemistry of gasification - types – comparison – application – performance evaluation – economics – dual fuelling in IC engines – 100 % Gas Engines – engine characteristics on gas mode – gas cooling and cleaning systems - Pyrolysis - Classification - process governing parameters – Typical yield rates. Carbonization Techniques – merits of carbonized fuels

UNIT V LIQUIFIED BIOFUELS 9

History of usage of Straight Vegetable Oil (SVO) as fuel - Biodiesel production from oil seeds, waste oils and algae - Process and chemistry - Biodiesel health effects / emissions /performance. Production of alcoholic fuels (methanol and ethanol) from biomass – engine modifications

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. Estimate the surplus biomass availability of any given area
2. Design a biogas plant for a variety of biofuels
3. Determine and compare the cost of steam generation from biofuels with that of coal and petroleum fuels
4. Analyse the influence of process governing parameters in thermochemical conversion of biomass
5. Synthesize liquid biofuels for power generation from biomass

REFERENCES

1. David Boyles, Bio Energy Technology Thermodynamics and costs, Ellis Hoknood Chichester,1984.
2. Iyer PVR et al, Thermochemical Characterization of Biomass, M N E S
3. Khandelwal KC, Mahdi SS, Biogas Technology – A Practical Handbook, Tata McGraw Hill, 1986
4. Mahaeswari, R.C. Bio Energy for Rural Energisation, Concepts Publication,1997
5. Tom B Reed, Biomass Gasification – Principles and Technology, Noyce Data Corporation, 1981

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.6				0.6		0.9		0.3			0.6	0.9		
2	0.6	0.6	0.9			0.6	0.6				0.3	0.6	0.9		
3	0.6	0.6	0.9	0.6			0.3				0.6	0.6	0.9	0.6	
4	0.6	0.6	0.9	0.6			0.3				0.6	0.6	0.9	0.3	
5	0.6	0.6	0.9	0.6			0.3				0.6	0.6	0.9	0.3	

EY5075	ENERGY FORECASTING, MODELING AND PROJECT MANAGEMENT	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To understand about National energy scenario.
2. To predict the energy demand using various forecasting models.
3. To develop an optimization model for the effective utilisation of energy sources.
4. To know the procedure to the write the project proposal.
5. To know the energy policies in the country.

UNIT – I ENERGY SCENARIO 9

Role of energy in economic development and social transformation: Energy & GDP, GNP and its dynamics - Energy Sources and Overall Energy demand and Availability - Energy Consumption in various sectors and its changing pattern -Status of Nuclear and Renewable Energy: Present Status and future promise.

UNIT – II FORECASTING MODEL 9

Forecasting Techniques - Regression Analysis - Double Moving Average - Double Experimental Smoothing - Triple Exponential Smoothing – ARIMA model- Validation techniques – Qualitative forecasting – Delphi technique - Concept of Neural Net Works.

UNIT – III OPTIMIZATION MODEL 9

Principles of Optimization - Formulation of Objective Function - Constraints - Multi Objective Optimization – Mathematical Optimization Software – Development of Energy Optimization Model - Development of Scenarios – Sensitivity Analysis - Concept of Fuzzy Logic.

UNIT – IV PROJECT MANAGEMENT 9

Project Preparation – Feasibility Study – Detailed Project Report - Project Appraisal – Social-cost benefit Analysis - Project Cost Estimation – Project Risk Analysis - Project Financing – Financial Evaluation.

UNIT – V ENERGY POLICY 9

National & State Level Energy Issues - National & State Energy Policy - Energy Security - National solar mission - state solar energy policy - Framework of Central Electricity Authority (CEA), Central & States Electricity Regulatory Commissions (CERC & ERCs)-Costing.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. Have knowledge in the National energy scenario.
2. Do Energy prediction using various forecasting techniques.
3. Develop optimization model for energy planning.
4. Capable of writing project proposals.
5. Understand the National and state energy policies.

REFERENCES:

1. Armstrong J.Scott (ed.), Principles of forecasting: a hand book for researchers and practitioners, Norwell, Massachusetts: Kluwer Academic Publishers.2001.
2. DhandapaniAlagiri, Energy Security in India Current Scenario, The ICFAI University Press, 2006.
3. Fred Luthans, Brett C. Luthan, Kyle W. Luthans, Organisational Behaviour: An Evidence-Based Approach, Information Age Publishing; 13 edition, 2015
4. Spyros G. Makridakis, Steven C. Wheelwright, Rob J. Hyndman, Forecasting: Methods and Applications, 4th Edition, ISBN: 978-0-471-53233-0,2003
5. Yang X.S., Introduction to mathematical optimization: From linear programming to Metaheuristics, Cambridge, Int. Science Publishing, 2008.

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.3	0.3	0.6	0.3	0.3	0.3	0.9	0.3	0.3	0.6	0.3	0.9	0.9	0.6	0.3
2	0.9	0.6	0.9	0.9	0.9	0.6	0.6				0.3	0.6	0.9	0.6	0.6
3	0.6	0.9	0.9	0.9	0.9			0.6			0.3	0.3	0.6	0.6	0.9
4	0.6	0.3	0.3	0.6		0.6		0.6	0.6	0.9	0.9	0.6	0.6	0.9	0.6
5	0.3	0.3				0.6	0.9	0.6	0.6	0.9	0.9	0.6	0.6	0.9	0.3

IC5005 HYBRID AND ELECTRIC VEHICLES L T P C
3 0 0 3

COURSE OBJECTIVES:

- To introduce the concept of hybrid and electric drive trains.
- To elaborate on the types and utilisation of hybrid and electric drive trains
- To expose on different types of AC and DC drives for electric vehicles.
- To understand and utilise different types of energy storage systems
- To introduce concept of energy management strategies and drive sizing

UNIT I INTRODUCTION 9

Basics of vehicle performance, vehicle power source characterization, transmission characteristics, History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies.

UNIT II HYBRID ELECTRIC DRIVE TRAINS 9

Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis.
Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis.

UNIT III CONTROL OF AC & DC DRIVES 9

Introduction to electric components used in hybrid and electric vehicles, Configuration and control - DC Motor drives, Induction Motor drives, Permanent Magnet Motor drive, and Switch Reluctance Motor drives, drive system efficiency.

UNIT IV ENERGY STORAGE 9

Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Energy storage and its analysis - Battery based, Fuel Cell based, and Super Capacitor based, Hybridization of different energy storage devices.

UNIT V DRIVE SIZING AND ENERGY MANAGEMENT STRATEGIES 9

Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selection of appropriate energy storage technology,
Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification and comparison of energy management strategies, implementation issues.

TOTAL : 45 PERIODS

COURSE OUTCOMES :

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

- Characterise and configure hybrid drivetrains requirement for a vehicle
- Design and apply appropriate hybrid and electric drive trains in a vehicle
- Design and install suitable AC and DC drives for electric vehicles.
- Arrive at a suitable energy storage system for a hybrid / electric vehicle
- Apply energy management strategies to ensure better economy and efficiency

REFERENCES:

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

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.9	-	-	-	-	-	0.6	-	-	-	-	0.3	0.9	0.6	0.3
2	0.9	0.6	0.6	0.6	0.3	0.3	0.6	-	-	-	0.6	0.6	0.6	0.9	-
3	0.3	0.3	0.3	0.3	0.6	-	-	0.3	0.6	-	0.9	-	-	-	0.9
4	0.3	0.3	-	0.3	0.3	-	-	0.3	0.3	-	0.9	0.6	-	0.6	-
5	0.3	-	-	-	-	0.6	0.9	0.3	-	-	0.6	0.3	0.9	-	-

IC5006 COMBUSTION AND REACTION KINETICS IN I.C. ENGINES **L T P C 3 0 0 3**

COURSE OBJECTIVES:

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

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, Ignition Delay and Burning rate estimation.

TOTAL: 45 PERIODS

COURSE 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.

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.9	-	-	-	-	-	0.6	-	-	-	-	0.3	0.9	0.6	0.3
2	0.9	0.6	0.6	0.6	0.3	0.3	0.6	-	-	-	0.6	0.6	0.6	0.9	-
3	0.3	0.3	0.3	0.3	0.6	-	-	0.3	0.6	-	0.9	-	-	-	0.9
4	0.3	0.3	-	0.3	0.3	-	-	0.3	0.3	-	0.9	0.6	-	0.6	-
5	0.3	-	-	-	-	0.6	0.9	0.3	-	-	0.6	0.3	0.9	-	-

IC5007 ENGINE POLLUTION AND CONTROL L T P C
3 0 0 3

COURSE OBJECTIVES

- To provide an insight about effect of engine out emissions on human health and environment
- To impart the knowledge on various pollutant species formations in SI and CI engine
- To divulge about various emission measurement techniques in engines and its significance
- To provide a discernment about various emission control methods
- To impart the knowledge about international and national driving cycles and emission standards

UNIT I AIR POLLUTION – ENGINES 8

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 9

Formation of Oxides of nitrogen, Carbon monoxide, Hydrocarbon, Aldehydes, Smoke and Particulate matter emissions. Effects of Engine design and operating variables on emission formation, Noise pollution.

UNIT III EMISSION MEASUREMENT TECHNIQUES 9

CO, CO_2 - Non dispersive infrared gas analyzer, NOx - Chemiluminescent analyzer, 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 10

Engine design modifications, Fuel modification, Evaporative emission control, EGR, Air injection, Thermal reactors, 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. Low temperature combustion concepts

UNIT V DRIVING CYCLES AND EMISSION STANDARDS 9

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

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

- Understand about atmospheric pollution from engines and its impact on human health and environment.
- Understand the formation of emissions in both SI and CI engines.
- Understand the various measurement techniques used globally for the measurement of automotive and stationary engine out emissions.
- Learn the various control methods/techniques used in IC engine to control the engine out emissions
- 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.

TEXT BOOKS:

1. Ganesan V., “Internal Combustion Engines”, V Edition, Tata McGraw Hill, 2012.
2. John. B. Heywood, “Internal Combustion engine fundamentals” McGraw – Hill, 1988.

REFERENCES:

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

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.9	-	-	-	-	-	0.6	-	-	-	-	0.3	0.9	0.6	0.3
2	0.9	0.6	0.6	0.6	0.3	0.3	0.6	-	-	-	0.6	0.6	0.6	0.9	-
3	0.3	0.3	0.3	0.3	0.6	-	-	0.3	0.6	-	0.9	-	-	-	0.9
4	0.3	0.3	-	0.3	0.3	-	-	0.3	0.3	-	0.9	0.6	-	0.6	-
5	0.3	-	-	-	-	0.6	0.9	0.3	-	-	0.6	0.3	0.9	-	-

EY5077 HYDROGEN AND FUEL CELLS L T P C

3 0 0 3

COURSE OBJECTIVES :

1. To study the basic production techniques of Hydrogen.
2. To understand the concepts of various storage methods of Hydrogen.
3. To study the thermodynamics and kinetics of fuel cell process.
4. To understand the classifications, construction and working of fuel cells.
5. To provide insights into fuel cell applications and its economics.

UNIT I HYDROGEN – BASICS AND PRODUCTION TECHNIQUES 9

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

UNIT II HYDROGEN STORAGE AND APPLICATIONS 9

Hydrogen storage options – compressed gas – liquid hydrogen – Hydride – chemical Storage – comparisons. Safety and management of hydrogen. Applications of Hydrogen.

UNIT III INTRODUCTION TO FUEL CELLS 9

History – principle - working - thermodynamics and kinetics of fuel cell process – performance evaluation of fuel cell – comparison on battery Vs fuel cell.

UNIT IV CLASSIFICATION OF FUEL CELLS 9

Types of fuel cells – AFC, PAFC, SOFC, MCFC, DMFC, PEMFC, MFC – principle, construction and working – relative merits and demerits.

UNIT V FUEL CELL APPLICATIONS AND ECONOMICS 9

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

TOTAL: 45 PERIODS

COURSE OUTCOMES:

1. Analyze the techniques of Hydrogen generation.
2. Apply the various options for Hydrogen storage.
3. Recognize the principle operations of fuel cell, types, its thermodynamics and kinetics.
4. Comprehend the different types of fuel cells.
5. Apply the fuel cells for domestic, automotive, space craft power generations and evaluate the techno-economics of a fuel cells.

REFERENCES

1. Barclay F.J., Fuel Cells, Engines and Hydrogen, Wiley, 2009.
2. Bent Sorensen (Sørensen), Hydrogen and Fuel Cells: Emerging Technologies and Applications, Elsevier, UK 2005.
3. Hart A.B. and G.J.Womack, Fuel Cells: Theory and Application, Prentice Hall, New York Ltd., London 1989.
4. Jeremy Rifkin, The Hydrogen Economy, Penguin Group, USA 2002.
5. Kordesch K. and G.Simader, Fuel Cell and Their Applications, Wiley-Vch, Germany 1996.
6. Rebecca L. and Busby, Hydrogen and Fuel Cells: A Comprehensive Guide, Penn Well Corporation, Oklahoma, 2005.
7. Viswanathan B. and Aulice Scibioh.M, Fuel Cells – Principles and Applications, Universities Press, 2006.

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.6	0.6	0.9	0.9	0.3	0.6	0.3					0.3	0.6	0.3	0.3
2	0.9	0.6	0.9	0.6	0.3	0.6	0.3					0.3	0.6		
3	0.6	0.3	0.6	0.6	0.6	0.3							0.3		
4	0.6	0.3	0.6	0.3	0.3	0.3							0.3		
5	0.6	0.3	0.9	0.6	0.3	0.6	0.9					0.3	0.6		

IC5008 BOUNDARY LAYER THEORY AND TURBULENCE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

1) To introduce the fundamental concepts of boundary layer in real flows.
2) To distinguish between turbulent and laminar boundary layers.
3) To model turbulent flows using various approaches.
4) To average various flow parameters using statistical principles.
5) To introduce the types, characteristics of wall shear flows from free shear flows.

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, Couette – 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

COURSE OUTCOMES :

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

1) Analyse flow with the principles of boundary layer theory
2) Distinguish turbulent boundary layer for various types of flows
3) Select and use various turbulence models for the appropriate applications.
4) Apply the statistical theory for averaging various flow parameters.
5) Differentiate the characteristics of wall shear and free shear flows.

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. G.C. Oates, "Aerothermodynamics of Aircraft Engine Components", AIAA Education Series,1985.
4. S. M. Yahya, Fundamentals of Compressible Flow. Third edition, New Age International Pvt Ltd,2003.
5. George P. Sutton, Oscar Biblarz. Rocket Propulsion Elements, John Wiley & Sons, 8th Edition, 2010.
6. Ramamurthy, Rocket Propulsion, Pan Macmillan (India) Ltd, 2010.
7. 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.

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.6	-	-	-	0.6	-	0.9	-	0.3	-	-	0.6	0.9	-	-
2	0.6	0.6	0.9	-	-	0.6	0.6	-	-	-	0.3	0.6	0.9	-	-
3	0.6	0.6	0.9	0.6	-	-	0.3	-	-	-	0.6	0.6	0.9	0.6	-
4	0.6	0.6	0.9	0.6	-	-	0.3	-	-	-	0.6	0.6	0.9	0.3	-
5	0.6	0.6	0.9	0.6	-	-	0.3	-	-	-	0.6	0.6	0.9	0.3	-

IC5009 ADVANCED COMBUSTION CONCEPTS IN ENGINES L T P C
3 0 0 3

COURSE OBJECTIVES

- To provide fundamental knowledge about HCCI and its background
- To provide insight about Gasoline and Diesel LTC combustion methods
- To impart knowledge on LTC control methods and its significance
- To provide insight about the fuel requirements for LTC combustion and its effect
- To impart knowledge on LTC combustion operation with alternative fuels

UNIT I LOW TEMPERATURE COMBUSTION ENGINE FUNDAMENTALS 8

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

UNIT II GASOLINE AND DIESEL LTC 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, Modulated kinetics (MK)combustion – First and Second generation of MK combustion, Emission, performance improvement.

UNIT III LOW TEMPERATURE COMBUSTION 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 ADVANCED COMBUSTION FUEL REQUIREMENTS 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, Method of combining DME and other fuels, Unmixed-ness of DME/air mixture

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

- Understand the fundamentals of HCCI combustion, benefits and challenges
- Learn the methods followed to achieve HCCI in Gasoline and Diesel engines
- Learn the HCCI combustion control methods and its significance
- Understand the fuel requirements for HCCI operation and its role on complete load range operation
- Learn the HCCI operation with alternative fuels and its comparison over conventional fuels

TEXT BOOKS:

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.

REFERENCES:

1. Ganesan, V, Internal Combustion Engines, Tata McGraw Hill Book Co., 2003
2. John B Heywood, "Internal Combustion Engines Fundamentals", McGraw Hill International Edition, 1988.
3. Pundir B.P. I.C. Engines Combustion and Emission, 2010, Narosa Publishing House.
4. HCCI Diesel Engines - Nptel - https://nptel.ac.in/courses/112104033/34
5. HCCI and CAI Engines – Nptel - https://nptel.ac.in/courses/112104033/33

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.9	-	-	-	-	-	0.6	-	-	-	-	0.3	0.9	0.6	0.3
2	0.9	0.6	0.6	0.6	0.3	0.3	0.6	-	-	-	0.6	0.6	0.6	0.9	-
3	0.3	0.3	0.3	0.3	0.6	-	-	0.3	0.6	-	0.9	-	-	-	0.9
4	0.3	0.3	-	0.3	0.3	-	-	0.3	0.3	-	0.9	0.6	-	0.6	-
5	0.3	-	-	-	-	0.6	0.9	0.3	-	-	0.6	0.3	0.9	-	-

IC5010 MANUFACTURING AND TESTING OF ENGINE COMPONENTS L T P C
3 0 0 3

COURSE OBJECTIVES:

- To provide a comprehensive module on the aspects of materials, manufacture and testing of piston engine assemblies, components and subsystems.
- To equip the learners with necessary domain inputs such that they can pursue research, consultancy, academics or other vocation.
- To introduce the students to CNC programming
- To emphasis on the importance of quality management system
- To provide knowledge necessary to perform computer aided engine testing

UNIT I MATERIALS AND PRODUCTION METHODS 9

Selection – types of Materials – Ferrous: Carbon and Low Alloy steels, High Alloy Steels, and Cast Irons – Nonferrous: Aluminium, Magnesium, Titanium, Copper and Nickel alloys - Composites - Production Methods: casting, forging, powder metallurgy - Machining.

UNIT II ENGINE COMPONENTS 9

Cylinder Block, Cylinder Head, Crankcase and Manifolds, Piston Assembly, Connecting Rod, Crankshaft, Camshaft and Valve Train - Testing Methods.

UNIT III ENGINE AUXILIARIES 9

Fuel injectors, radiators, fans, coolant pumps, ignition system, intake and exhaust systems, and catalytic converters.

UNIT IV COMPUTER INTEGRATED MANUFACTURING 9

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 for engine testing - computer aided engine testing - metrology for manufacture of engine components - engine tribological aspects.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The student will be able to

1. Choose appropriate materials for manufacturing of engine components.
2. Develop the production process for manufacturing engine components and auxiliaries.
3. Choose appropriate test methods and parameters to test the quality of engine components.
4. Develop CNC programs for simple components.
5. Perform computer aided engine testing.

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.9	0.6	0.9												
2	0.9	0.9	0.9												
3	0.9	0.3	0.3		0.9										
4	0.9	0.3	0.3		0.9										
5	0.9	0.3	0.3		0.9										

REFERENCES:

1. Ammar Grous. Applied Metrology for Manufacturing Engineering, ISTE Ltd. 2011.
2. Bosch Automotive Handbook, (8th Edition), Robert Bosch GmbH, Germany, 2011.
3. Haslehurst.S.E.,Manufacturing Technology , ELBS, London, 1990
4. James D. Halderman and Chase D. Mitchell Jr., Automotive Engines: Theory and Servicing, Pearson Education Inc., 2005.
5. Paul E. Mix, Introduction to Non destructive Testing: A Training Guide, second edition, John Wiley & Sons, Inc., 2005.
6. Richard D. Atkins, An Introduction to Engine Testing and Development, SAE International, USA, 2009.

EY5078 MODELING AND ANALYSIS OF ENERGY SYSTEMS L T P C

3 0 0 3

COURSE OBJECTIVES:

1. To learn to apply mass and energy balances for the energy systems
2. To learn the modeling and simulation techniques for energy systems.
3. To learn the optimization techniques to optimize the energy system.
4. To learn to use the energy-economy models.
5. To understand the application of case studies.

UNIT – I INTRODUCTION 9

Primary energy analysis - energy balance for closed and control volume systems - applications of energy analysis for selected energy system design - modeling overview - levels and steps in model development - Examples of models – curve fitting and regression analysis

UNIT – II MODELLING AND SYSTEMS SIMULATION 9

Modeling of energy systems – heat exchanger - solar collectors – distillation -rectification turbo machinery components - refrigeration systems - information flow diagram - solution of set of non- linear algebraic equations - successive substitution - Newton Raphson method- examples of energy systems simulation

UNIT – III OPTIMISATION TECHNIQUES 9

Objectives - constraints, problem formulation - unconstrained problems - necessary and sufficiency conditions. Constrained optimization - Lagrange multipliers, constrained variations, Linear Programming - Simplex tableau, pivoting, sensitivity analysis - New generation optimization techniques – Genetic algorithm and simulated annealing – examples.

UNIT – IV ENERGY- ECONOMY MODELS 9

Multiplier Analysis - Energy and Environmental Input / Output Analysis - Energy Aggregation – Econometric Energy Demand Modeling - Overview of Econometric Methods - Dynamic programming- Search Techniques - Univariate / Multivariate

UNIT – V APPLICATIONS AND CASE STUDIES 9

Case studies of optimization in Energy systems problems- Dealing with uncertainty- probabilistic techniques – Trade-offs between capital and energy using Pinch analysis

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. Apply mass and energy balances for the energy systems
2. Do Simulation and Modeling of typical energy system
3. Use the optimization techniques to optimize the energy system.
4. Perform Energy-Economic Analysis for the typical applications
5. Have knowledge in optimization of Energy systems problems

REFERENCES:

1. Bejan, A, Tsatsaronis, G and Moran, M., Thermal Design and Optimization, John Wiley & Sons, 1996
2. Balaji C., Essentials of Thermal System Design and Optimization, Aue Books, 2011
3. Chang, Ni-Bin, Systems analysis for sustainable engineering: theory and applications, New York : McGraw-Hill, c2011.
4. Stoecker W.F., Design of Thermal Systems, McGraw Hill, 2011
5. Yogesh Jaluria, Design and Optimization of Thermal Systems, CRC Press INC, 2008

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.9	0.6	0.6	0.9	0.6							0.6		0.6	0.9
2	0.9	0.6	0.9	0.9	0.6							0.3	0.3	0.6	0.6
3	0.6	0.9	0.6	0.6	0.3	0.6	0.3								0.9
4	0.6	0.3	0.6	0.6	0.9	0.3	0.3				0.9				0.6
5	0.3	0.6	0.6	0.9	0.6	0.3					0.6	0.6		0.6	0.3

IC5011 SUPERCHARGING AND SCAVENGING L T P C
3 0 0 3

COURSE OBJECTIVES:

1. To gain knowledge in supercharging and scavenging.
2. To study the thermodynamics of turbo charging
3. To introduce the basic concepts of two stroke cycle engines
4. To gain knowledge in the design of ports and exhaust systems
5. To introduce students the future trends in the design of two stroke cycle engines

UNIT I SUPERCHARGING 9

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 9

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

UNIT III SCAVENGING OF TWO STROKE ENGINES 9

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 9

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.

COURSE OUTCOMES:

1. Recognise and understand reasons for differences among operating characteristics of superchargers
2. Differentiate among different types of turbocharging methods and design turbochargers
3. Exposure to the different terminologies and scavenging systems
4. Design a two stroke cycle engine
5. Develop skills to run engine dynamometer experiments and understand methods of eliminating short circuiting

REFERENCES:

1. Blair G P, Two stroke Cycle Engines Design and Simulation, SAE Publications, 1997.
2. Heinz Heisler, Advanced Engine Techology, Butterworth Heinmann Publishers, 2002.
3. John B. Heywood, Two Stroke Cycle Engine, SAE Publications, 1999.
4. Schweitzer, P.H., Scavenging of Two Stroke Cycle Diesel Engine, MacMillan Co., 1949.
5. Watson, N. and Janota, M.S., Turbocharging the I.C. Engine, MacMillan Co., 1982.

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.9	0.6	0.6	0.9	0.6	-	-	-	-	-	-	0.6	-	0.6	0.9
2	0.9	0.6	0.9	0.9	0.6	-	-	-	-	-	-	0.3	0.3	0.6	0.6
3	0.6	0.9	0.6	0.6	0.3	0.6	0.3	-	-	-	-	-	-	-	0.9
4	0.6	0.3	0.6	0.6	0.9	0.3	0.3	-	-	-	0.9	-	-	-	0.6
5	0.3	0.6	0.6	0.9	0.6	0.3	-	-	-	-	0.6	0.6	-	0.6	0.3

EY5071 ADVANCED ENERGY STORAGE TECHNOLOGIES L T P C

3 0 0 3

COURSE OBJECTIVES:

1. To understand the various types of energy storage technologies and its applications.
2. To study the various modelling techniques of energy storage systems using TRNSYS.
3. To learn the concepts and types of batteries.
4. To make the students to get understand the concepts of Hydrogen and Biogas storage.
5. To provide the insights on Flywheel and compressed energy storage systems.

UNIT – I INTRODUCTION 9

Necessity of energy storage – types of energy storage – comparison of energy storage technologies – Applications.

UNIT – II THERMAL STORAGE SYSTEM 9

Thermal storage – Types – Modelling of thermal storage units – Simple water and rock bed storage system – pressurized water storage system – Modelling of phase change storage system – Simple units, packed bed storage units - Modelling using porous medium approach, Use of TRNSYS.

UNIT – III ELECTRICAL ENERGY STORAGE 9

Fundamental concept of batteries – measuring of battery performance, charging and discharging of a battery, storage density, energy density, and safety issues. Types of batteries – Lead Acid, Nickel – Cadmium, Zinc Manganese dioxide and modern batteries for example (i) zinc-Air (ii) Nickel Hydride, (iii) Lithium Battery.

UNIT – IV HYDROGEN AND BIOGAS STORAGE 9

Hydrogen storage options – compressed gas – liquid hydrogen – Metal Hydrides, chemical Storage, Biogas storage - comparisons. Safety and management of hydrogen and Biogas storage - Applications.

UNIT – V ALTERNATE ENERGY STORAGE TECHNOLOGIES 9

Flywheel, Super capacitors, Principles & Methods – Applications, Compressed air Energy storage, Concept of Hybrid Storage – Applications.

TOTAL: 45 PERIODS

OUTCOMES:

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

1. Identify the energy storage technologies for suitable applications.
2. Analyze the energy storage systems using TRNSYS.
3. Recognize the concepts and types of batteries.
4. Diagnose the principle operations of Hydrogen and Biogas storage.
5. Analyze the concepts of Flywheel and compressed energy storage systems

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

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.9	0.3	0.9	0.3	0.3	0.6	0.9	0.3	0.3	0.3	0.6	0.3	0.9	0.6	0.6
2	0.9	0.3	0.9	0.3	0.3	0.6	0.9	0.3	0.3	0.3	0.6	0.3	0.9	0.6	0.6
3	0.9	0.3	0.9	0.3	0.3	0.6	0.9	0.3	0.3	0.3	0.6	0.3	0.9	0.6	0.6
4	0.9	0.3	0.9	0.3	0.3	0.6	0.9	0.3	0.3	0.3	0.6	0.3	0.9	0.6	0.6
5	0.9	0.3	0.9	0.3	0.3	0.6	0.9	0.3	0.3	0.3	0.6	0.3	0.9	0.6	0.6

EY5076 ENVIRONMENTAL ENGINEERING AND POLLUTION CONTROL

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

1. To impart knowledge on the atmosphere and its present condition and, global warming.
2. To detail on the sources of water pollution and possible solutions for mitigating their degradation.
3. To detail on the sources of air pollution and possible solutions for mitigating their degradation.
4. To detail on the sources of solid waste and possible ways to dispose them safely.
5. To impart knowledge on hazardous waste management.

UNIT – I INTRODUCTION 9

Man & Environment – Types of Pollution – Global Environmental issues – Environmental Impact Assessment – Global Warming Issues – CO_2 Mitigation – Basic definition of Pollution Indicators – Noise Pollution

UNIT – II WATER POLLUTION 9

Pollutants in Water & Wastewater – Physical and Chemical Treatment Methods – (An Overview) Neutralization – Aeration –Colour / Odour Removal - Sludge dewatering – Biological Treatment including Aerobic & Anaerobic Treatment

UNIT – III AIR POLLUTION 9

Sources – Ambient Air Quality Standards – Emission Limits – Equipment for Ambient Air & Stack Monitoring – Principles of operation of Particulate Control Equipments -ESPs, Bag Filters, Cyclone Separators– Vehicular Pollution and its Control – BS standards

UNIT – IV SOLID WASTE MANAGEMENT 9

Types & Sources – Types– Waste Generation – Composition – Physical, Chemical and Biological Properties – Transformation Technologies for Waste Treatment – Landfill Management – Layout, Closure & Post Closure Operation – Reclamation Leachate Generation – e Waste Disposal

UNIT – V HAZARDOUS WASTE MANAGEMENT 9

Sources – Classification – Characterization of waste - health effects - Incineration– Radioactive Waste from nuclear power plants and disposal options - RDF- Mass Firing – Material Recycling

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. Types and effects of each type of pollution on man – earth will be made known.
2. Technical aspects of Global Warming will make them understand the impact they have on climate
3. Technologies that are available for reduction of pollutants dumped into the atmosphere
4. Cursory / superficial formation - the students – had in Hazardous waste, waste disposal hitherto will be deep & sensible enough after studying this subject
5. Comprehend the different techniques available for safe disposal of hazardous waste

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1. Peavy, H.S. and D.R. Rowe, G.Tchobanoglous: Environmental Engineering - McGraw- Hill Book Company, NewYork, 1985.
2. Ludwig, H. W.Evans: Manual of Environmental Technology in Developing Countries, International Book Company, Absecon Highlands, N.J, 1991.
3. Arcadio P Sincero and G. A. Sincero, Environmental Engineering – A Design Approach, Prentice Hall of India Pvt Ltd, New Delhi, 2002.
4. G. Masters: Introduction to Environmental Engineering and Science, Prentice Hall of India Pvt Ltd, New Delhi, 2003.
5. Richard J. Watts, Hazardous Wastes - Sources, Pathways, Receptors John Wiley and Sons, New York,1997

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.6	0.3	0.3	0.3	0.3	0.3	0.3						0.3		
2	0.6	0.3	0.3	0.3	0.3		0.3						0.3		0.3
3	0.9	0.3	0.6	0.3	0.3		0.6						0.3	0.9	0.3
4	0.6	0.3	0.3	0.3	0.3		0.6						0.3	0.3	0.3
5	0.3	0.3	0.6	0.6	0.9										0.9

EY5073 ELECTRICAL DRIVES AND CONTROLS L T P C

3 0 0 3

COURSEOBJECTIVES

1. To impart the knowledge on the principle of conventional motor drives, various starting and speed control methods of motors.
2. To understand the concepts of various losses and harmonics effects in motors.
3. To study the Power Electronics components and controllers.
4. To provide insights of Superconductivity theory and super conducting magnetic energy storage.
5. To understand the concept of Solid State motor controllers and their applications

UNIT I CONVENTIONAL MOTOR DRIVES 9

Characteristics of DC and AC motor for various applications - starting and speed control - methods of breaking

UNIT II PHYSICAL PHENOMENA IN ELECTRICAL MACHINES 9

Various losses in motors-Saturation and Eddy current effects - MMF harmonics and their influence of leakage-stray losses - vibration and noise.

UNIT III SOLID STATE POWER CONTROLLERS 9

Power devices: Triggering Circuits, Rectifiers – Single Phase and Three Phase with R, RL and Freewheeling Diode, Choppers - Type-A, Type-B, Type C and Type D, Inverters – Single Phase and Three Phase with R, RL and Freewheeling Diode, AC Voltage Controllers

UNIT IV SUPERCONDUCTIVITY 9

Principle of Super conductivity, Super conducting generators-motors and magnets - Super conducting magnetic energy storage (SMES).

UNIT V SOLID STATE MOTOR CONTROLLERS 9

Single and Three Phase fed DC motor drives - AC motor drives - Voltage Control - Rotor resistance control - Frequency control - Slip Power Recovery scheme

TOTAL: 45 PERIODS

OUTCOMES

1. Diagnose the operations of conventional motor drives, various starting and speed control methods of motors.
2. Analyze the different losses and harmonic effects in motors.
3. Recognize the Power electronics components and design the controllers.
4. Apply the Superconductivity theory and analyze the super conducting magnetic energy storage.
5. Analyse the concept of Solid State motor controllers and their applications

REFERENCES

1. Subrahmanyam, Electric Drives : Concepts & Applications 2/E, Tata McGraw Hill Education,2011
2. Robert A. Huggins, Energy Storage , Springer(2010)
3. Rene Husson, Modelling and Control of Electrical machines, Elsevier Science Ltd, 2009
4. D.Singh, K.B.Khanchandani, Power Electronics, Tata McGraw Hill Education Ltd, s2006
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CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.9	0.6	0.3	0.3		0.3							0.6	0.3	0.3
2	0.9	0.6	0.3	0.3		0.3							0.6	0.3	0.3
3	0.9	0.6	0.9	0.6		0.9							0.6	0.3	0.6
4	0.9	0.3	0.3	0.3		0.3							0.6	0.3	0.6
5	0.9	0.3	0.3	0.3		0.3							0.3	0.6	0.3

OPEN ELECTIVE COURSES (OEC)

OE5091 BUSINESS DATA ANALYTICS L T P C
3 0 0 3

COURSE OBJECTIVES:

- To understand the basics of business analytics and its life cycle.
- To gain knowledge about fundamental business analytics.
- To learn modeling for uncertainty and statistical inference.
- To understand analytics using Hadoop and Map Reduce frameworks.
- To acquire insight on other analytical frameworks.

UNIT I OVERVIEW OF BUSINESS ANALYTICS 9

Introduction – Drivers for Business Analytics – Applications of Business Analytics: Marketing and Sales, Human Resource, Healthcare, Product Design, Service Design, Customer Service and Support – Skills Required for a Business Analyst – Framework for Business Analytics Life Cycle for Business Analytics Process.

Suggested Activities:

- Case studies on applications involving business analytics.
- Converting real time decision making problems into hypothesis.
- Group discussion on entrepreneurial opportunities in Business Analytics.

Suggested Evaluation Methods:

- Assignment on business scenario and business analytical life cycle process.
- Group presentation on big data applications with societal need.
- Quiz on case studies.

UNIT II ESSENTIALS OF BUSINESS ANALYTICS 9

Descriptive Statistics – Using Data – Types of Data – Data Distribution Metrics: Frequency, Mean, Median, Mode, Range, Variance, Standard Deviation, Percentile, Quartile, z-Score, Covariance, Correlation – Data Visualization: Tables, Charts, Line Charts, Bar and Column Chart, Bubble Chart, Heat Map – Data Dashboards.

Suggested Activities:

- Solve numerical problems on basic statistics.
- Explore chart wizard in MS Excel Case using sample real time data for data visualization.
- Use R tool for data visualization.

Suggested Evaluation Methods:

- Assignment on descriptive analytics using benchmark data.
- Quiz on data visualization for univariate, bivariate data.

UNIT III MODELING UNCERTAINTY AND STATISTICAL INFERENCE 9

Modeling Uncertainty: Events and Probabilities – Conditional Probability – Random Variables – Discrete Probability Distributions – Continuous Probability Distribution – Statistical Inference: Data Sampling – Selecting a Sample – Point Estimation – Sampling Distributions – Interval Estimation – Hypothesis Testing.

Suggested Activities:

- Solving numerical problems in sampling, probability, probability distributions and hypothesis testing.
- Converting real time decision making problems into hypothesis.

Suggested Evaluation Methods:

- Assignments on hypothesis testing.
- Group presentation on real time applications involving data sampling and hypothesis testing.
- Quizzes on topics like sampling and probability.

UNIT IV ANALYTICS USING HADOOP AND MAPREDUCE FRAMEWORK 9

Introducing Hadoop – RDBMS versus Hadoop – Hadoop Overview – HDFS (Hadoop Distributed File System) – Processing Data with Hadoop – Introduction to MapReduce – Features of MapReduce – Algorithms Using Map-Reduce: Matrix-Vector Multiplication, Relational Algebra Operations, Grouping and Aggregation – Extensions to MapReduce.

Suggested Activities:

- Practical – Install and configure Hadoop.
- Practical – Use web based tools to monitor Hadoop setup.
- Practical – Design and develop MapReduce tasks for word count, searching involving text corpus etc.

Suggested Evaluation Methods:

- Evaluation of the practical implementations.
- Quizzes on topics like HDFS and extensions to MapReduce.

UNIT V OTHER DATA ANALYTICAL FRAMEWORKS 9

Overview of Application development Languages for Hadoop – PigLatin – Hive – Hive Query Language (HQL) – Introduction to Pentaho, JAQL – Introduction to Apache: Sqoop, Drill and Spark, Cloudera Impala – Introduction to NoSQL Databases – Hbase and MongoDB.

Suggested Activities:

- Practical – Installation of NoSQL database like MongoDB.
- Practical – Demonstration on Sharding in MongoDB.
- Practical – Install and run Pig
- Practical – Write PigLatin scripts to sort, group, join, project, and filter data.
- Design and develop algorithms to be executed in MapReduce involving numerical methods for analytics.

Suggested Evaluation Methods:

- Mini Project (Group) – Real time data collection, saving in NoSQL, implement analytical techniques using Map-Reduce Tasks and Result Projection.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course, the student will be able to:

CO1: Identify the real world business problems and model with analytical solutions.
CO2: Solve analytical problem with relevant mathematics background knowledge.
CO3: Convert any real world decision making problem to hypothesis and apply suitable statistical testing.
CO4: Write and Demonstrate simple applications involving analytics using Hadoop and MapReduce
CO5: Use open source frameworks for modeling and storing data.
CO6: Apply suitable visualization technique using R for visualizing voluminous data.

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1. Vignesh Prajapati, “Big Data Analytics with R and Hadoop”, Packt Publishing, 2013.
2. Umesh R Hodeghatta, Umesha Nayak, “Business Analytics Using R – A Practical Approach”, Apress, 2017.
3. Anand Rajaraman, Jeffrey David Ullman, “Mining of Massive Datasets”, Cambridge University Press, 2012.
4. Jeffrey D. Camm, James J. Cochran, Michael J. Fry, Jeffrey W. Ohlmann, David R. Anderson, “Essentials of Business Analytics”, Cengage Learning, second Edition, 2016.

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6. A. Ohri, “R for Business Analytics”, Springer, 2012
7. Rui Miguel Forte, “Mastering Predictive Analytics with R”, Packt Publication, 2015.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	2	3	1
CO2	2	1	1	2	1	1
CO3	1	1	2	3	3	1
CO4	2	2	1	2	1	1
CO5	1	1	2	2	1	1
CO6	1	1	1	3	2	1

OE5092 INDUSTRIAL SAFETY L T P C
3 0 0 3

COURSE OBJECTIVES:

- Summarize basics of industrial safety
- Describe fundamentals of maintenance engineering
- Explain wear and corrosion
- Illustrate fault tracing
- Identify preventive and periodic maintenance

UNIT I INTRODUCTION 9

Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

UNIT II FUNDAMENTALS OF MAINTENANCE ENGINEERING 9

Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

UNIT III WEAR AND CORROSION AND THEIR PREVENTION 9

Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

UNIT IV FAULT TRACING 9

Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment’s like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

UNIT V PERIODIC AND PREVENTIVE MAINTENANCE 9

Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of

preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Ability to summarize basics of industrial safety
CO2: Ability to describe fundamentals of maintenance engineering
CO3: Ability to explain wear and corrosion
CO4: Ability to illustrate fault tracing
CO5: Ability to identify preventive and periodic maintenance

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓											
CO3	✓	✓	✓									
CO4	✓	✓	✓									
CO5	✓	✓	✓									

REFERENCES:

1. Audels, Pump-hydraulic Compressors, Mcgrew Hill Publication, 1978.
2. Garg H P,Maintenance Engineering, S. Chand and Company,1987.
3. Hans F. Winterkorn ,Foundation Engineering Handbook, Chapman & Hall London,2013.
4. Higgins & Morrow , Maintenance Engineering Handbook, Eighth Edition,2008

OE5093 OPERATIONS RESEARCH L T P C
3 0 0 3

COURSE OBJECTIVES:

- Solve linear programming problem and solve using graphical method.
- Solve LPP using simplex method
- Solve transportation , assignment problems
- Solve project management problems
- Solve scheduling problems

UNIT I LINEAR PROGRAMMING 9

Introduction to Operations Research – assumptions of linear programming problems - Formulations of linear programming problem – Graphical method

UNIT II ADVANCES IN LINEAR PROGRAMMING 9

Solutions to LPP using simplex algorithm- Revised simplex method - primal dual relationships – Dual simplex algorithm - Sensitivity analysis

UNIT III NETWORK ANALYSIS – I 9

Transportation problems -Northwest corner rule, least cost method, Voges's approximation method - Assignment problem -Hungarian algorithm

UNIT IV NETWORK ANALYSIS – II 9

Shortest path problem: Dijkstra's algorithms, Floyds algorithm, systematic method -CPM/PERT

UNIT V NETWORK ANALYSIS – III 9

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: To formulate linear programming problem and solve using graphical method.
CO2: To solve LPP using simplex method
CO3: To formulate and solve transportation, assignment problems
CO4: To solve project management problems
CO5: To solve scheduling problems

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓											
CO3	✓	✓	✓									
CO4	✓	✓	✓									
CO5	✓	✓	✓									

REFERENCES:

1. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010
2. Hitler Libermann, Operations Research: McGraw Hill Pub. 2009
3. Pant J C, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Pannerselvam, Operations Research: Prentice Hall of India 2010
5. Taha H A, Operations Research, An Introduction, PHI, 2008

OE5094 COST MANAGEMENT OF ENGINEERING PROJECTS L T P C
3 0 0 3

COURSE OBJECTIVES:

- Summarize the costing concepts and their role in decision making
- Infer the project management concepts and their various aspects in selection
- Interpret costing concepts with project execution
- Develop knowledge of costing techniques in service sector and various budgetary control techniques
- Illustrate with quantitative techniques in cost management

UNIT I INTRODUCTION TO COSTING *CONCEPTS* 9

Objectives of a Costing System; Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost; Creation of a Database for operational control.

UNIT II INTRODUCTION TO PROJECT MANAGEMENT 9

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and nontechnical activities, Detailed Engineering activities, Pre project execution main clearances and documents, Project team: Role of each member, Importance Project site: Data required with significance, Project contracts.

UNIT III PROJECT EXECUTION AND COSTING CONCEPTS 9

Project execution Project cost control, Bar charts and Network diagram, Project commissioning: mechanical and process, Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis, Various decision-making problems, Pricing strategies: Pareto Analysis, Target costing, Life Cycle Costing.

UNIT IV COSTING OF SERVICE SECTOR AND BUDGETERY CONTROL 9

Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis, Budgetary Control: Flexible Budgets; Performance budgets; Zero-based budgets.

UNIT V QUANTITATIVE TECHNIQUES FOR COST MANAGEMENT 9

Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Learning Curve Theory.

TOTAL: 45 PERIODS

OUTCOMES

CO1 – Understand the costing concepts and their role in decision making
CO2–Understand the project management concepts and their various aspects in selection
CO3–Interpret costing concepts with project execution
CO4–Gain knowledge of costing techniques in service sector and various budgetary control techniques
CO5 - Become familiar with quantitative techniques in cost management

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓		✓			✓	✓		✓	✓
CO2	✓	✓	✓		✓				✓		✓	✓
CO3	✓	✓	✓		✓	✓					✓	✓
CO4	✓	✓	✓		✓		✓				✓	✓
CO5	✓	✓	✓		✓	✓	✓				✓	✓

REFERENCES:

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

OE5095 COMPOSITE MATERIALS L T P C
3 0 0 3

COURSE OBJECTIVES:

- Summarize the characteristics of composite materials and effect of reinforcement in composite materials.
- Identify the various reinforcements used in composite materials.
- Compare the manufacturing process of metal matrix composites.
- Understand the manufacturing processes of polymer matrix composites.
- Analyze the strength of composite materials.

UNIT I INTRODUCTION 9

Definition – Classification and characteristics of Composite materials - Advantages and application of composites - Functional requirements of reinforcement and matrix - Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

UNIT II REINFORCEMENTS 9

Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers - Properties and applications of whiskers, particle reinforcements - Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures - Isostrain and Isostress conditions.

UNIT III MANUFACTURING OF METAL MATRIX COMPOSITES 9

Casting – Solid State diffusion technique - Cladding – Hot isostatic pressing - Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving - Properties and applications.

UNIT IV MANUFACTURING OF POLYMER MATRIX COMPOSITES 9

Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding - Properties and applications.

UNIT V STRENGTH 9

Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

- CO1 - Know the characteristics of composite materials and effect of reinforcement in composite materials.
- CO2 – Know the various reinforcements used in composite materials.
- CO3 – Understand the manufacturing processes of metal matrix composites.
- CO4 – Understand the manufacturing processes of polymer matrix composites.
- CO5 – Analyze the strength of composite materials.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		✓	✓	✓								
CO2		✓	✓	✓	✓						✓	
CO3			✓	✓	✓		✓				✓	
CO4			✓	✓	✓		✓				✓	
CO5				✓	✓		✓					

REFERENCES:

1. Cahn R.W. - Material Science and Technology – Vol 13 – Composites, VCH, West Germany.
2. Callister, W.D Jr., Adapted by Balasubramaniam R, Materials Science and Engineering, An introduction, John Wiley & Sons, NY, Indian edition, 2007.
3. Chawla K.K., Composite Materials, 2013.
4. Lubin.G, Hand Book of Composite Materials, 2013.

OE5096 WASTE TO ENERGY L T P C
3 0 0 3

COURSE OBJECTIVES:

- Interpret the various types of wastes from which energy can be generated
- Develop knowledge on biomass pyrolysis process and its applications
- Develop knowledge on various types of biomass gasifiers and their operations
- Invent knowledge on biomass combustors and its applications on generating energy
- Summarize the principles of bio-energy systems and their features

UNITI INTRODUCTION TO EXTRACTION OF ENERGY FROM WASTE 9

Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

UNITII BIOMASS PYROLYSIS 9

Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

UNIT III BIOMASS GASIFICATION 9

Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

UNIT IV BIOMASS COMBUSTION 9

Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

UNITV BIO ENERGY 9

Properties of biogas (Calorific value and composition), Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production -Urban waste to energy conversion - Biomass energy programme in India.

TOTAL: 45 PERIODS

OUTCOMES:

CO1 – Understand the various types of wastes from which energy can be generated
CO2 – Gain knowledge on biomass pyrolysis process and its applications
CO3 – Develop knowledge on various types of biomass gasifiers and their operations
CO4 – Gain knowledge on biomass combustors and its applications on generating energy
CO5 – Understand the principles of bio-energy systems and their features

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓		✓									✓
CO2	✓		✓									✓
CO3	✓	✓	✓		✓							✓
CO4	✓	✓	✓		✓		✓					✓
CO5	✓	✓	✓		✓							✓

REFERENCES:

1. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
2. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.

AUDIT COURSES (AC)

AX5091 ENGLISH FOR RESEARCH PAPER WRITING L T P C
2 0 0 0

COURSE OBJECTIVES:

- Teach how to improve writing skills and level of readability
- Tell about what to write in each section
- Summarize the skills needed when writing a Title
- Infer the skills needed when writing the Conclusion
- Ensure the quality of paper at very first-time submission

UNIT I INTRODUCTION TO RESEARCH PAPER WRITING 6

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

UNIT II PRESENTATION SKILLS 6

Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts, Introduction

UNIT III TITLE WRITING SKILLS 6

Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check

UNIT IV RESULT WRITING SKILLS 6

Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions

UNIT V VERIFICATION SKILLS 6

Useful phrases, checking Plagiarism, how to ensure paper is as good as it could possibly be the first- time submission

TOTAL: 30 PERIODS

COURSE OUTCOMES:

CO1 –Understand that how to improve your writing skills and level of readability
CO2 – Learn about what to write in each section
CO3 – Understand the skills needed when writing a Title
CO4 – Understand the skills needed when writing the Conclusion
CO5 – Ensure the good quality of paper at very first-time submission

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1										✓		✓
CO2										✓		✓
CO3										✓		✓
CO4										✓		✓
CO5										✓		✓

REFERENCES

1. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011
2. Day R How to Write and Publish a Scientific Paper, Cambridge University Press 2006
3. Goldbort R Writing for Science, Yale University Press (available on Google Books) 2006
4. Highman N, Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book 1998.

AX5092 **DISASTER MANAGEMENT** **L T P C**
2 0 0 0

COURSE OBJECTIVES :

- Summarize basics of disaster
- Explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.
- Illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
- Describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
- Develop the strengths and weaknesses of disaster management approaches

UNIT I INTRODUCTION **6**

Disaster: Definition, Factors and Significance; Difference between Hazard And Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude.

UNIT II REPERCUSSIONS OF DISASTERS AND HAZARDS **6**

Economic Damage, Loss of Human and Animal Life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.

UNIT III DISASTER PRONE AREAS IN INDIA **6**

Study of Seismic Zones; Areas Prone To Floods and Droughts, Landslides And Avalanches; Areas Prone To Cyclonic and Coastal Hazards with Special Reference To Tsunami; Post-Disaster Diseases and Epidemics

UNIT IV DISASTER PREPAREDNESS AND MANAGEMENT **6**

Preparedness: Monitoring Of Phenomena Triggering a Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data from Meteorological And Other Agencies, Media Reports: Governmental and Community Preparedness.

UNIT V RISK ASSESSMENT **6**

Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People's Participation in Risk Assessment. Strategies for Survival

TOTAL : 30 PERIODS

COURSE OUTCOMES:

CO1: Ability to summarize basics of disaster
CO2: Ability to explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.
CO3: Ability to illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
CO4: Ability to describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
CO5: Ability to develop the strengths and weaknesses of disaster management approaches

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓											
CO3	✓	✓	✓									
CO4	✓	✓	✓									
CO5	✓	✓	✓									

REFERENCES

1. Goel S. L., Disaster Administration And Management Text And Case Studies",Deep & Deep Publication Pvt. Ltd., New Delhi,2009.
2. NishithaRai, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'NewRoyal book Company, 2007.
3. Sahni, PardeepEt.Al. ," Disaster Mitigation Experiences And Reflections", Prentice Hall OfIndia, New Delhi, 2001.

AX5093 SANSKRIT FOR TECHNICAL KNOWLEDGE L T P C
2 0 0 0

COURSE OBJECTIVES:

- Illustrate the basic sanskrit language.
- Recognize sanskrit, the scientific language in the world.
- Appraise learning of sanskrit to improve brain functioning.
- Relate sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power.
- Extract huge knowledge from ancient literature.

UNIT I ALPHABETS 6

Alphabets in Sanskrit

UNIT II TENSES AND SENTENCES 6

Past/Present/Future Tense - Simple Sentences

UNIT III ORDER AND ROOTS 6

Order - Introduction of roots

UNIT IV SANSKRIT LITERATURE 6

Technical information about Sanskrit Literature

UNIT V TECHNICAL CONCEPTS OF ENGINEERING 6

Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics

TOTAL: 30 PERIODS

COURSE OUTCOMES:

- CO1 - Understanding basic Sanskrit language.
- CO2 - Write sentences.
- CO3 - Know the order and roots of Sanskrit.
- CO4 - Know about technical information about Sanskrit literature.
- CO5 - Understand the technical concepts of Engineering.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1										✓		✓
CO2										✓		✓
CO3												✓
CO4												✓
CO5												✓

REFERENCES

1. "Abhyaspustakam" – Dr. Vishwas, Samskrita-Bharti Publication, New Delhi
2. "Teach Yourself Sanskrit" Prathama Deeksha-Vempati Kutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3. "India's Glorious Scientific Tradition" Suresh Soni, Ocean books (P) Ltd., New Delhi, 2017.

AX5094 **VALUE EDUCATION** **L T P C**
2 0 0 0

COURSE OBJECTIVES:
Students will be able to
- Understand value of education and self-development
- Imbibe good values in students
- Let the should know about the importance of character

UNIT I
Values and self-development–Social values and individual attitudes. Work ethics, Indian vision of humanism. Moral and non-moral valuation. Standards and principles. Value judgements

UNIT II
Importance of cultivation of values. Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness. Honesty, Humanity. Power of faith, National Unity. Patriotism. Love for nature, Discipline

UNIT III
Personality and Behavior Development-Soul and Scientific attitude. Positive Thinking. Integrity and discipline. Punctuality, Love and Kindness. Avoid fault Thinking. Free from anger, Dignity of labour.
Universal brother hood and religious tolerance. True friendship. Happiness Vs suffering, love for truth. Aware of self-destructive habits. Association and Cooperation. Doing best for saving nature

UNIT IV
Character and Competence–Holy books vs Blind faith. Self-management and Good health. Science of reincarnation. Equality, Nonviolence, Humility, Role of Women. All religions and same message. Mind your Mind, Self-control. Honesty, Studying effectively.

TOTAL: 30 PERIODS

COURSE OUTCOMES:
Students will be able to
- Knowledge of self-development.
- Learn the importance of Human values.
- Developing the overall personality.

SUGGESTED READING
1. Chakroborty, S.K."Values and Ethics for organizations Theory and practice", Oxford University Press, New Delhi

AX5095 **CONSTITUTION OF INDIA** **L T P C**
2 0 0 0

COURSE OBJECTIVES:
Students will be able to:
- Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
- To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional
- Role and entitlement to civil and economic rights as well as the emergence nation hood in the early years of Indian nationalism.
- To address the role of socialism in India after the commencement of the Bolshevik Revolutionin1917and its impact on the initial drafting of the Indian Constitution.

UNIT I HISTORY OF MAKING OF THE INDIAN CONSTITUTION:
History, Drafting Committee, (Composition & Working)

UNIT II PHILOSOPHY OF THE INDIAN CONSTITUTION:
Preamble, Salient Features

UNIT III CONTOURS OF CONSTITUTIONAL RIGHTS AND DUTIES:
Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.

UNIT IV ORGANS OF GOVERNANCE:
Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions.

UNIT V LOCAL ADMINISTRATION:
District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO, Municipal Corporation. Pachayati raj: Introduction, PRI: Zila Pachayat. Elected officials and their roles, CEO Zila Pachayat: Position and role. Block level: Organizational Hierarchy (Different departments), Village level:Role of Elected and Appointed officials, Importance of grass root democracy.

UNIT VI ELECTION COMMISSION:
Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners - Institute and Bodies for the welfare of SC/ST/OBC and women.

TOTAL: 30 PERIODS

COURSE OUTCOMES:
Students will be able to:

- Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
- Discuss the intellectual origins of the framework of argument that informed the conceptualization
- of social reforms leading to revolution in India.
- Discuss the circumstances surrounding the foundation of the Congress Socialist Party[CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
- Discuss the passage of the Hindu Code Bill of 1956.

SUGGESTED READING

1. The Constitution of India,1950(Bare Act),Government Publication.
2. Dr.S.N.Busi, Dr.B. R.Ambedkar framing of Indian Constitution,1st Edition, 2015.
3. M.P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis,2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

AX5096 PEDAGOGY STUDIES L T P C
2 0 0 0

COURSE OBJECTIVES
Students will be able to:

- Review existing evidence on there view topic to inform programme design and policy
- Making under taken by the DfID, other agencies and researchers.
- Identify critical evidence gaps to guide the development.

UNIT I INTRODUCTION AND METHODOLOGY:
Aims and rationale, Policy background, Conceptual framework and terminology - Theories of learning, Curriculum, Teacher education - Conceptual framework, Research questions **-** Overview of methodology and Searching.

UNIT II THEMATIC OVERVIEW

Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries - Curriculum, Teacher education.

UNIT III EVIDENCE ON THE EFFECTIVENESS OF PEDAGOGICAL PRACTICES

Methodology for the in depth stage: quality assessment of included studies - How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? - Theory of change - Strength and nature of the body of evidence for effective pedagogical practices - Pedagogic theory and pedagogical approaches - Teachers' attitudes and beliefs and Pedagogic strategies.

UNIT IV PROFESSIONAL DEVELOPMENT

Professional development: alignment with classroom practices and follow up support - Peer support - Support from the head teacher and the community - Curriculum and assessment - Barriers to learning: limited resources and large class sizes

UNIT V RESEARCH GAPS AND FUTURE DIRECTIONS

Research design – Contexts – Pedagogy - Teacher education - Curriculum and assessment - Dissemination and research impact.

TOTAL: 30 PERIODS

COURSE OUTCOMES:

Students will be able to understand:

- What pedagogical practices are being used by teachers informal and informal classrooms in developing countries?
- What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
- How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

SUGGESTED READING

1. Ackers J, HardmanF (2001) Classroom interaction in Kenyan primary schools, Compare, 31(2): 245-261.
2. Agrawal M (2004)Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36(3):361-379.
3. Akyeampong K (2003) Teacher training in Ghana-does it count? Multi-site teacher education research project (MUSTER) country report 1.London:DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33(3): 272–282.
5. Alexander RJ(2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.
6. Chavan M(2003) Read India: Amass scale, rapid, 'learning to read' campaign.
7. www.pratham.org/images/resource%20working%20paper%202.pdf

AX5097 **STRESS MANAGEMENT BY YOGA** **L T P C**
2 0 0 0

COURSE OBJECTIVES

- To achieve overall health of body and mind
- To overcome stress

UNIT I

Definitions of Eight parts of yoga.(Ashtanga)

UNIT II

Yam and Niyam - Do`s and Don't's in life - i) Ahinsa, satya, astheya, bramhacharya and aparigraha, ii) Ahinsa, satya, astheya, bramhacharya and aparigraha.

UNIT III

Asan and Pranayam - Various yog poses and their benefits for mind & body - Regularization of breathing techniques and its effects-Types of pranayam

TOTAL: 30 PERIODS

COURSE OUTCOMES

Students will be able to:

- Develop healthy mind in a healthy body thus improving social health also
- Improve efficiency

SUGGESTED READING

1. 'Yogic Asanas for Group Tarining-Part-I":Janardan Swami Yoga bhyasi Mandal, Nagpur
2. "Rajayoga or conquering the Internal Nature" by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata

AX5098 **PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS** **L T P C**
2 0 0 0

COURSE OBJECTIVES:

- To learn to achieve the highest goal happily
- To become a person with stable mind, pleasing personality and determination
- To awaken wisdom in students

UNIT I

Neetisatakam-holistic development of personality - Verses- 19,20,21,22 (wisdom) - Verses- 29,31,32 (pride & heroism) – Verses- 26,28,63,65 (virtue) - Verses- 52,53,59 (dont's) - Verses- 71,73,75,78 (do's)

UNIT II

Approach to day to day work and duties - Shrimad Bhagwad Geeta: Chapter 2-Verses 41, 47,48 - Chapter 3-Verses 13, 21, 27, 35 Chapter 6-Verses 5,13,17,23, 35 - Chapter 18-Verses 45, 46, 48.

UNIT III

Statements of basic knowledge - Shrimad Bhagwad Geeta: Chapter2-Verses 56, 62, 68 Chapter 12 -Verses 13, 14, 15, 16,17, 18 - Personality of role model - shrimad bhagwad geeta - Chapter2-Verses 17, Chapter 3-Verses 36,37,42 - Chapter 4-Verses 18, 38,39 Chapter18 – Verses 37,38,63

TOTAL: 30 PERIODS

COURSE OUTCOMES:

Students will be able to

- Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life
- The person who has studied Geeta will lead the nation and mankind to peace and prosperity
- Study of Neet is hatakam will help in developing versatile personality of students.

SUGGESTED READING

1. Gopinath, Rashtriya Sanskrit Sansthanam P, Bhartrihari's Three Satakam, Niti-sringar-vairagya, New Delhi,2010
2. Swami Swarupananda , Srimad Bhagavad Gita, Advaita Ashram, Publication Department, Kolkata, 2016.