GOVERNMENT COLLEGE OF ENGINEERING, SALEM-11

(An Autonomous Institution Affiliated to Anna University, Chennai)

Department of Mechanical Engineering

Curriculum and Syllabus – Regulation 2018A

M.E. THERMAL ENGINEERING (FT)

GOVERNMENT COLLEGE OF ENGINEERING, SALEM

DEPARTMENT OF MECHANICAL ENGINEERING

M.E – THERMAL ENGINEERING

VISION OF THE DEPARTMENT

- The department of Mechanical Engineering is committed to blossom into a centre of excellence, dedicated and competent engineers by providing global quality interactive technical education to cater the needs of the industries and nation into a technologically, socially and culturally advanced one.

MISSION OF THE DEPARTMENT

- Constantly updating the departmental resources, faculty and other infrastructure by acquiring the state of the art equipments and by imparting constant in-service training to the faculty and supporting staff.
- Promoting skilled and employable graduates to meet the challenges in emerging fields of engineering.
- To prepare the students for prosperous career in entrepreneurship with leader ship qualities, ethics and human values.
- The department executes life-long learning skills and provides engineering services for sustainable development of the society.

PROGRAMME EDUCATIONAL OBJECTIVES – (Thermal Engineering)

PEO 1: Excel in higher education by acquiring knowledge in mathematical, analytical and engineering principles.

PEO 2: Expertise in analyzing real life problems in various Thermal engineering systems, giving appropriate solutions that are technically sound, economically feasible and socially acceptable.

PEO 3: Exhibit professionalism, ethical attitude, communication skills, team work in their profession and adapt to current trends by engaging in lifelong learning.

PROGRAMME OUTCOMES – (Thermal Engineering)

PO 1: An ability to apply knowledge of computing, mathematics, science and engineering fundamentals appropriate to the discipline.

PO 2: An ability to analyze a problem, and identify and formulate the computing requirements appropriate to its solution.

PO 3: An ability to design, implement, and evaluate a computer-based system, process, component, or program to meet desired needs with appropriate consideration for public health and safety, cultural, societal and environmental considerations.

PO 4: An ability to design and conduct experiments, as well as to analyze and interpret data.

PO 5: An ability to use current techniques, skills, and modern tools necessary for computing practice.

PO 6: An ability to function effectively individually and on teams, including diverse and multidisciplinary, to accomplish a common goal.

PO 7: An understanding of engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects.

PO 8: An ability to communicate effectively with a range of audiences.

PO 9: Recognition of the need for and an ability to engage in continuing professional development.

PO 10: An understanding of professional, ethical, legal, security and social issues and responsibilities.

PO 11: An ability to examine the outcomes of actions and making corrective measures individually.

PROGRAM SPECIFIC OUTCOMES – (Thermal Engineering)

PSO 1: Capability to apply the basic and advanced technical knowledge to solve the real case problems in various domains of thermal engineering.

PSO 2: Ability to identify, formulate and analyze the complex problems in thermal engineering field for the benefit of the society and environment.

PSO 3: Ability to find out the local and global industrial problems and solve them with the use of mechanical engineering tools and the software for attaining the realistic outcome

GOVERNMENT COLLEGE OF ENGINEERING, SALEM – 636 011

DEPARTMENT OF MECHANICAL ENGINEERING

Curriculum 2018A

M.E. THERMAL ENGINEERING – Full Time

Course code	Name of the Course	Hours/Week						Maximum Marks		
		Category	Contact periods	Lecture	Tutorial/ Demo*	Practical	Credit	CA	FE	Total
SEMESTER I										
18THC11	Thermodynamics and Combustion	PC	45	3	0	0	3	40	60	100
18THC12	Advanced Fluid Dynamics	PC	45	3	0	0	3	40	60	100
18THE1X	Programme Electives-I	PE	45	3	0	0	3	40	60	100
18THE2X	Programme Electives-II	PE	45	3	0	0	3	40	60	100
18THC13	Thermal Engineering Lab –I	PC	60	0	0	4	2	40	60	100
18THC14	Simulation Laboratory	PC	60	0	0	4	2	40	60	100
18MLC01	Research Methodology and IPR	MLC	30	2	0	0	3	40	60	100
18AC0X	Audit Course – 1	AC	24	2	0	0	0	-	-	-
TOTAL				**16**	**0**	**8**	**19**	**280**	**420**	**700**
SEMESTER II										
18THC21	Advanced Heat Transfer	PC	45	3	0	0	3	40	60	100
18THC22	Instrumentation for Thermal Systems	PC	45	3	0	0	3	40	60	100
18THE3X	Programme Electives- III	PE	45	3	0	0	3	40	60	100
18THE4X	Programme Electives-IV	PE	45	3	0	0	3	40	60	100
18THC23	Thermal Engineering Laboratory-II	PC	60	0	0	4	2	40	60	100
18THC24	Modelling Laboratory	PC	60	0	0	4	2	40	60	100
18AC0X	Audit Course -2	AC	24	2	0	0	0	-	-	-
18THC25	Mini-Project	PRO	30	0	0	4	2	40	60	100
TOTAL				**16**	**0**	**12**	**18**	**280**	**420**	**700**

SEMESTER III										
18THE5X	Programme Electives-V	PE	45	3	0	0	3	40	60	100
18THE6X	Programme Electives-VI	OE	45	3	0	0	3	40	60	100
18THC31	Dissertation Phase - I	PRO		0	0	20	10	80	120	200
TOTAL				**6**	**0**	**20**	**16**	**160**	**240**	**400**
SEMESTER IV										
18THC41	Dissertation Phase - II	PRO		0	0	32	16	160	240	400
TOTAL				**0**	**0**	**32**	**16**	**160**	**240**	**400**

Total Credits for the Programme = 19 + 18 + 16 + 16 = 69

List of Programme Electives:

Course Code	Name of Course
Elective 1	
18CDE11	Advanced Mathematical methods in Engineering
18THE11	Nuclear Engineering
18THE12	Energy Conservation and Management
18THE13	Alternative Fuels for IC Engines
18THE14	Electronic Engine Management Systems
18THE15	Analysis of Heat Transfer
Elective II	
18THE21	Air Conditioning System Design
18THE22	Advanced IC Engines
18THE23	Optimization Techniques in Engineering
18THE24	Boundary Layer Theory and Turbulence
18THE25	Combustion in IC Engines
18CDE26	Nanomaterials Technology
Elective III	
18THE31	Refrigeration and cryogenics
18THE32	Design of Heat Exchangers
18THE33	Cogeneration and Waste Heat Recovery Systems

18THE34	Design of Condensers Evaporators and Cooling Towers
18THE35	Steam Engineering
Elective – IV	
18THE41	Computational Fluid Dynamics
18THE42	Simulation of IC Engines Processes
18THE43	Fuels and Combustion
18THE44	Environment and Pollution Control
18THE45	Modern Power Plant Engineering
Elective –V	
18THE51	Design of Solar and Wind System
18THE52	Design and Analysis of Turbo machines
18THE53	Energy Systems Modelling & Analysis
18THE54	Internal Combustion Engine Design
18THE55	Advanced Finite Element Analysis
Elective –VI	
18THE61	Business Analytics
18THE62	Industrial Safety
18THE63	Operations Research
18THE64	Cost Management of Engineering Projects
18THE65	Waste to Energy

List of Audit Courses

Course Code	**Name of Course**
18AC01	English for Research Paper Writing
18AC02	Disaster Management

SEMESTER –I

18THC11	THERMODYNAMICS AND COMBUSTION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To impart the fundamental concepts about availability
2. To impart knowledge on real gas behaviour and different thermodynamic relationship.
3. To study the combustion principles and statistical interpretation of thermodynamic laws.

UNIT I AVAILABILITY ANALYSIS 9 + 0

First law and state postulates, availability, irreversibility second-Law Efficiency for a closed System and steady-State control volume- Availability analysis of simple cycles.

UNIT II REAL GAS BEHAVIOR 9 + 0

Real gas mixtures, ideal solution of real gases and liquids, activity, equilibrium in multi-Phase systems- Gibbs phase rule for non-reactive components.

UNIT III GENERALIZED THERMODYNAMIC RELATIONSHIP 9 + 0

Maxwell relations, generalized relation for changes in entropy, internal energy and enthalpy-Generalized relations for C_p and C_v - Clausius Clayperon Equation - Joule-Thomson Coefficient - Bridgman tables for thermodynamic relations.

UNIT IV COMBUSTION PRINCIPLES 9 + 0

Concepts of combustion – Combustion equations, stoichiometry, thermo chemistry, adiabatic temperature-Availability analysis of reacting mixture chemical equilibrium. Heat of combustion - Theoretical flame temperature, chemical equilibrium and dissociation.

UNIT V STATISTICAL THERMODYNAMICS AND THIRD LAW OF THERMODYNAMICS 9 + 0

Statistical thermodynamics - Statistical interpretations of first and second law and Entropy -Third law of thermodynamics, nernst heat theorem.

Total (45+0)= 45 Periods

COURSE OUTCOMES:

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

CO1 : understand the basic laws governing energy conversion in multi component systems and application of chemical thermodynamics.

CO2 : understand the real gas behavior and thermodynamic relationship.

CO3 : understand the combustion principles and statistical interpretation of thermodynamic laws.

TEXT BOOKS:

1. Cengel, “Thermodynamics”, Tata McGraw Hill Co., New Delhi, 1980.
2. Howell and Dedcius, “Fundamentals of Engineering Thermodynamics”, McGraw Hill Inc., U.S.A.

REFERENCE BOOKS:

1. Van Wylen& Sonntag, “Thermodynamics”, John Wiley and Sons Inc., U.S.A.
2. Jones and Hawkings, “Engineering Thermodynamics”, John Wiley and Sons Inc., U.S.A, 2004.
3. Faires V.M. and Simmag, “Thermodynamics”, Macmillan Publishing Co. Inc., U.S.A.
4. Holman, “Thermodynamics”, McGraw Hill Inc., New York, 2002.
5. Rao Y.V.C., “Postulational and Statistical Thermodynamics”, Allied Publishers Inc, 1994.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	1	-	1	-	1	1	-	-	-	2	3	2	1
CO2	1	3	2	2	2	2	-	-	-	-	2	2	2	2
CO3	2	2	2	2	1	1	1	-	-	-	2	3	1	1

1- Faintly
2- Moderately
3- Strongly

18THC12 **ADVANCED FLUID DYNAMICS** **L T P C**
3 0 0 3

COURSE OBJECTIVES:

1. To understand the fundamental equation for fluid flow.
2. To impart knowledge to find solution for Navier stokes equation
3. To understand the concept of boundary layer and find solution for boundary layer equation.

UNIT I TYPES OF FLOW **9 + 0**

Fully developed flows, parallel flow in straight channel, couette flow, creeping flows

UNIT II GOVERNING EQUATIONS IN FLUID DYNAMICS **9 + 0**

Derivation of Continuity and Momentum equations using integral and differential approach - Dimensionless form of governing equations - Special forms of governing equations - Integral quantities.

UNIT III POTENTIAL FLOW **9 + 0**

Reynolds – Transport theorem - Kelvin's theorem - Irrotational flow - Stream function- Vorticity approach

UNIT IV BOUNDARY LAYERS **9 + 0**

Boundary layer equations, flow over flat plate - Momentum integral equation for boundary layer - Approximate solution methodology for boundary layer equations

UNIT V TURBULENT FLOW CHARACTERISTICS **9 + 0**

Characteristics of turbulent flow - Laminar turbulent transition - Time mean motion and fluctuations - Derivation of governing equations for turbulent flow - Shear stress models - Universal velocity distribution

Total (45+0)= 45 Periods

COURSE OUTCOMES:

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

CO1 *:* understand and define the fluid flow problems along with range of governing parameters
CO2 *:* solve the navier stokes equation.
CO3 *:* describe the boundary layer and find solution for it.

TEXT BOOKS:

1. Muralidhar and Biswas, Advanced Engineering Fluid Mechanics, , Alpha Science International, 2005.
2. Irwin Shames, Mechanics of Fluids, , McGraw Hill, 2003.

REFERENCE BOOKS:

1. Fox R.W., McDonald A.T , Introduction to Fluid Mechanics, John Wiley and Sons Inc,1985.
2. Pijush K. Kundu, Ira M Kohen and David R. Dawaling, Fluid Mechanics, Fifth Edition,2005.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	2	2	2	1	1	1	-	-	1	2	3	-
CO2	3	1	1	-	1	1	-	-	-	-	1	2	3	-
CO3	3	2	2	2	2	1	1	-	-	-	1	2	2	1

1- Faintly
2- Moderately
3- Strongly

18THC13	THERMAL LABORATORY- I	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES:

1. Obtain numerical solutions for conduction heat transfer problems.
2. Evaluate heat transfer coefficients for natural and forced convection.
3. To provide hands on experience in operating various types of internal combustion engines and understand their functioning and performance.

LIST OF EXERCISES

1. Thermal conductivity of Lagged pipe
2. Heat transfer from Pin-Fin Apparatus
3. Heat Balanced through Composite Wall
4. Heat transfer in Natural & Forced Convection
5. Advanced Measurement system for Computerized Diesel engine test
6. Multi cylinder Marine Diesel Engine
7. Variable load test on single cylinder Four stroke diesel engine (horizontal)
8. Variable compression ratio diesel engine test rig
9. Performance test on Reciprocating air compressor
10. Performance test on Centrifugal blower rig

Total = 60hours

COURSE OUTCOMES:

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

CO1 : understand the concepts of thermal conductivity.
CO2 : understand the concepts of forced and natural convection.
CO3 : understand the working principle and performance of IC Engine.
CO4 : understand the working principle and performance of air compressors.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	-	1	3	3	2	1	-	2	-	2	2	2	3
CO2	2	-	1	3	2	2	-	-	2	-	2	2	3	3
CO3	1	2	2	2	2	1	-	-	1	1	2	2	1	2

1- Faintly
2- Moderately
3- Strongly

18THC14 **SIMULATION LABORATORY** **L T P C**
0 0 4 2

COURSE OBJECTIVES:

1. To develop modelling and analysis skills on steady state heat conduction, convection and radiation problems
2. To develop modelling and analysis skills on unsteady state heat conduction, convection and radiation problems
3. To develop modelling and analysis on phase change processes heat transfer.

LIST OF EXERCISES

1. Steady State Conduction in solid
2. Steady State Convection in solid
3. Steady State Radiation in solid
4. Combined Conduction and Radiation
5. Un-Steady State Conduction and Convection
6. Un-Steady State Conduction and radiation
7. Steady state Conduction in Fluids
8. Steady state Convection in Fluids
9. Condensation and Boiling heat transfer
10. Solar Radiation Model

Total = 60hours

COURSE OUTCOMES:

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

CO1 : simulate and analyze the steady state heat transfer heat transfer problems.
CO2 : simulate and analyze the unsteady state heat transfer heat transfer problems.
CO3 : simulate and analyze boiling and condensation heat transfer problems.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	-	2	2	2	2	1	1	-	-	-	2	2	3	1
CO2	2	2	3	2	2	1	2	1	-	-	2	3	3	1
CO3	2	2	2	3	2	2	1	1	-	-	2	1	2	2

1- Faintly
2- Moderately
3- Strongly

18MLC01	RESEARCH METHODOLOGY AND IPR	L	T	P	C
		2	0	0	3

COURSE OBJECTIVES:

1. To develop the skills required for defining research problems.
2. To develop skills required for effective literature studies.
3. To develop technical thesis writing skills.
4. To impact knowledge about IPR.

UNIT I INTRODUCTION TO RESEARCH 6 + 0

Meaning of research problem -Sources of research problem - Criteria and 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 EFFECTIVE LITERATURE STUDIES, APPROACHES AND ANALYSIS 6 + 0

Developing the theoretical frame work of the research - Developing operational statements of the problem - Criteria for evaluating research approach – Hypotheses - Parametric and non-parametric testing - Establishing the reliability and validity of findings with literature review and experiments – documentation – Plagiarism - Research ethics.

UNIT III EFFECTIVE TECHNICAL WRITING 6 + 0

Developing a Research Proposal - Format of research proposal - Presentation - Assessment by a review committee

UNIT IV NATURE OF INTELLECTUAL PROPERTY 6 + 0

Patents – Designs - Trade and copyright - Process of patenting and development - Technological research – Innovation and patenting - International scenario: International cooperation on Intellectual property - Procedure for grants of patents - Patenting under PCT.

UNIT V PATENT RIGHTS AND IPR 6 + 0

Scope of patent rights - Licensing and transfer of technology - Patent information and databases - Geographical Indications - Administration of patent system - New developments in IPR - IPR of Biological Systems - Computer software etc - Traditional knowledge and Case Studies - IPR.

Total (30+0)= 30 Periods

COURSE OUTCOMES:

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

CO1 : acquire the skills required for defining research problems.
CO2 : acquire the skills required for effective literature studies.
CO3 : acquire the technical thesis writing skills.
CO4 : understand the concept of patent and IPR

TEXT BOOKS:

1. Stuart Melville and Wayne Goddard, “Research methodology: an introduction for science & engineering students’”
2. Wayne Goddard and Stuart Melville, “Research Methodology: An Introduction”
3. Ranjit Kumar, 2 nd Edition, “Research Methodology: A Step by Step Guide for beginners”
4. Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd ,2007.

REFERENCE BOOKS:

1. Mayall , “Industrial Design”, McGraw Hill, 1992.
2. Niebel , “Product Design”, McGraw Hill, 1974.
3. Asimov, “Introduction to Design”, Prentice Hall, 1962.
4. Robert P. Merges, Peter S. Menell, Mark A. Lemley, “ Intellectual Property in New Technological Age”, 2016.
5. T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	3	2	2	2	1	1	-	-	-	2	1	3	-
CO2	2	3	3	2	2	1	1	1	-	-	2	1	3	-
CO3	-	-	-	-	-	2	1	-	3	3	2	1	3	1
CO4	1	-	-	-	2	2	2	-	2	-	2	2	2	3
CO5	2	1	-	-	2	2	2	-	2	-	2	-	1	2

1- Faintly
2- Moderately
3- Strongly

SEMESTER –II

18THC21	ADVANCED HEAT TRANSFER	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To study Heisler and Grober charts and to discuss about transient heat conduction
2. To compare and optimization of longitudinal fin of rectangular, triangular and parabolic profiles
3. To understand boundary layers and to formulate pool and flow boiling correlations
4. To discuss thermal radiation, view factor, gas radiation, radiation effect on temperature measurement.

UNIT I TRANSIENT HEAT CONDUCTION 9 + 0

Transient heat conduction – Exact solution – Use of Heisler and Grober charts-Semi-infinite solids – Multidimensional systems.

UNIT II EXTENDED SURFACES 9 + 0

Extended surfaces – Steady state analysis and optimization – Longitudinal fin of rectangular, triangular and parabolic profile radiating to free space – Radial fins.

UNIT III BOUNDARY LAYER CONCEPT 9 + 0

Thermal boundary layers – Momentum and energy equations – Internal and external flows – Forced convection over cylinders, spheres and bank of tubes.

UNIT IV PHASE CHANGE HEAT TRANSFER 9 + 0

Heat transfer with phase change – Condensation and boiling heat transfer – Heat transfer in condensation, Effect of non-condensable gases in condensing equipment – Pool and flow boiling correlations.

UNIT V RADIATION HEAT TRANSFER 9 + 0

Thermal radiation – View factor – Gas radiation – Transmitting, reflecting and absorbing media – Flame radiation in furnaces – Radiation effect on temperature measurement.

Total (45+0)= 45 Periods

COURSE OUTCOMES:

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

CO1 : analyze about transient heat conduction and to use Heisler and Grober charts
CO2 : analyze and optimize various fins like rectangular, triangular and parabolic profiles for heat transfer applications.
CO3 : understand thermal boundary layers, momentum and energy equations
CO4 : describe condensation and boiling heat transfer and estimate pool and flow boiling heat transfer
CO5 : analyze thermal and gas radiation in heat transfer equipment.

TEXT BOOKS:

1. J.P. Holman, “Heat Transfer”, McGraw Hill Book Company, New York, 1990
2. Ozisik, M.N., Heat Transfer - A Basic Approach, McGraw-Hill, 1987
3. Incropera and Dewitt, “Fundamentals of Heat and Mass Transfer”, John Wiley and Sons, New York, 2000
4. Frank Kreith, “Principles of Heat Transfer”, Harper and Row Publishers, New York, 1973

REFERENCE BOOKS:

1. Donald Q. Kern “Process Heat Transfer”, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1975
2. Gupta and Prakash, “Engineering Heat Transfer”, New Chand and Bros, Roorkee (U.P.)India, 1996
3. R.C. Sachdeva “Fundamentals of Engineering Heat and Mass Transfer”, Wiley Eastern Ltd., India

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	2	2	2	1	2	-	-	-	1	2	2	2
CO2	3	3	2	2	2	1	1	-	-	-	1	2	3	1
CO3	2	3	2	2	2	1	-	-	-	-	1	3	1	1
CO4	2	3	3	3	2	2	1	-	-	-	1	2	2	1
CO5	2	3	3	3	2	2	1	-	-	-	1	2	2	-

1- Faintly
2- Moderately
3-Strongly

18THC22	INSTRUMENTATION FOR THERMAL SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To study about various measurement characteristics
2. To learn how to use computers in measurement
3. To learn how to use data acquisition system in measuring the parameters

UNIT I MEASUREMENT CHARACTERISTICS 9 + 0

Instrument Classification, characteristics of instruments – Static and dynamic - Experimental error analysis - Systematic and random errors - Statistical analysis – Uncertainty - Experimental planning and selection of measuring instruments - Reliability of instruments

UNIT II MICROPROCESSORS AND COMPUTERS IN MEASUREMENT 9 + 0

Data logging and acquisition – use of sensors for error reduction - Elements of micro computer interfacing - Intelligent instruments in use.

UNIT III MEASUREMENT OF PHYSICAL QUANTITIES 9 + 0

Measurement of thermo-physical properties - Instruments for measuring temperature, pressure and flow - Use of sensors for physical variables

UNIT IV ADVANCE MEASUREMENT TECHNIQUES 9 + 0

Shadowgraph – Schlieren – Interferometer - Laser doppler anemometer - Hot wire anemometer, heat flux sensors - Telemetry in measurement

UNIT V MEASUREMENT ANALYSIS 9 + 0

Chemical, thermal, magnetic and optical gas analyzers - Measurement of smoke, dust and moisture - Gas chromatography – Spectrometry - Measurement of pH - Review of basic measurement techniques

Total = 45 Periods

COURSE OUTCOMES:

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

CO1 : select the suitable measurement technique
CO2 : choose the suitable instruments for measurement
CO3 : apply the correct advanced techniques in measurement
CO4 : use the data acquisition system in the real time measurements

TEXT BOOKS:

1. Holman, J.P., Experimental methods for Engineers, Tata McGraw-Hill, 7th Ed.2001.
2. Bolton.W, Industrial Control & Instrumentation, Universities Press, Second Edition, 2001

REFERENCE BOOKS:

1. Barney G.C, Intelligent Instrumentation, Second Edition, Prentice Hall of India, 1988.
2. Doblin E.O, Measurement System Application and Design, Second Edition, McGraw Hill, 1978
3. Nakra, B.C., Choudhry K.K., Instrumentation, Measurements and Analysis Tata McGraw Hill, New Delhi, 2nd Edition 2003
4. Morris.A.S, Principles of Measurements and Instrumentation, Prentice Hall of India, 1998

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	1	2	2	3	1	1	-	-	-	2	1	2	1
CO2	2	1	2	2	3	1	1	-	-	-	2	1	2	1
CO3	2	1	3	2	3	1	1	-	-	-	2	2	2	1
CO4	1	2	2	3	2	1	1	-	-	-	2	2	2	1

1- Faintly
2- Moderately
3- Strongly

18THC23 **THERMAL LABORATORY – II** **L T P C**
0 0 4 2

COURSE OBJECTIVES:

1. To analyze the performance of several types of heat exchangers.
2. To analyze the performance of refrigeration system.
3. To analyze the performance of air conditioning systems.

LIST OF EXERCISES

1. Parallel flow heat exchanger
2. Counter flow heat exchanger
3. Shell and tube heat exchanger
4. Double pipe heat exchanger
5. Solar PV Grid Tied Training system
6. Solar Concentrator Training System
7. Compact heat exchanger
8. Refrigeration test rig
9. Vapor absorption test rig
10. Air conditioning rig

Total = 60hours

COURSE OUTCOMES:

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

CO1 : acquire hands on experience on the various test-rigs, experimental set up.
CO2 : measure the various technical parameters using instrument and using Mathematical relationship.
CO3 : identify the effect of various parameters on the system and able to correlate them.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	1	1	3	3	1	1	-	-	-	2	2	3	2
CO2	3	3	2	1	1	1	-	-	-	-	2	2	3	1
CO3	2	2	1	2	2	1	-	-	-	-	2	2	3	1

1- Faintly
2- Moderately
3- Strongly

18THC24 **MODELLING LABORATORY** **L T P C**
0 0 4 2

COURSE OBJECTIVES:

1. To impart the fundamental knowledge on using MATLAB.
2. To impart knowledge on how MATLAB tool is used by solving various heat transfer problems.

LIST OF EXERCISES

1. Simulation of heat transfer and pressure drop of a Double Pipe Heat Exchanger using MATLAB
2. Simulation of heat transfer and pressure drop of a shell and Tube Heat Exchanger Using MATLAB
3. Simulation of heat transfer and pressure drop of a Parallel flow Heat Exchanger Using MATLAB
4. Simulation of Transient heat conduction
5. Simulation of Boundary layer Flow over Flat plate using MATLAB
6. Simulation of 3D Finite Element Analysis Using MATLAB

Total = 60hours

COURSE OUTCOMES:

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

CO1 : expertise on simulation software, for analyzing machine components

CO2 : to have knowledge in various heat transfer simulation study on different thermal engineering applications using MATLAB.

CO3 : the graphical and animation of the simulation results helps to the students, to understanding the load or its functional effects on machine components.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	3	2	3	2	1	1	-	-	-	2	2	3	-
CO2	3	3	2	2	2	1	1	-	-	-	2	3	2	-
CO3	2	2	2	3	3	1	2	-	-	-	2	2	3	1

1- Faintly
2- Moderately
3- Strongly

18THC25	MINI PROJECT	L	T	P	C
		0	0	4	2

Students can take up small problems in the field of thermal engineering as mini project.

It can be related to solution to an engineering problem, verification and analysis of experimental data available, conducting experiments on various engineering subjects, material characterization, studying a software tool for the solution of an engineering problem etc.

Total = 30 Periods

COURSE OUTCOMES:

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

CO1 : get an opportunity to work in actual industrial environment if they opt for internship.
CO2 : solve live problem using software or analytical or computational tools.
CO3 : write technical reports.
CO4 : develop skills to present and defend their work in front of technically qualified audience.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	-	1	2	3	-	1	3	-	1	1	-	-	-	1
CO2	-	2	3	3	-	2	3	-	2	1	-	2	3	-
CO3	-	2	3	3	-	2	3	-	2	2	-	2	-	-
CO4	-	2	3	3	-	2	3	-	3	2	-	-	-	-

1- Faintly
2- Moderately
3- Strongly

18THC31 **DISSERTATION PHASE – I**

L	T	P	C
0	0	20	10

COURSE OBJECTIVES:

1. To develop the ability to solve a specific problem right from its identification and literature review until the successful solution of the same.
2. To train the students in preparing project reports and to face reviews and viva voce examination

CONTENTS:

1. The Project Work will start in semester III and should preferably be a problem with research potential and should involve scientific research, design, generation/collection and analysis of data, determining solution and must preferably bring out the individual contribution.
2. The seminar should be based on the area in which the candidate has undertaken the dissertation work as per the common instructions for all branches of M. E.
3. The examination shall consist of the preparation of a report consisting of a detailed problem statement and a literature review.
4. The preliminary results (if available) of the problem may also be discussed in the report. The work has to be presented in front of the examiner's panel set by Headland PG coordinator.
5. The candidit has to being regular contact with his guide and the topic of the dissertation must be mutually decided by the guide and student.

COURSE OUTCOMES:

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

CO1 : practice self-learning on various topics.
CO2 : learn to write technical reports.
CO3 : develop oral and written communication skills to present and defend their audience work in front of technically qualified.
CO4 : conduct tests on existing setups/equipment and draw logical conclusions from the results after analyzing them.
CO5 : work in a research environment or in an industrial environment.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	3	3	1	1	1	1	1	2	1	1	-	1	1
CO2	2	-	1	2	-	1	-	1	2	1	-	1	2	-
CO3	-	-	-	-	-	2	-	1	-	1	-	-	2	-
CO4	-	-	-	-	-	2	2	-	1	-	1	-	-	1
CO5	1	1	1	-	3	-	1	1	-	-	-	-	-	1

1- Faintly
2- Moderately
3- Strongly

SEMESTER IV

18THC41	DISSERTATION PHASE – II	L	T	P	C
		0	0	32	16

COURSE OBJECTIVES:

1. To work on the topic, and get the result
2. To develop the skill of achieving specific research target in a limited time
3. To implement/complete the thesis work

CONTENTS:

1. It is a continuation of Project work started in semester III. He has to submit the report in prescribed format and also present a seminar. The dissertation should be presented in standard format as provided by the department.

2. The candidate has to prepare a detailed project report consisting of introduction of the problem, problem statement, literature review, objectives of the work, methodology (experimental set up or numerical details as the case may be) of solution and results and discussion.

3. The report must bring out the conclusions of the work and future scope for the study. The work has to be presented in front of the examiners panel consisting of an approved external examiner, an internal examiner and a guide, co-guide etc. as decided by the Head and PG coordinator. The candidate has to be in regular contact with his guide.

COURSE OUTCOMES:

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

CO1 : use different experimental techniques
CO2 : design and develop an experimental set up/ equipment/test rig.
CO3 : conduct tests on existing set ups/equipment's and draw logical conclusions from the results after analyzing them.
CO4 : work in a research environment or in an industrial environment
CO5 : conversant with technical report writing.
CO6 : present and convince their topic of study to the engineering community.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	3	3	1	1	1	1	1	2	1	1	-	-	-
CO2	-	1	1	-	-	-	3	1	-	1	-	-	-	1
CO3	2	-	1	2	-	1	-	1	2	1	1	-	-	1
CO4	-	-	-	-	-	2	-	1	-	1	-	-	-	1
CO5	-	-	-	-	-	2	2	-	1	-	1	-	-	1
CO6	1	1	1	-	-	1	3	1	1	-	1	-	-	2
CO7	1	1	1	-	-	-	1	1	-	-	-	-	-	-

1- Faintly
2- Moderately
3- Strongly

PROGRAMME ELECTIVES-1

18CDE11	ADVANCED MATHEMATICAL METHODS IN ENGINEERING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To familiarize with the numerical solution of linear and non-linear equations and fitting curves by the method of least squares.
2. To acquire the knowledge to obtain solution of wave equation using Eigen function.
3. To obtain the solutions of diffusion and wave equation using techniques of Laplace and Fourier transforms
4. To analyze the variance of factors by one way and two way classification and some standard design of experiments.
5. To understand the significance of central limit theorem and testing of hypothesis

UNIT I CURVE FITTING AND SOLUTION OF EQUATIONS 9 + 0

Curve fitting by the Method of Least Squares –Fitting of straight lines, second degree parabolas and curves reducible to linear forms- Solution of algebraic and transcendental equations by Newton- Raphson method- Solutions of linear system of equations by Gauss elimination, Gauss Jordan and Gauss Seidal methods**.**

UNIT II PARTIAL DIFFERENTIAL EQUATIONS 9 + 0

Classification of second order PDE- Solution of PDE by separation of variables- Solution of Parabolic, elliptic and hyperbolic equation in cylindrical and spherical co-ordinates- Initial and boundary value problems for Two dimensional wave equation by the method of Eigen function - D Alembert's solution for the wave equation

UNIT III FOURIER AND LAPLACE TRANSFORMS 9 + 0

Maximum-Minimum principle for Elliptic equations- Solution of diffusion equation and wave equation by Laplace transform technique – Solution of Diffusion equation, wave equation and Laplace equation by Fourier transform technique.

UNIT IV STANDARD DISTRIBUTIONS AND TESTING OF HYPOTHESIS 9 + 0

Random variables - Standard discrete and continuous distributions (Binomial, poisson, normal, uniform and exponential) – Central limit theorem and its significance - Testing a statistical hypothesis sampling distributions (t-test, F-test and Chi-square test).

UNIT V ANALYSIS OF VARIANCE AND DESIGN OF EXPERIMENTS 9 + 0

Analysis of variance - One way and two way classifications- Principles of design of experiments- Some standard designs (completely randomized design, randomized block design and latin square design).

Total (45)= 45 Periods

COURSE OUTCOMES:

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

CO1 : obtain the numerical solution of linear and non-linear equations and fitting curves by method of least squares.

CO2 : obtain the solution of wave equation using of eigen function

CO3 : obtain the solutions of diffusion and wave equation involved in engineering problems using Laplace and Fourier transform techniques.

CO4 gain the knowledge on statistical sampling and its applications, analysis of variance as one and two way classification.

TEXT BOOKS:

1. K.Sankara Rao, "Introduction to Partial Differential Equations", Prentice Hall of India Pvt. Ltd., New Delhi, 2003.
2. Veerarajan.T, "Probability, Statistics and Random process", Tata McGraw- Hill publications, second edition, New Delhi, 2002.
3. Kandasamy.P, Thilagavathy.K, Gunavathi.K, "Numerical Methods" S.Chand& Co., New Delhi, 2005.

REFERENCE BOOKS:

1. Grewal, B.S., "Higher Engineering Mathematics", 43rd edition, Khanna Publishers, New Delhi 2014.
2. J.B.Joshi, "Differential equations for Scientists and Engineers", Narosa Publications, 2010.
3. O'Neil, "Advanced Engineering Mathematics", 7th edition, Cengage Learning, 2012
4. Gupta, S.C. and Kapur, V.K., "Fundamentals of Mathematical Statistics", S.Chand and Sons, New Delhi, 11th Edition 2014
5. Devore, Jay L., "Probability and Statistics for Engineering and the Sciences", 5th Edition, Brooks- Cole, 1999

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	2	1	1	-	-	-	1	1	2	-
CO2	3	2	1	1	2	1	-	-	-	-	1	1	1	1
CO3	2	3	2	2	2	1	1	-	-	-	1	1	2	-
CO4	2	3	2	1	2	-	-	-	-	-	1	1	1	-

1- Faintly
2- Moderately
3-Strongly

18THE11	NUCLEAR ENGINEERING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To describe fundamental study of nuclear reactions
2. To impart knowledge on neutron transport and diffusion.
3. To impart knowledge on reactor kinetics and heat removal form reactor core.

UNIT I BASICS OF NUCLEAR FISSION AND POWER FROM FISSION 9 + 0

Radioactivity - Nuclear reactions, cross sections - Nuclear fission - Power from fission, conversion and breeding.

UNIT II NEUTRON TRANSPORT AND DIFFUSION 9 + 0

Neutron transport equation - Diffusion theory approximation - Fick's law - Solutions to diffusion equation for point source, planar source, etc., - Energy loss in elastic collisions, neutron slowing down

UNIT III MULTIGROUP, MULTI REGION DIFFUSION EQUATION, CONCEPT OF CRITICALITY 9 + 0

Solution of multi group diffusion equations in one region and multi region reactors - Concept of criticality of thermal reactors

UNIT IV REACTOR KINETICS AND CONTROL 9 + 0

Derivation of point kinetics equations – In hour equation - Solutions for simple cases of reactivity additions, fission product poison, reactivity coefficients

UNIT V HEAT REMOVAL FROM REACTOR CORE AND REACTOR SAFETY. 9 + 0

Solution of heat transfer equation in reactor core - Temperature distribution - Critical heat flux. Reactor safety philosophy - Units of radioactivity exposure - Radiation protection standards

Total (45+0)= 45 Periods

COURSE OUTCOMES:

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

CO1 : understand the nuclear reactions and breeding.
CO2 : explain the diffusion and reactor kinetics.
CO3 : understand heat removal from reactor core, reactor safety and radiation protection.

TEXT BOOKS:

1. Introduction to Nuclear Engineering (3rd Edition) by John R. Lamarsh, Anthony J.Barrata, Prentice Hall, (2001)
2. Introduction to Nuclear Reactor Theory, by John R. Lamarsh, Addison-Wesley, 1966)
3. Nuclear Reactor Analysis, by James J. Duderstadt and Lewis J. Hamilton, John Wiley(1976)

REFERENCE BOOKS:

1. Collier J.G. and Hewitt.G.F, "Introduction to Nuclear Power", Hemisphere Publishing, New York, 1987
2. Glasstone S. and Sesonske A., "Nuclear Reactor Engineering", 3rd Edition, Von Nostrand, 1984.
3. Winterton R.H.S., "Thermal Design of Nuclear Reactors", Pergamon Press, 1981.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	1	1	2	2	1	1	-	-	-	1	2	-	1
CO2	3	1	1	1	1	1	1	-	-	-	1	2	1	-
CO3	3	2	1	1	1	1	1	-	-	-	2	2	2	-

1- Faintly
2- Moderately
3-Strongly

18THE12 ENERGY CONSERVATION AND MANAGEMENT

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

1. To learn the present energy scenario and the need for energy conservation
2. To understand energy requirement ,optimization study and different instruments for energy audit.
3. To study the performance of different thermal equipment.

UNIT I INTRODUCTION **9 + 0**

Indian energy scenario – Basics of energy and its various forms - Primary / secondary energy sources – Energy conservation – Energy intensive industries – Barriers - EC Act 2003: Salient features - Schemes of Bureau of Energy Efficiency (BEE) including designated consumers, state designated agencies - Integrated energy policy - National action plan on climate change.

UNIT II ENERGY AUDIT AND MANAGEMENT **9 + 0**

Definition, energy audit, need, types of energy audit. energy management (audit) approach - understanding energy costs, bench marking, energy performance, matching energy use to requirement, maximizing system efficiencies, optimizing the input energy requirements, fuel and energy substitution, energy audit instruments and metering, precautions, smart metering.

UNIT III ENERGY ECONOMICS **9 + 0**

Roles and responsibilities of energy manager, accountability. energy consumption, production, cumulative sum of differences (CUSUM) – Cost / Energy Share Diagram – Break Even Analysis – Depreciation – Financial Analysis Techniques – CUSUM Technique – Energy Management Information Systems (EMIS) ESCO Concept – ESCO Contracts

UNIT IV THERMAL UTILITIES: OPERATION AND ENERGY CONSERVARTION **9 + 0**

i) Boilers (ii) Thermic Fluid Heaters (iii) Furnaces (iv) Waste Heat Recovery Systems (v) Thermal Storage

UNIT V PERFORMANCE STUDY OF THERMAL UTILITIES **9 + 0**

Basics of R & A/C – COP / EER / SEC Evaluation – Psychometric Chart Analysis – Types & Applications of Cooling Towers – Basics – Performance Analysis – DG Set – Performance Prediction – Cost of Power Generation – Scope for Energy Thermal systems.

Total (45+0)= 45 Periods

COURSE OUTCOMES:

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

CO1 *:* describe the present energy scenario of India and standards and EC act.
CO2 *:* analyze and optimize the energy requirement and identify the suitable instrument for energy audit.
CO3 *:* analyze the cost vs. energy and identify suitable technique for cost analysis.
CO4 *:* examine the performance analysis of thermal equipment.

TEXT BOOKS:

1. Industrial energy conservation,Charles M Gottschalk, John Wiley & Sons, 1996

REFERENCE BOOKS:

1. Energy management principles, Craig B Smith,Pergamon Press
2. Energy management Hand Book,Wayne C Turner,The Fairmount Press, Inc., 1997 6.Energy Technology,S Rao and B B Parulekar,Khanna Publishers, 1999
3. Optimizing energy efficiencies in industry,G G Rajan,Tata McGraw Hill, Pub. Co., 2001
4. Energy management,Paul OCallaghan,McGraw Hill Book Co

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	2	1	1	2	1	2	-	2	3	1	1	3	3
CO2	2	3	2	1	2	1	-	-	-	-	1	2	3	-
CO3	2	3	2	2	2	1	1	-	-	-	1	1	3	2
CO4	2	3	2	1	2	-	-	-	-	-	1	2	3	-

1- Faintly
2- Moderately
3-Strongly

18THE13	ALTERNATIVE FUELS FOR I.C.ENGINES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To impart knowledge about the alternates fuel for petroleum.
2. To impart knowledge about various liquid and gasses fuels suitable for SI and CI engine.
3. To impart knowledge about electric and hybrid vehicles.

UNIT I FUELS **9 + 0**

Availability and suitability to Piston Engines - Concept of conventional fuels - Potential alternative fuels – Ethanol, Methanol, DEE/DME – Hydrogen, LPG, natural gas, producer gas, bio gas and vegetable oils – Use in I.C. Engines – Merits and demerits of various fuels.

UNIT II ALCOHOL FUELS **9 + 0**

Properties as engine fuels – Performance in S.I. Engines – Alcohol & Gasoline blends – Flexible Fuel Vehicle – Reformed alcohols – Use in C.I. Engines – Emulsions – Dual fuel systems – Spark assisted diesel engines – Surface ignition engines – Ignition accelerators – Manufacture of alcohol fuels.

UNIT III GASEOUS FUELS **9 + 0**

Hydrogen – Properties – Use in C.I. Engines and S.I. Engines – Storage methods – Safety precautions – Production methods, Producer gas and bio gas – Raw materials – Gasification – Properties – Cleaning up the gas – Use in S.I. and dual fuel engines, LPG & CNG – Properties – Use in S.I. and C.I. Engines.

UNIT IV VEGETABLE OILS **9 + 0**

Indian scenario of vegetable oil usage and its application – Viscosity Reduction Techniques-Types - Properties – Biodiesel Esterification – Performance and emission characteristics of Engines – Merits and demerits of biodiesel

UNIT V ELECTRIC AND HYBRID VEHICLES **9 + 0**

Layout of Electric Vehicle and Hybrid Vehicles – Advantages and Drawbacks of Electric and Hybrid Vehicles. System Components, Electronic Control System – Different Configurations of Hybrid Vehicles. Power Split Device. High Energy and Power Density Batteries – Basics of Fuel Cell Vehicles.

Total (45+0)= 45 Periods

COURSE OUTCOMES:

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

CO1 : describe various alternative fuels for IC engine.
CO2 : examine the characteristics of various liquid and gases fuels suitable for SI and CI engine.
CO3 : understand the concept of electric, hybrid and fuel cell vehicles.

TEXT BOOKS:

1. Osamu Hirao and Richard K.Pefley, Present and Future Automotive Fuels, John Wiley and Sons, 1988.
2. Keith Owen and Trevor Eoley, Automotive Fuels Handbook, SAE Publications,1990.

REFERENCE BOOKS:

1. Richard L.Bechtold, Automotive Fuels Guide Book, SAE Publications, 1997.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	1	2	2	1	-	-	-	-	1	2	1	-
CO2	2	2	1	2	2	1	-	-	-	-	1	2	2	-
CO3	2	2	1	1	2	1	-	-	-	-	1	2	1	-

1- Faintly
2- Moderately
3-Strongly

18THE14 ELECTRONIC ENGINE MANAGEMENT SYSTEMS

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

1. To study various electronics components used in automobile.System
2. To learn the working Principle of Engines and Vehicle Electronic Management System.

UNIT I FUNDAMENTALS OF AUTOMOTIVE ELECTRONICS 9 + 0

Microprocessor architecture, open and closed loop control strategies, PID control, look up tables, introduction to modern control strategies like fuzzy logical and adaptive control. Parameters to be controlled in SI and CI engines and in the other parts of the automobile

UNIT II SENSORS 9 + 0

Inductive, hall effect, hot wire, thermistor, piezo electric, piezo resistive, based sensors. Throttle position, air mass flow, crank shaft position, cam position, engine and wheel speed, steering position, tire pressure, brake pressure, steering torque, fuel level, crash, exhaust oxygen level (two step and linear lambda), knock, engine temperature, manifold temperature and pressure sensors

UNIT III SI ENGINE MANAGEMENT 9 + 0

Three-way catalytic converter, conversion efficiency versus lambda. Layout and working of si engine management systems like bosch l-jetronic and IH-jetronic. Group and sequential injection techniques. Working of the fuel system components. Cold start and warm up phases, idle speed control, acceleration and full load enrichment, deceleration fuel cutoff. Fuel control maps, open loop control of fuel injection and closed loop lambda control. Electronic ignition systems and spark timing control. Closed loop control of knock.

UNIT IV CI ENGINE MANAGEMENT 9 + 0

Fuel injection system parameters affecting combustion, noise and emissions in ci engines. Pilot, main, advanced post injection and retarded post injection. Electronically controlled unit injection system. Layout of the common rail fuel injection system. Working of components like fuel injector, fuel pump, rail pressure limiter, flow limiter, EGR valves

UNIT V VEHICLE MANAGEMENT AND SAFETY SYSTEMS 9 + 0

Abs system, its need, layout and working. Electronic control of suspension – Damping control, electric power steering, supplementary restraint system of air bag system– Crash sensor, seat belt tightening. Cruise control. Vehicle security systems- Alarms, vehicle tracking system. On board diagnostics. Collision avoidance radar warning system

Total (45+0)= 45 Periods

COURSE OUTCOMES:

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

CO1 : understand the different electronic components available in the present days engine management system.

CO2 : understand the role of electronic components in SI and CI Engine management system.

CO3 : understand the role of electronic components in vehicle management system.

TEXT BOOKS:

1. William B Ribbens “Understanding Automotive Electronics”, SAE Publications, 1998
2. Eric Chowanietz “Automobile Electronics” SAE Publications, 1994

REFERENCE BOOKS:

1. Robert Bosch “Diesel Engine Management” SAE Publications, 2006.
2. Robert Bosch, “Gasoline Engine Management” SAE Publications, 2005

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	1	1	1	2	2	3	-	-	-	1	1	2	1
CO2	2	1	1	2	2	2	2	-	-	-	1	2	2	1
CO3	2	1	1	2	2	1	2	-	-	-	1	2	1	1

1- Faintly
2- Moderately
3-Strongly

18THE15	ANALYSIS OF HEAT TRANSFER	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To develop the ability to use the heat transfer concepts for various applications like finned Systems, turbulence flows, high speed flows.
2. To analyze the thermal analysis and sizing of heat exchangers and to learn the heat transfer coefficient for compact heat exchangers.
3. To achieve an understanding of the basic concepts of phase change processes and micro scale heat transfer

UNIT I LAMINAR FORCED CONVECTIVE HEAT TRANSFER 9 + 0

Exact solutions to N-S equations for flow through channels and circular pipe, fully developed forced convection in pipes with different wall boundary conditions, Forced convection in the thermal entrance region of ducts and channels (Graetz solution), heat transfer in the combined entrance region, Integral method for internal flows with different wall boundary conditions.

UNIT II TURBULENT FORCED CONVECTIVE HEAT TRANSFER 9 + 0

Momentum and Energy Equations, Turbulent Boundary Layer Heat Transfer, Mixing length concept, Turbulence Model - k-ε Model, Analogy between Heat and Momentum Transfer – Reynolds, Colburn, Von Karman, Turbulent flow in a Tube, High speed flows

UNIT III PHASE CHANGE HEAT TRANSFER AND HEAT EXCHANGER 9 + 0

Condensation with shear edge on bank of tubes, Boiling – Pool and flow boiling, heat exchanger, ε – NTU approach and design procedure, compact heat exchangers.

UNIT IV NUMERICAL METHODS IN HEAT TRANSFER 9 + 0

Difference formulation of steady and transient heat condition problems – Discretization schemes – Explicit, Crank Nicolson and Fully implicit schemes, Control volume formulation, steady one-dimensional convection and Diffusion problems, calculation of the flow field – Simpler Algorithm.

UNIT V INTRODUCTION TO MICROSCLAE HEAT TRANSFER 9 + 0

Introduction ,Continuum flow (with slip), free molecular flow, electro-osmotic flow, electric double layer, capillary filling, passive valves, electro-wetting, continuum assumption and limits of linear transport properties, momentum and heat transfer equations in micro scale.

Total (45)= 45 Periods

COURSE OUTCOMES:

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

CO1 : calculate and evaluate the impacts of initial and boundary conditions on the solutions of a particular heat transfer problem

CO2 : evaluate the relative contributions of different modes of heat transfer.

CO3 : apply the heat transfer principles to design and to evaluate performance of thermal systems

TEXT BOOKS:

1. Incropera F.P. and DeWitt. D.P., Fundamentals of Heat & Mass Transfer, John Wiley &Sons, 1996
2. Ghoshdasdidar. P.S., Compiler simulation of flow and Heat Transfer, Tata McGraw-Hill, 1998
3. Kakac, S. and Yener, Y., *Convective Heat Transfer,* CRC Press, 1995.

REFERENCE BOOKS:

1. Convective Heat and Mass Transfer, 4th Edition by W. Kays, M. Crawford and B. Weigand, McGraw Hill International, 2005
2. Convection Heat Transfer, 3rd Edition by A. Bejan, John Wiley, 2004
3. Rohsenow. W.M., Harnett. J.P., and Ganic. E.N., Handbook of Heat Transfer Applications, McGraw-Hill, NY1985
4. Patankar. S.V. Numerical heat Transfer and Fluid flow, Hemisphere Publishing Corporation,1980

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	3	2	2	3	1	-	-	-	-	1	2	1	-
CO2	2	3	2	2	3	1	-	-	-	-	1	2	2	-
CO3	2	2	3	3	2	1	-	-	-	-	1	2	1	-

1- Faintly
2- Moderately
3-Strongly

PROGRAMME ELECTIVES-2

18THE21	AIR CONDITIONING SYSTEM DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To learn the psychometric concepts underlying Air conditioning process.
2. To learn the design features and load estimation principles of specific Air conditioning system.
3. To learn about the critical auxiliary systems such as air distribution circuits, water distribution circuits etc

UNIT I PSYCHROMETRY AND AIR CONDITIONING PROCESSES 9 + 0

Moist Air properties, use of psychrometric chart, various psychrometric processes, air Washer, adiabatic saturation. Air conditioning processes - RSHF, summer air conditioning and winter air conditioning Bypass Factor. Applications with specified ventilation air quantity, application with low latent heat loads and high latent heat loads.

UNIT II LOAD ESTIMATION 9 + 0

Thermal comfort – Design conditions – Solar Radiation-Heat Gain through envelopes – Infiltration and ventilation loads – Internal loads – Procedure for heating and cooling load estimation

UNIT III AIR CONDITIONING SYSTEMS 9 + 0

Thermal distribution systems – Single, multi zone systems, terminal reheat systems, dual duct systems, variable air volume systems, water systems and Unitary type systems.

UNIT IV AIR DISTRIBUTION AND CONTROL 9 + 0

Flow through Ducts, static & dynamic losses, diffusers , duct design-Equal Friction Method, system balancing , fans & duct system Characteristics , fan arrangement variable air volume systems , air handling units and fan Coil units – Control of temperature, humidity, air flow and quality.

UNIT V CHILLED WATER CIRCUITS 9 + 0

Water piping in Chilled Water Systems, multiple Fan Coil Units. Condensers - Multiple Condensers and Cooling Towers.

Total (45+0)= 45 Periods

COURSE OUTCOMES:

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

CO1 : understand the construction and design features Air-conditioning system.
CO2 : describe various types loads and design the air conditioning system for a specific application.
CO3 : understand the components involved in air distribution system and able to design seasonal energy efficient system

TEXT BOOKS:

1. Norman C. Harris, “Modern Air Conditioning”, New York, McGraw-Hill,1974.
2. Jones W.P., “Air Conditioning Engineering”, Edward Arnold Publishers Ltd., London,1984.
3. Hainer R.W., “Control Systems for Heating, Ventilation and Air-Conditioning”, Van Nostrand

REFERENCE BOOKS:

1. ASHRAE Handbook.
2. “Handbook of air-conditioning system design”, Carrier Incorporation, McGraw Hill Book Co., USA 1965
3. Refrigeration and air-conditioning”, ARI, Prentice Hall, New Delhi, 1993.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	1	1	2	1	1	-	-	-	1	2	2	-
CO2	2	2	1	2	2	1	1	-	-	-	1	2	3	-
CO3	3	2	1	2	3	1	-	-	-	-	1	2	2	-

1- Faintly
2- Moderately
3-Strongly

18THE22	ADVANCED IC ENGINES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To understand the principles of operation of different IC Engines, combustion process and Fuel injection systems.
2. To provide knowledge on pollutant formation and control, suitability of alternate fuels, and recent technological advances.

UNIT I SPARK IGNITION ENGINES 9 + 0

Mixture requirements – Fuel injection systems – Mono point, Multipoint & Direct injection -Stages of combustion – Normal and Abnormal combustion, spark Knock, factors affecting knock, combustion chambers.

UNIT II COMPRESSION IGNITION ENGINES 9 + 0

Diesel Fuel Injection Systems - Stages of combustion – Knocking – Factors affecting knock – Direct and Indirect injection systems – Combustion chambers – Fuel Spray behavior – Spray structure and spray penetration – Air motion - Introduction to Turbo charging.

UNIT III POLLUTANT FORMATION AND CONTROL 9 + 0

Pollutant – Sources – Formation of Carbon Monoxide, unburnt hydrocarbon, oxides of Nitrogen, smoke and particulate matter – Methods of controlling Emissions – Catalytic converters, selective catalytic reduction and particulate traps – Methods of measurement –Emission norms and Driving cycles.

UNIT IV ALTERNATIVE FUELS 9 + 0

Alcohol, hydrogen, compressed Natural Gas, liquefied Petroleum Gas and Bio Diesel - Properties, suitability, merits and demerits - Engine Modifications.

UNIT V RECENT TRENDS 9 + 0

Air assisted Combustion, homogeneous charge compression ignition engines – Variable Geometry turbochargers – Common Rail Direct Injection Systems - Hybrid Electric Vehicles –NOx Adsorbers - Onboard Diagnostics.

Total (45+0)= 45 Periods

COURSE OUTCOMES:

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

CO1 : understand the combustion process, and the fuel injection techniques adopted in modern day IC engines

CO2 : adopt potential alternative fuel systems and exposed to recent developments in engine technology

TEXT BOOKS:

1. V. Ganesan, “Internal Combustion Engines”, V Edition, Tata McGraw Hill, 2012.
2. K.K. Ramalingam, “Internal Combustion Engine Fundamentals”, Scitech Publications, II Ed., 2011.

REFERENCE BOOKS:

1. R.B. Mathur and R.P. Sharma, “Internal Combustion Engines”, Dhanpat Rai & Sons 2007
2. B.P. Pundir, “IC Engines Combustion & Emission”, Narosa Publishing House, 2014.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	1	2	3	2	1	-	-	-	1	2	2	1
CO2	2	2	3	3	2	-	-	-	-	-	1	2	2	2

1- Faintly
2- Moderately
3- **Strongly**

18THE23	OPTIMIZATION TECHNIQUES IN ENGINEERING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To learn the fundamentals of various optimization techniques
2. To acquire the knowledge about various linear programming models
3. To study the various optimization techniques used in engineering applications

UNIT I INTRODUCTION **9**

Classification of optimization problems, concepts of design vector, design constraints, constrains surface, objective function, surface and multi-level optimization, parametric linear programming

UNIT II DECISION ANALYSIS **9**

Decision Trees, utility theory, game theory, multi Objective Optimization, MCDM- Goal Programming, analytic hierarchy process, ANP

UNIT III LINEAR PROGRAMMING **9**

Standard form of linear programming problem; Canonical form of LP problem; Assumptions in LP Models; Elementary operations Graphical method for two variable optimization problem; Examples Motivation of simplex method, Simplex algorithm and construction of simplex tableau; Simplex criterion; Minimization versus maximization problems

UNIT IV NON-LINEAR OPTIMIZATION **9**

Unconstrained single variable and multi variable optimization, KKT Conditions, constrained optimization, quadratic programming, Convex programming, Separable programming, Geometric programming, non-Convex programming

UNIT V NON-TRADITIONAL OPTIMIZATION **9**

Genetic algorithms, simulated annealing, neural network based optimization, particle swarm optimization, ant Colony Optimization, Optimization of Fuzzy Systems

Total = 45 Periods

COURSE OUTCOMES:

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

CO1 : formulate the suitable optimization technique to the engineering applications
CO2 : find the suitable optimization method for a real life problems in engineering field
CO3 : apply the concept of nontraditional optimization
CO4 : choose a suitable method of linear programming for a particular application

TEXT BOOKS:

1. SingiresuS. Rao, “Engineering optimization – Theory and practices”, John Wiley and Sons, 1996.
2. Ravindran – Phillips –Solberg, “Operations Research – Principles and Practice”, John Wiley India, 2006.

REFERENCE BOOKS:

1. Kalymanoy Deb, “Optimization for Engineering Design”, PHI, 2003
2. Fredrick S.Hillier and G.J.Liberman, “Introduction to Operations Research”, McGraw Hill Inc. 1995.
3. G. Hadley, "Linear programming", Narosa Publishing House, New Delhi, 1990

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	3	2	2	3	1	-	-	-	-	1	2	2	1
CO2	2	3	2	2	3	1	2	-	-	-	1	2	2	1
CO3	2	3	2	2	2	1	1	-	-	-	1	1	1	-
CO4	2	3	3	2	2	1	-	-	-	-	1	2	1	-

1- Faintly
2- Moderately
3- **Strongly**

18THE24	BOUNDARY LAYER THEORY AND TURBULENCE	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To understand the theory of turbulent flow and its modeling,
2. To understand the structure types and a detailed insight about turbulence

UNIT I FUNDAMENTALS OF BOUNDARY LAYER THEORY 9 + 0

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 + 0

Internal Flows – Couette flow – Two-Layer Structure of the velocity Field – Universal Laws of the wall – Friction law – Fully developed Internal flows – Channel Flow, Couettee – Poiseuille flows, Pipe Flow

UNIT III TURBULENCE MODELS 9 + 0

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 + 0

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 + 0

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:

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

CO1 : Problems related to boundary layer theory and turbulence
CO2 : understand the statistical theory and kinematics of turbulence
CO3 : understand the turbulence models and turbulent flows

TEXT BOOKS:

1. David C. Wilcox, Turbulence Modeling for CFD, Publisher: D C W Industries, Nov 1, 2006
2. G. Biswas and E. Eswaran, Turbulent Flows, Fundamentals, Experiments and Modelling,Narosa Publishing House, 2002
3. H. Schlichting and Klaus Gersten, Boundary Layer Theory, Springer 2004

REFERENCE BOOKS:

1. Pope S B., Turbulent Flow, Cambridge University Press, Cambridge, U.K., 2001.
2. R.J. Garde,Turbulent Flow, New Age International (p) Limited, Publishers, 2006.
3. Schlichting H., Boundary layer theory, Mc Graw Hill Book Company, 1979.
4. Yunus A Cengel, John M.Cimbala, Fluid Mechanics: Fundamentals and Applications – Second Edition, McGraw-Hill,2013

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	1	2	3	2	1	-	-	-	1	2	1	-
CO2	2	2	3	3	2	-	-	-	-	-	1	2	2	-
CO3	2	2	2	2	2	-	-	-	-	-	1	2	2	-

1- Faintly
2- Moderately
3-Strongly

18THE25	COMBUSTION IN IC ENGINES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To impart knowledge on various engine combustion processes used in prime movers and power plants.
2. To learn the chemical kinetics involved in the combustion processes.

UNIT I COMBUSTION PRINCIPLES 9 + 0

Thermodynamics, concepts of combustion – Combustion equations, heat of combustion: Theoretical flame temperature, chemical equilibrium and dissociation.

UNIT II CHEMICAL KINETICS 9 + 0

Theories of Combustion, pre-flame reactions, reaction rates, laminar and turbulent flame Propagation in Engines.

UNIT III COMBUSTION IN S.I. ENGINES 9 + 0

Initiation of combustion, flame velocities, normal and abnormal combustion, knocking combustion, pre-ignition, knock and engine variables, features and design consideration of combustion chambers, stratified charge combustion, concepts of lean burn engines, heat release correlations.

UNIT IV COMBUSTION IN C.I. ENGINES 9 + 0

Various stages of combustion, vaporization of fuel droplets and spray formation, air motion, swirl, squish, tumble flow, velocities, swirl measurement, delay period correlations, diesel knock and engine variables, features and design considerations of combustion chambers, heat release correlations.

UNIT V COMBUSTION IN GAS TURBINE 9 + 0

Power plant cycles for stationary and aircraft applications, component behaviors, analysis of ramjet, turbojet and turbo-propeller. Flame stability, re-circulation zone and requirements. Combustion chamber configuration, materials.

Total (45+0)= 45 Periods

COURSE OUTCOMES:

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

CO1 : understand the combustion processes and form combustion equation.
CO2 : understand the concepts of chemical kinetics and combustion in SI and CI engine.
CO3 : understand the concepts of combustion taking place in gas engine and analyse the factors affecting their performance.

TEXT BOOKS:

1. Ganesan, V, Internal Combustion Engines, Tata McGraw Hill Book Co., 1995.
2. John B.Heywood, Internal Combustion Engine Fundamentals, McGraw Hill Book, 1998
3. Ramalingam, K.K., Internal Combustion Engines, Scitech Publications (India) Pvt. Ltd., 2000.

REFERENCE BOOKS:

1. Mathur,M.L., and Sharma, R.P., A Course in Internal Combustion Engines, DhanpatRai Publications Pvt. New Delhi-2, 1993.
2. Obert,E.F.,I C Engine and Air Pollution, International Text Book Publishers, 1983.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	1	2	2	1	1	-	-	-	1	2	2	-
CO2	2	2	2	2	3	1	-	-	-	-	1	3	1	-
CO3	2	3	3	2	2	-	-	-	-	-	1	2	1	1

1- Faintly
2- Moderately
3-Strongly

18CDE26	NANOMATERIALS TECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To understand the concepts of nanotechnology and behaviour of nanomaterial and their properties.
2. To learn about the different routes for the synthesis and consolidation of nanoparticles and Nano crystalline materials.
3. To study about the various field of applications of Nano-materials.

UNIT I INTRODUCTION 9 + 0

Importance of Nano-Technology - Emergence of Nano-Technology - Bottom-Up and Top-down approaches-challenges in Nano-Technology. Properties of materials and Nano-materials- The role of size in Nano-materials- Electronic Properties- Magnetic Properties- Thermal Properties- Mechanical Properties- Optical Properties.

UNIT II SYNTHESIS TECHNIQUES OF NANO-MATERIALS 9 + 0

Physical methods - Inert gas condensation - Ball Milling - Chemical vapour deposition method Electrochemical synthesis - Sol-gel- Micelles and microemulsions - Cluster compounds. M based nanolithography and Nano-manipulation- E beam lithography and SEM-based nanolithography and Nano-manipulation- Ion beam lithography- oxidation and metallization- Mask and its application. Deep UV lithography- X-ray based lithography.

UNIT III CHARACTERIZATIONS OF NANO-MATERIALS 9 + 0

Scanning Electron Microscopy (SEM) - Scanning Probe Microscopy (SPM) - TEM and EDAX analysis - X-ray diffraction-Optical Microscope - Operational principle and application for analysis of Nano-materials- UV-VIS-IR Spectrophotometers- Principle of operation and application for band gap measurement.

UNIT IV NANO SENSORS AND NANO DEVICES 9 + 0

Micro and Nano-sensors - Fundamentals of sensors – Biosensor- Micro fluids- MEMS and NEMS - Packaging and characterization of sensors - Method of packaging at zero level - Dye level and first level. Sensors for aerospace and defense: Accelerometer - Pressure Sensor- Night Vision System - Nanotweezers - Nano-cutting tools - Integration of sensor with actuators and electronic circuitry.

UNIT V NANO FLUIDS AND THEIR APPLICATIONS 9 + 0

Preparation of Nano-fluids – Thermo and optical Properties of Nano-Fluids – Characterization of Nano-fluids - Mechanism of Heat Transfer – Role of Brownian Motion – Constraints for nano-fluids -Models for the measurements of thermal conductivities of Nano-fluids - current Applications– Issues with the Environment

Total = 45 Periods

COURSE OUTCOMES:

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

CO1 : understand processing techniques for nanomaterials.
CO2 : knowledge about various properties of nano-materials and to optimize the methods for specific material application
CO3 : use various nano-fluids in the fields of engineering.
CO4 : use of Nano particles for the health, ecological and environmental hazards

TEXT BOOKS:

1. B.S.Murthy, P.Shankar, Baldevraj, B.B.Rath and James Murday, “Text Book of Nanoscience and Nanotechnology”, Universities Press (India) Private Limited, 2013
2. Mark Ratneer, Daniel Ratner, “Nanotechnology” Pearson Education, Inc, 2003

REFERENCE BOOKS:

1. Guozhong Cao , “Nanostructures &Nanomaterials: Synthesis- Properties and Applications”, Imperial College Press, 2004
2. Bharat Bhusan (Ed.), “Springer Handbook of Nanotechnology”, Springer Verlag Berlin- Heidelberg, 2004.
3. Rainer Wasser (Ed.), “Nanoelectronics and Information Technology: Advanced Electronic Materials and Novel Devices” Wiley-VchVerlag GmbH & Co, 2003.
4. Charles P. Poole- Jr. and Frank J. Owens , “Introduction to Nanotechnology”, Wiley Interscience, 2003
5. M.J. Madou, “Fundamentals of Microfabrication: Science of Miniaturization”, CRC Press- 2nd Edition, 2002.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	1	3	2	1	1	-	1	-	-	1	1	-
CO2	1	1	2	1	-	1	1	-	2	1	1	-	-	-
CO3	2	2	1	2	2	1	1		2	1	1	1	-	-
CO4	1	1	1	1	-	-	-	2	2	2	2	1	-	1

1- Faintly
2- Moderately
3- Strongly

PROGRAMME ELECTIVES-3

18THE31	REFRIGERATION AND CRYOGENICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To learn in detail of the cycle analysis of various refrigeration systems
2. To study about the different components of refrigeration system
3. To learn about the principles of liquefaction and cryogenics

UNIT I ANALYSIS OF REFRIGERATION CYCLES 9 + 0

Development of vapour compression refrigeration cycle from reverse Carnot cycle- Conditions for high COP-Deviations from ideal vapour compression cycle, multi pressure system, cascade systems-analysis. Vapour absorption systems-Aqua ammonia & Li-Br systems, steam jet refrigeration, thermo electric refrigeration, air refrigeration cycles, heat pumps.

UNIT II REFRIGERATION SYSTEM COMPONENTS 9 + 0

Compressors- Types, performance, characteristics, types of evaporators & condensers and their functional aspects, expansion devices and their behavior with fluctuating load, cycling controls, other components such as accumulators, receivers, oil separators, strainers, driers, check valves, solenoid valves, defrost controllers, etc.

UNIT III PRINCIPALS OF LIQUEFACTION 9 + 0

Joule thomson effect and inversion curve; adiabatic and isenthalpic expansion with their comparison. Properties of cryogenic fluids; properties of solids at cryogenic temperatures; Superconductivity.

UNIT IV GAS LIQUEFACTION SYSTEMS 9 + 0

Recuperative – Linde – Hampson, Claude, cascade, Heylandt, Kapitza, Collins, Simon; regenerative – stirling cycle and refrigerator, Slovay refrigerator, Gifford-mcmahon refrigerator, vuilleumier refrigerator, pulse tube refrigerator; liquefaction of natural gas.

UNIT V STORAGE OF CRYOGENIC LIQUIDS 9 + 0

Design considerations of storage vessel; dewar vessels; industrial storage vessels; storage of cryogenic fluids in space; transfer systems and lines for cryogenic liquids; cryogenic valves in transfer lines; two phase flow in transfer system; cool-down of storage and transfer systems

Total = 45 Periods

COURSE OUTCOMES:

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

CO1 : analyse the various cycles of refrigeration
CO2 : design the refrigeration system components
CO3 : choose the suitable method of gas liquefaction
CO4 : select the required storage method for the cryogenics liquids

TEXT BOOKS:

1. Dossat R.J., Principles of refrigeration, John Wiley, S.I. Version, 2001.
2. R.Barron, “Cryogenic systems”, McGraw-Hill Company, New Yourk, 1985

REFERENCE BOOKS:

1. Arora C.P., Refrigeration and Air conditioning, McGraw Hill, 3rd Ed., 2010
2. Jordan and Priester, Refrigeration and Air conditioning 1985
3. Bailey, “Advanced Cryogenics”, Plenum Press, London, 1971
4. Cryogenic Systems, R. Barron, Oxford University Press

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	3	2	3	3	1	-	-	-	-	1	2	3	-
CO2	2	3	3	2	3	1	-	-	-	-	1	2	3	1
CO3	2	3	2	2	2	1	-	-	-	-	1	2	2	-
CO4	2	2	1	2	2	1	-	-	-	-	1	2	2	-

1- Faintly
2- Moderately
3-Strongly

18THE32	DESIGN OF HEAT EXCHANGERS	L	T	P	C
	(Use of approved Data Book and Charts may be permitted)	3	0	0	3

COURSE OBJECTIVES:

1. To learn about the heat exchanger basics and its methods of analysis
2. To study about the design of different types of heat exchangers
3. To study the designing of compact and plate heat exchangers

UNIT I FUNDAMENTALS OF HEAT EXCHANGERS 9 + 0

Heat Exchangers – Classification according to transfer process, number of fluids, surface compactness, and construction features. Tubular heat exchanger, plate type heat exchangers, extended surface heat exchangers, heat pipe, Regenerators. Classification according to flow arrangement: counter flow, parallel flow, cross flow exchanger.

UNIT II DESIGN ASPECTS 9 + 0

Heat exchanger design methodology, assumption for heat transfer analysis, problem Model formulation, e-NTU method, P-NTU method, Mean temperature difference method, fouling of heat exchanger, effects of fouling, categories of fouling, fundamental processes of fouling.

UNIT III DOUBLE PIPE & COMPACT HEAT EXCHANGERS 9 + 0

Design of double pipe - finned tube - Shell and tube heat exchangers - Thermal and Hydraulic design of inner tube, Thermal and hydraulic analysis of Annulus, Total pressure drop simulation of heat exchangers. Thermal and Hydraulic design of compact heat exchanger, performance influencing parameters – limitations

UNIT IV SHELL AND TUBE HEAT EXCHANGERS 9 + 0

Thermal design considerations, Design of Shell, Tube, Tube pitch, tube-layout and tube-count, Tube passes, Tube sheet, Baffles, Fouling Considerations, Selection of fluids for tube and the shell side, thermal design procedure, Tinker's, kern's, and Bell Delaware's methods, for thermal and hydraulic design of Shell and Tube heat exchangers

UNIT V MECHANICAL DESIGN OF HEAT EXCHANGERS 9 + 0

Design standards and codes, key terms in heat exchanger design, material selection, and thickness calculation for major components such as tube sheet, shell, tubes, flanges and nozzles. Introduction to simulation and optimization of heat exchangers, flow induced vibrations.

Total = 45 Periods

COURSE OUTCOMES:

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

CO1 : apply the knowledge of the in designing the heat exchangers
CO2 : choose the method of analysing the heat exchangers
CO3 : design the double pipe & other heat exchangers for a particular application
CO4 : apply the concepts of simulation & optimization of the designing

TEXT BOOKS:

1. Arthur P. Frass, Heat Exchanger Design, John Wiley & Sons, 1988.
2. Ramesh K. Shah and Dusan P. Sekulic, "Fundamentals of Heat Exchanger Design" John Wiley & sons Inc., 2003.

REFERENCE BOOKS:

1. Sekulic D.P., Fundamentals of Heat Exchanger Design, John Wiley, 2003.
2. D.C. Kern, "Process Heat Transfer", McGraw Hill, 1950.
3. SadikKakac and Hongton Liu, "Heat Exchangers: Selection, Rating and Thermal Design" CRC Press, 1998.
4. A .P. Frass and M.N. Ozisik, "Heat Exchanger Design", McGraw Hill, 1984
5. Heat Exchanger Design Handbook by Kuppan, T, Macel Dekker, CRC Press

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	3	2	1	1	-	-	-	-	1	2	2	-
CO2	2	3	2	3	2	1	1	-	-	-	1	2	2	-
CO3	2	2	2	3	2	1	1	-	-	-	1	2	3	-
CO4	2	2	2	2	3	-	2	-	-	-	1	2	3	1

1- Faintly
2- Moderately
3-Strongly

18THE33 COGENERATION AND WASTE HEAT RECOVERY SYSTEMS

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

1. To learn about the various techniques of cogeneration and waste heat management
2. To identify the applications of cogeneration technologies
3. To learn about the various heat recovery technologies

UNIT I INTRODUCTION **9 + 0**

Introduction – Principles of thermodynamics – Cycles – Topping – Bottoming – Combined cycle – Organic rankine cycles – Performance indices of cogeneration systems – Waste heat recovery – Sources and types – Concept of tri and quad generation

UNIT II COGENERATION TECHNOLOGIES **9 + 0**

Configuration and thermodynamic performance – Steam turbine cogeneration systems – Gas turbine cogeneration systems –Reciprocating IC engines cogeneration systems – Combined cycles cogeneration systems – Advanced cogeneration systems: fuel cell, stirling engines etc.,

UNIT III ISSUES AND APPLICATIONS OF COGENERATION TECHNOLOGIES **9 + 0**

Cogeneration plants electrical interconnection issues – Utility and cogeneration plant interconnection issues – Applications of cogeneration in utility sector – Industrial sector – Building sector – Rural sector – Impacts of cogeneration plants – Fuel, electricity and environment.

UNIT IV WASTE HEAT RECOVERY SYSTEMS **9 + 0**

Selection criteria for waste heat recovery technologies – Recuperators – Regenerators – Economizers – Plate heat exchangers – Thermic fluid heaters – Waste heat boilers – Classification, location, service conditions, design Considerations – Fluidized bed heat exchangers – Heat pipe exchangers – Heat pumps – Sorption systems.

UNIT V HEAT RECOVERY TECHNOLOGIES **9 + 0**

Heat pipes & Vapor Chambers, Direct conversion technologies – Thermoelectric Generators. Thermo-ionic conversion, Thermo-PV Heat Pump; Heat Recovery from Incinerators, Energy Storage

Total = 45 Periods

COURSE OUTCOMES:

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

CO1 : apply a suitable technology for waste heat management
CO2 : find a suitable heat recovery technology for a particular field
CO3 : select a proper heat recovery system to enhance the performance
CO4 : do the economic analysis of cogeneration and heat recovery

TEXT BOOKS:

1. Charles H. Butler, Cogeneration, McGraw Hill Book Co., 1984.
2. De Nevers, Noel, Air Pollution Control Engineering, McGraw Hill, New York,1995.

REFERENCE BOOKS:

1. Horlock JH., Cogeneration - Heat and Power, Thermodynamics and Economics, Oxford,1987
2. Institute of Fuel, London, Waste Heat Recovery, Chapman & Hall Publishers, London, 1963.
3. Seagate Subrata, Lee SS EDS, Waste Heat Utilization and Management, Hemisphere, Washington, 1983.
4. Energy Cogeneration Hand book, George Polimveros, Industrial Press Inc, New york 1982.
5. EDUCOGEN – The European Educational tool for cogeneration, Second Edition, 2001.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	-	2	-	2	2	1	-	2	-	1	2	1	1
CO2	2	2	2	2	2	2	2	-	-	-	1	2	-	2
CO3	2	3	2	2	2	1	-	-	-	-	1	2	-	2
CO4	1	1	2	2	1	2	3	-	2	2	1	1	1	-

1- Faintly
2- Moderately
3-Strongly

18THE34 DESIGN OF CONDENSERS EVAPORATORS AND COOLING TOWERS **L T P C**
(Use of approved Data Book and Charts may be permitted) **3 0 0 3**

COURSE OBJECTIVES:

1. To study about the basic principles of designing the power plant components
2. To know about the various aspects of the designing of power plant components
3. To acquire the concepts of heat exchangers in power plants

UNIT I INTRODUCTION **9 + 0**

Principles of heat transfer, types of heat exchangers, standard representation, parts description, TEMA Classifications.

UNIT II DESIGN ASPECTS **9 + 0**

Heat transfer and pressure loss – Flow configuration – Effect of baffles – Effect of deviations from ideality – Design of double pipe - Finned tube - Shell and tube heat exchangers - Simulation of heat exchangers.

UNIT III DESIGN OF CONDENSERS **9 + 0**

Estimation of heat transfer coefficient, fouling factor, friction factor. Design procedures, wilson plots, designing different types of condensers, BIS Standards

UNIT IV DESIGN OF EVAPORATORS **9 + 0**

Different types of evaporators, design procedure, selection procedure, thermal Stress calculations, matching of components, design of evaporative condensers

UNIT V DESIGN OF COOLING TOWERS **9 + 0**

Types of cooling towers, analytical and graphical design procedures, tower Characteristics Parametric analysis, packaging, Flow control strategies and energy saving opportunities, assessment of cooling towers.

Total = 45 Periods

COURSE OUTCOMES:

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

CO1 : design a suitable type of condensers for a particular application
CO2 : design the particular type of cooling tower for improving the plant performance
CO3 : select the suitable type of heat exchanger in the plants
CO4 : choose the required type of evaporator for any application

TEXT BOOKS:

1. Arthur, P. Frass, Heat Exchanger Design, John Wiley and Sons, 1988.
2. Kern K.H., Process heat transfer, McGraw-Hill, 2002

REFERENCE BOOKS:

1. Sarit Kumar Das, Process Heat Transfer, Narosa Publishing House, 2009
2. Lieke Wang, Bengt Sunden, Raj M.Manglik., Plate Heat Exchangers: Design, Applications and Performance, WIT Press, 2007
3. TEMA Hand book, Tubular Exchanger Manufacturer Association, New York, 2004.
4. Sadik Kakac and Hongtan Liu, Heat Exchangers Selection, Rating and Thermal Design, CRC Press, 2002

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	1	2	3	2	1	1	-	-	-	1	1	2	1
CO2	2	1	2	3	2	1	1	-	-	-	1	1	2	1
CO3	2	1	2	2	2	1	-	-	-	-	1	2	1	-
CO4	3	2	2	2	3	1	-	-	-	-	1	2	1	1

1- Faintly
2- Moderately
3-Strongly

18THE35 **STEAM ENGINEERING** **L T P C**
3 0 0 3

COURSE OBJECTIVES:

1. To learn about steam generation technologies and cycles
2. To acquire the knowledge of piping & insulation
3. To understand the performance assessment of boilers

UNIT I INTRODUCTION **9 + 0**

Fundamentals of steam generation, quality of steam, use of steam table, Mollier Chart Boilers ,types, mountings and accessories, combustion in boilers, determination of adiabatic flame temperature, quantity of flue gases, feed water and its quality, blow down; IBR, boiler standards

UNIT II PIPING & INSULATION **9 + 0**

Water Line, steam line design and insulation; Insulation-Types and application, economic thickness of insulation, heat savings and application criteria, refractory-Types, selection and application of refractory, heat loss.

UNIT III STEAM SYSTEMS **9 + 0**

Assessment of steam distribution losses, steam leakages, steam trapping, condensate and flash steam recovery system, steam Engineering Practices; Steam Based Equipment's / Systems.

UNIT IV BOILER PERFORMANCE ASSESSMENT **9 + 0**

Performance Test codes and procedure, boiler efficiency, analysis of losses; performance evaluation of accessories; factors affecting boiler performance.

UNIT V INSTRUMENTATION & CONTROL **9 + 0**

Process instrumentation; control and monitoring. Flow, pressure and temperature measuring and controlling instruments, its selection

Total = 45 Periods

COURSE OUTCOMES:

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

CO1 : explain the steam generation, combustion, and the boiler standards
CO2 : use techniques, skills, and modern engineering tools necessary for boiler performance assessment
CO3 : design a steam piping system, its components for a process and also design economical and effective insulation
CO4 : design and develop controls and instrumentation for effective monitoring of the process.

TEXT BOOKS:

1. Domkundwar; A Course in Power Plant Engineering; Dhanapat Rai and Sons
2. Yunus A. Cengel and Boles, "Engineering Thermodynamics ",Tata McGraw-Hill Publishing Co. Ltd

REFERENCE BOOKS:

1. Mason, Charles J, A text book on Steam Engineering, International Textbook Company, Scranton 1902
2. Edited by J. B. Kitto& S C Stultz; Steam: Its Generation and Use; The Babcock and Wilcox Company
3. P. Chatopadhyay; Boiler Operation Engineering: Questions and Answers; Tata McGrawHill Education Pvt Ltd, N Delhi

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	3	2	1	2	-	-	-	1	2	-	-
CO2	3	2	1	2	3	1	2	-	-	-	1	2	2	1
CO3	2	1	2	2	2	-	1	-	1	2	1	2	1	1
CO4	-	1	2	3	2	-	1	-	1	2	1	1	2	-

1- Faintly
2- Moderately
3-Strongly

PROGRAMME ELECTIVES-4

18THE41	COMPUTATIONAL FLUID DYNAMICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To impart knowledge on fundamental of CFD
2. To study modelling grid simulation of conduction problems
3. To study convection and incompressible fluid flow simulation

UNIT I FUNDAMENTALS OF CFD **9 + 0**

Classification, initial and boundary conditions – Initial and boundary value problems – Finite difference method, central, forward, backward difference, uniform and non-uniform grids, numerical errors, grid independence test.

UNIT II GEOMETRY MODELING AND GRID GENERATION **9 + 0**

Practical aspects of computational modeling of flow domains, grid Generation, types of mesh and selection criteria, mesh quality, key parameters and their importance

UNIT III CONDUCTION HEAT TRANSFER BY FINITE DIFFERENCE METHOD AND FINITE VOLUME METHOD **9 + 0**

Steady one-dimensional conduction, two and three dimensional steady state problems, transient one-dimensional problem, two-dimensional transient Problems.

UNIT IV CONVECTION HEAT TRANSFER BY FINITE DIFFERENCE METHOD AND FINITE VOLUME METHOD **9 + 0**

Steady one-dimensional and two-dimensional convection – Diffusion, unsteady one-dimensional convection – Diffusion, unsteady two-dimensional convection – Diffusion.

UNIT V INCOMPRESSIBLE FLUID FLOW BY FINITE DIFFERENCE METHOD AND FINITE VOLUME METHOD **9 + 0**

Governing equations, stream function – Vorticity method, determination of pressure for viscous flow, simple, computation of boundary layer flow - Finite difference approach.

Total = 45 Periods

COURSE OUTCOMES:

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

CO1 : solve the problems in conduction and convection heat transfer
CO2 : model and grids generation for heat transfer
CO3 : apply the suitable CFD technique to the real life problems
CO4 : solve the problems in incompressible fluid flow field

TEXT BOOKS:

1. Muralidhar, K., and Sundararajan, T., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, New Delhi, 2003.
2. Fletcher C.A.J. "Computational Techniques for Fluid Dynamics", Volumes I and II, Springer, Second Edition [2000]

REFERENCE BOOKS:

1. Ghoshdasdidar, P.S., "Computer Simulation of flow and heat transfer" Tata McGraw-Hill Publishing Company Ltd., 1998.
2. Subas, V.Patankar "Numerical heat transfer fluid flow", Hemisphere Publishing Corporation, 1980.
3. Versteeg and Malalasekera, N, "An Introduction to computational Fluid Dynamics The Finite volume Method," Pearson Education, Ltd., 2007.
4. Anderson, D.A., Tannehill, J.I., and Pletcher, R.H., "Computational fluid Mechanics and Heat Transfer " Hemi sphere Publishing Corporation, New York, USA, 2012.
5. C. Hirsch, "Numerical Computation of Internal and External Flows", Volumes I and II, John Wiley & Sons [2001]

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	3	2	2	2	1	-	-	-	-	1	2	1	-
CO2	2	2	2	2	3	1	-	-	-	-	1	1	2	2
CO3	2	3	3	2	2	-	-	-	-	-	1	1	3	-
CO4	3	3	2	1	2	1	-	-	-	-	1	2	2	1

1- Faintly
2- Moderately
3-Strongly

18THE42	SIMULATION OF IC ENGINES PROCESSES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To learn about the basics of the engine modeling
2. To acquire the knowledge about the various models used for the engine analysis
3. To practice the simulation of IC engines

UNIT I SIMULATION PRINCIPLES **9 + 0**

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

UNIT II SIMULATION OF COMBUSTION IN SI ENGINES **9 + 0**

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 + 0**

Combustion in CI engines Single zone models – Premixed-Diffusive models – Wiebe' model – Whitehouse way model, Two zone models – Multi zone 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 + 0**

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 + 0**

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

Total = 45 Periods

COURSE OUTCOMES:

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

CO1 : apply the knowledge to model an IC engine
CO2 : analyse the components of IC engine
CO3 : frame the suitable mathematical models for an SI & CI engines
CO4 : apply the concepts of simulation to the IC engine components

TEXT BOOKS:

1. J.I Ramos – Internal Combustion Engine Modeling- Hemisphere Publishing Corporation, 1989.
2. Introduction to Modeling and Control of IC Engine Systems, GuzzellaLino, Springer Verlag, 2004.

REFERENCE BOOKS:

1. Ramos J (1989) Internal Combustion Engine Modeling. Hemisphere Publishing Company
2. Ganesan V, "Computer Simulation of spark ignition engine process", Universities Press (I) Ltd, Hyderabad, 2001
3. Heywood J B, "Internal Combustion Engine Fundamentals" McGraw Hill Book Co., USA – 2001.
4. Ramoss A L, "Modeling of Internal Combustion Engines Processes", McGraw Hill Publishing Co.,
5. Ashley Campbel, "Thermodynamic analysis of combustion engines", John Wiley & Sons, New York, 1986.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	3	2	2	2	-	-	-	-	1	2	2	-
CO2	2	3	3	2	3	2	-	-	-	-	1	1	2	-
CO3	3	3	2	1	2	-	-	-	-	-	1	2	2	-
CO4	2	3	3	2	3	2	-	-	-	-	1	1	2	-

1- Faintly
2- Moderately
3-Strongly

18THE43	FUELS AND COMBUSTION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To study various types of fuels for heat generation
2. To learn about the principles of combustion Stoichiometry
3. To study about various combustion equipments

UNIT I FUEL CHARACTERIZATION 9 + 0

Fuels - Types and Characteristics of Fuels - Determination of Properties of Fuels - Fuels Analysis - Proximate and Ultimate Analysis - Moisture Determination - Calorific Value - Gross & Net Calorific Values - Calorimetry - DuLong's Formula for CV Estimation - Flue gas Analysis – Orsat Apparatus - Fuel & Ash Storage & Handling - Spontaneous Ignition Temperatures.

UNIT II SOLID FUELS AND LIQUID FUELS 9 + 0

Types of solid fuels - Coal Family - Properties - Calorific Value - ROM, DMMF, DAF and Bone Dry Basis - Ranking - Bulk & Apparent Density - Storage - Washability - Coking & Caking Coals - Renewable Solid Fuels - Biomass - Wood Waste - Agro Fuels - Manufactured Solid Fuels. Types & sources of liquid fuels, properties of liquid fuels, refining, calorific value, specific gravity, flash & fire point, octane number, cetane number- alcohols, liquefaction of solid fuels.

UNIT III GASEOUS FUELS 9 + 0

Classification- composition & properties - Estimation of Calorific Value - Gas Calorimeter- Rich & Lean Gas - Wobbe Index - Natural Gas - Dry & Wet Natural Gas - Stripped NG – Foul & Sweet NG - LPG - LNG - CNG - Methane - Producer Gas – Gasifiers- Water Gas - Town Gas. Coal gasification- gasification efficiency. Non Thermal Route - Biogas - Digesters - Reactions- Viability – Economics

UNIT IV COMBUSTION : STOICHIOMETRY 9 + 0

Stoichiometry - Mass Basis & Volume Basis - Excess Air Calculation - Fuel & Flue Gas Compositions - Calculations - Rapid Methods - Combustion Processes - Stationary Flame - Surface or Flameless Combustion - Submerged Combustion - Pulsating & Slow Combustion, Explosive Combustion.

UNIT V KINETICS OF COMBUSTION 9 + 0

Mechanism of Combustion - Ignition & Ignition Energy - Spontaneous Combustion - Flame Propagation - Solid, Liquid & Gaseous Fuels Combustion - Flame Temperature - Theoretical, Adiabatic & Actual - Ignition Limits - Limits of Inflammability

Total = 45 Periods

COURSE OUTCOMES:

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

CO1 : apply the knowledge of combustion kinetics for characteristics of fuel.
CO2 : calculate the correct air fuel ratio for complete combustion
CO3 : select the suitable combustion equipment for particular fuel burning
CO4 : design a suitable combustion equipment for burning combination of fuels

TEXT BOOKS:

1. Samir Sarkar, Fuels & Combustion, 2nd Edition, Orient Longman, 2007
2. Bhatt, Vora, Stoichiometry, 2nd Edition, Tata McGraw Hill, 4th Edition , 2009.

REFERENCE BOOKS:

1. Blokh AG, Heat Transfer in Steam Boiler Furnace, Hemisphere Publishing Corporation, 1988
2. Civil Davies, Calculations in Furnace Technology, Pergamon Press, Oxford, 1966
3. Sharma SP, Mohan Chander, Fuels & Combustion, Tata McGraw Hill, 1984

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	1	2	2	1	-	-	-	-	1	3	1	1
CO2	2	3	1	3	3	-	-	-	-	-	1	2	2	-
CO3	2	1	1	3	2	1	-	-	-	-	1	2	2	-
CO4	2	2	2	3	2	1	1	-	-	-	1	1	3	-

1- Faintly
2- Moderately
3-Strongly

18THE44 **ENVIRONMENT AND POLLUTION CONTROL** **L T P C**
3 0 0 3

COURSE OBJECTIVES:

1. To Impart knowledge on fundamental aspects of air pollution & control, noise pollution, and solid waste management.
2. To Introduces some basics of sanitation methods essential for protection of community health.
3. To Differentiate the solid and hazardous waste based on characterization

UNIT I AIR POLLUTION **9 + 0**

Sources and effects of particulate and gaseous air pollutants - Air pollution Control Methods-Particulate control devices – Methods of Controlling Gaseous Emissions – Air quality standards. Air pollution sampling and measurement -Measurement of Total suspended particulate.

UNIT II WATER POLLUTION **9 + 0**

Introduction to various aspects of water pollution and water quality standards. BOD, COD, Oxygen sag curve. Water quality standards of Municipal waste water treatment systems.

UNIT III SOLID WASTE **9 + 0**

Characteristics of solid waste. Overview of solid waste generation and management techniques. solid waste characteristics – Basics of on-site handling and collection – Separation and processing – Incineration-Composting-Solid waste disposal methods – Fundamentals of Land filling.

UNIT IV NOISE POLLUTION **9 + 0**

Nature of sound - Human ear - Quantification of sound in terms of SPL and PWL. Typical noise levels at different places and effects of noise. Noise control methods

UNIT V HAZARDOUS WASTE **9 + 0**

Hazardous wastes- Biomedical wastes – Electronic wastes – Chemical wastes – Treatment and management of hazardous waste-Disposal and Control methods.

Total = 45 Periods

COURSE OUTCOMES:

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

CO1 : identify the air pollutant control devices

CO2 : differentiate the treatment techniques used for sewage and industrial wastewater treatment methods.

CO3 : understand the fundamentals of solid waste management, practices adopted in his town/village and its importance in keeping the health of the city.

TEXT BOOKS:

1. Environmental Engineering, by Ruth F. Weiner and Robin Matthews – 4th Edition Elesevier, 2003.
2. Environmental Science and Engineering by J.G. Henry and G.W. Heinke – Pearson Education.
3. Environmental Engineering by Mackenzie L Davis & David A Cornwell. McGraw Hill Publishing.

REFERENCE BOOKS:

1. Mackenzie L. Davis & David A. Cornwell, “Introduction to Environmental Engineering”, McGraw Hill.
2. Gilbert M. Masters, Standford University, “Introduction to Environmental Engineering and Science”, Printice Hall.
3. Stephan Konz, Kansas State University, “Work design”, Grid Publishing Inc., Colombus, Ohio
4. C. S. Rao, “Environmental Pollution Control Engineering”, New age International (P) Limited, India.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	1	2	3	-	-	-	-	-	1	1	1	2
CO2	2	2	1	1	2	2	3	-	2	1	1	1	1	2
CO3	2	2	3	1	2	2	3	-	2	1	1	2	3	-

1- Faintly
2- Moderately
3-Strongly

18THE45	MODERN POWER PLANT ENGINEERING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To know the current energy scenario in India.
2. To understand the details of Steam Boilers and the Cycles.
3. To understand the environmental issues and government policies.

UNIT I INTRODUCTION **9 + 0**

Overview of Indian power sector – Load curves for various applications – Types of power plants – Merits and Demerits – Criteria for comparison and selection - Economics of power plants

UNIT II STEAM POWER PLANTS **9 + 0**

Basics of typical power plant utilities - Boilers, nozzles, turbines, condensers, cooling towers, water treatment and Piping system - Rankine Cycle – Thermodynamic analysis. Cycle improvements – Superheat, reheat, regeneration

UNIT III DIESEL AND GAS TURBINE POWER PLANTS **9 + 0**

I.C Engine Cycles - Otto, Diesel & Dual –Theoretical vs actual – Typical diesel power plant – Types – Components - Layout - Performance analysis and improvement - Combustion in CI engines - E.C cycles – Gas turbine & Stirling - Gas turbine cycles – Thermodynamic analysis – Cycle improvements - Intercoolers, re heaters, regenerators.

UNIT IV ADVANCED POWER CYCLES **9 + 0**

Cogeneration systems – Topping & Bottoming cycles - Performance indices of cogeneration systems – Heat to power ratio - Thermodynamic performance of steam turbine cogeneration systems – Gas turbine cogeneration systems – Reciprocating IC engines cogeneration systems- Binary Cycle - Combined cycle – IGCC – AFBC / PFBC cycles – Thermionic steam power plant. MHD – Open cycle and closed cycle- Hybrid MHD & steam power plants

UNIT V HYDROELECTRIC & NUCLEAR POWER PLANTS **9 + 0**

Hydroelectric Power plants – Classifications - Essential elements – Pumped storage systems – Micro and mini hydel power plants General aspects of Nuclear Engineering – Components of nuclear power plants - Nuclear reactors & types – PWR, BWR, CANDU, gas cooled, liquid metal cooled and breeder reactor - Nuclear safety – Environmental issues

Total = 45 Periods

COURSE OUTCOMES:

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

CO1 : identify the possible mitigation of anthropogenic emissions by optimizing the power plant cycles or utilities
CO2 : understand the operation of various power plants in India
CO3 : choose a suitable combined cycle power plant for better performance
CO4 : apply and follow the government and legislation policies imposed on pollution control

TEXT BOOKS:

1. Haywood, R.W., Analysis of Engineering Cycles, 4th Edition, Pergamon Press, Oxford, 1991
2. Wood, A.J., Wollenberg, B.F., Power Generation, operation & control, John Wiley, New York, 1984

REFERENCE BOOKS:

1. Nag, P.K., Power Plant Engineering, Tata Mcgraw Hill Publishing Co Ltd, New Delhi, 1998.
2. Arora and Domkundwar, A course in power Plant Engineering, Dhanpat Rai and CO, 2004.
3. Gill, A.B., Power Plant Performance, Butterworths, 1984
4. Lamarsh, J.R., Introduction to Nuclear Engg.2nd edition, Addison-Wesley, 1983.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	3	-	1	2	2	-	-	-	1	1	1	1
CO2	2	2	1	1	2	2	1	-	2	1	1	1	1	-
CO3	2	3	1	2	2	1	-	-	-	-	1	2	1	-
CO4	2	1	3	1	2	2	2	-	2	3	1	-	-	2

1- Faintly
2- Moderately
3-Strongly

PROGRAMME ELECTIVE – V

18THE51	DESIGN OF SOLAR AND WIND SYSTEM	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To learn and study the radiation principles with respective solar energy estimation
2. To understand PV technology principles and techniques of various solar cells / materials for energy conversion
3. Understand the fundamentals of wind energy and its conversion system

UNIT I SOLAR RADIATION AND COLLECTORS 9 + 0

Solar angles – Sun path diagrams – Radiation - extra terrestrial 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 + 0

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

UNIT III SOLAR PV SYSTEM DESIGN AND APPLICATIONS 9 + 0

Solar cells - p-n junction- 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 - stand alone - hybrid and grid connected system - System installation - operation and maintenances - field

UNIT IV WIND ENERGY FUNDAMENTALS & WIND MEASUREMENTS 9 + 0

Wind Energy Basics, Wind Speeds and scales, Terrain, Roughness, Wind Mechanics, Power Content, Class of wind turbines, Atmospheric Boundary Layers, Turbulence. Instrumentation for wind measurements, Wind data analysis, tabulation, Wind resource estimation, Betz's Limit, Turbulence Analysis

UNIT V AERODYNAMICS THEORY & WIND TURBINE TYPES 9 + 0

Airfoil terminology, Blade element theory, Blade design, Rotor performance and dynamics, Balancing technique (Rotor & Blade), Types of loads; Sources of loads Vertical Axis Type, Horizontal Axis, Constant Speed Constant Frequency, Variable speed Variable Frequency, Up Wind, Down Wind, Stall Control, Pitch Control, Gear Coupled Generator type, Direct Generator Drive /PMG/Rotor Excited Sync Generator

Total = 45 Periods

COURSE OUTCOMES:

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

CO1 : suggest and design solar thermal based applications
CO2 : designing of solar photovoltaic based power systems for both domestic and industrial applications
CO3 : know the energy conversion techniques in wind energy
CO4 : learn about wind turbine components and their constructions

TEXT BOOKS:

1. Goswami D.Y., Kreider, J. F. and Francis., "Principles of Solar Engineering', Taylor and Francis, 2000.
2. Chetan Singh Solanki, "Solar Photovoltatics – Fundamentals, Technologies and Applications", PHI Learning Private limited, 2011.
3. Mario Garcia –Sanz, Constantine H. Houpis, "Wind Energy Systems",CRC Press 2012.

REFERENCE BOOKS:

1. Sukhatme S.P.,. Nayak.J.P, 'Solar Energy – Principle of Thermal Storage and collection", Tata McGraw Hill, 2008.
2. Solar Energy International, "Photovoltaic – Design and Installation Manual" – New Society Publishers, 2006.

3. Duffie A. and Beckmann W. A., “Solar Engineering of Thermal Processes, John Wiley, 1991.
4. John D Sorensen and Jens N Sorensen, “Wind Energy Systems”, Woodhead Publishing Ltd, 2011.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	2	3	2	1	1	-	-	-	1	2	3	-
CO2	2	3	2	2	2	1	2	-	-	-	1	2	3	1
CO3	3	1	2	3	2	-	-	-	-	-	1	2	2	-
CO4	2	2	3	3	2	1	1	-	-	-	1	2	2	-

1- Faintly
2- Moderately
3-Strongly

18THE52 DESIGN AND ANALYSIS OF TURBOMACHINES

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

1. To design and analyze the performance of turbo machines for engineering applications
2. To understand the energy transfer process in turbo machines and governing equations of various forms
3. To understand the structural and functional aspects of major components of turbo machines. .
4. To design various turbo machines for power plant and aircraft applications

UNIT I INTRODUCTION **9 + 0**

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

UNIT II CENTRIFUGAL AND AXIAL FLOW COMPRESSORS **9 + 0**

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

UNIT III COMBUSTION CHAMBER **9 + 0**

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

UNIT IV AXIAL AND RADIAL FLOW TURBINES **9 + 0**

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

UNIT V GAS TURBINE AND JET ENGINE CYCLES **9 + 0**

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

Total = 45 Periods

COURSE OUTCOMES:

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

CO1 : understand the design principles of the Turbomachines
CO2 : analyze the Turbomachines to improve and optimize its performance
CO3 : able to study and analysis the various engine cycles

TEXT BOOKS:

1. C.sanady G.T., Theory of Turbo machines, McGraw Hill, 1964.
2. Ganesan V., Gas Turbines, Tata McGrawHill, 2011

REFERENCE BOOKS:

1. Hill P G. and Peterson C R, Mechanics and Thermodynamics of Propulsion, Addition-Wesley, 1970.
2. Cohen H., Rogers, G F C. and Saravan motto H I H., Gas Turbine Theory-5th Edition, John Wiely, 2001.
3. Austin H. Chruch, Centrifugal pumps and blowers, John wiley and Sons, 1980.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	3	2	2	1	-	-	-	-	1	2	3	-
CO2	2	3	1	2	3	1	1	-	-	-	1	2	3	-
CO3	3	2	2	2	2	-	1	-	-	-	1	2	2	-

1- Faintly
2- Moderately
3- Strongly

18THE53	ENERGY SYSTEMS MODELING AND ANALYSIS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To study the energy balance for closed and open system.
2. To study the modelling and simulation of energy system optimization of parameters to improve.
3. To study energy economy models and case studies.

UNIT I INTRODUCTION 9 + 0

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

UNIT II MODELING AND SYSTEMS SIMULATION 9 + 0

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 + 0

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 + 0

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 + 0

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:

CO1 : simulate and model of typical energy system
CO2 : analysis the effects of constraints on the performance of energy systems
CO3 : have a potential to do design HEN net work and perform energy-economic analysis for a typical applications

TEXT BOOKS:

1. B.K.Hodge, “Analysis and Design of Thermal Systems”, Prentice Hall Inc., 1990
2. C. Balaji, “Essentials of Thermal System Design and Optimization”, Aue Books, 2011

REFERENCE BOOKS:

1. Bejan A., Tsatsaronis G. and Moran M., “Thermal Design and Optimization”, John Wiley & Sons 1996.
2. Kapur J. N., “Mathematical Modelling” , Wiley Eastern Ltd , New York , 1989.
3. Stoecker W.F., “Design of Thermal Systems”, McGraw Hill, 2011.
4. Yogesh Jaluria, “Design and Optimization of Thermal Systems”,CRC Press INC, 2008.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	3	2	3	2	1	1	-	-	-	2	1	2	-
CO2	2	2	2	2	2	-	1	-	-	-	1	1	3	-
CO3	2	1	1	2	2	1	2	-	2	2	1	1	3	1

1- **Faintly**
2- **Moderately**
3- **Strongly**

18THE54 **INTERNAL COMBUSTION ENGINE DESIGN** **L T P C**

3 0 0 3

COURSE OBJECTIVES:

1. To understand the basics of engine design and other components of an engine
2. To study the design of two stroke engine and other components
3. To study the applications of computers in engine design

UNIT I GENERAL CONSIDERATIONS IN ENGINE DESIGN 9 + 0

Principle of similitude, choice of cycle, speed, fuel, bore and stroke, cylinder arrangement, choice of material, stress and fatigue considerations, design for manufacture.

UNIT II DESIGN OF MAJOR COMPONENTS 9 + 0

Piston system, connecting rod assembly, crankshaft system, valve gearing , stress analyses.

UNIT III DESIGN OF OTHER COMPONENTS 9 + 0

Inlet and exhaust manifolds, cylinder block, cylinder liner, cylinder head, crankcase, Engine foundations and mountings, gaskets, bearings, flywheel. Turbocharger, supercharger, computer controlled fuel injection system.

UNIT IV DESIGN OF TWO-STROKE ENGINES 9 + 0

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 9 + 0

Preparation of working drawings of designed components using CAD system.

Total = 45 Periods

COURSE OUTCOMES:

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

CO1 : demonstrate the basics of engine design

CO2 : design major engine components

CO3 : design two stroke engines and study the applications of computers in engine design

TEXT BOOKS:

1. Gordon P.Blair, Basic design of Two-stroke Engines, S.A.E., 1992.
2. Gordon P.Blair, Advanced Concepts of Two-stroke Engines, S.A.E., 1990.
3. Pounder, C.C., Marine Diesel Engines, Butterworths, 1981.

REFERENCE BOOKS:

1. A.Kolchin and V.Demidov, Design of Automotive Engines, Mir Publishers, Moscow, 1984.
2. Gordon P.Blair, Design and Simulation of Four-Stroke Engines, Society of Automotive Engineers, Inc., USA, 1999.
3. D.E. Winterbone and R.J.Pearson, Design Techniques for Engine Manifolds, Wave action methods for I.C Engines, Professinal Engineering Publishing Ltd., UK, 2000.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	2	2	3	1	1	2	-	-	1	2	1	-
CO2	2	2	1	1	2	1	1	-	1	2	-	2	1	-
CO3	3	2	2	3	3	1	-	-	-	-	1	2	2	-

1- **Faintly**
2- **Moderately**
3- **Strongly**

18THE55 ADVANCED FINITE ELEMENT ANALYSIS

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

1. To study the differential equations and to apply finite element methods for solving the boundary value problems
2. To develop problem solving skills and understanding of the application of various methods in solving engineering problems

UNIT I REVIEW OF LINEAR FEA **9 + 0**

FE formulation of 1D bar, 3D linear elastic continuum, 2D plane strain, plane stress and axi-symmetric elements; Iso-parametric mapping; numerical integration.

UNIT II FE FORMULATION FOR 1D PLASTICITY **9 + 0**

Elastic-perfectly plastic material; Isotropic and kinematic hardening; Integration algorithms for 1Dplasticity; FE formulation; Newton-Raphson method for solving nonlinear equilibrium equations;1D visco-plasticity and integration algorithm..

UNIT III CONTINUUM THEORIES OF PLASTICITY **9 + 0**

Review of tensor algebra; Yield condition, flow rule and hardening rules; loading and unloading conditions; Drucker's stability postulates; Convexity and normality; J2 flow theory of plasticity and visco-plasticity, Gurson model

UNIT IV FE PROCEDURES FOR 2D AND 3D PLASTICITY **9 + 0**

Integration algorithms for rate independent plasticity–explicit forward Euler and implicit backward Euler; Return mapping algorithm; visco-plasticity; FE formulation; Consistent linearization; Algorithmic and consistent tangent module; Treatment of incompressible deformation (Locking); B-bar method.

UNIT V FE PROCEDURES FOR LARGE DEFORMATION PROBLEMS **9 + 0**

Continuum mechanics–deformation gradient, polar decomposition, Green-Lagrange strain, rate of deformation, Cauchy stress, P-K stresses, Balance laws; Principle of objectivity and isotropy; Constitutive equations for hyper elasticity; Neo-Hookean model; FE formulation–Total Lagrangian and updated Lagrangian descriptions; Tangent Stiffness Matrix. Introduction to finite strain plasticity.

Total = 45 Periods

COURSE OUTCOMES:

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

CO1 : understand of FE formulation for linear problems in solid mechanics

CO2 : understand behaviour of elastic-plastic materials and visco-plasticity, Use of Newton-raphson method for solving nonlinear equations of equilibrium

CO3 : understand flow rules and strain hardening, loading and unloading conditions, Drucker's stability postulates, J2 flow of theory of plasticity

TEXT BOOKS:

1. K. J. Bathe, Finite Element Procedures, Prentice-Hall of India Private Limited, New Delhi,1996
2. J. C. Simo and T. J. R. Hughes, Computational Inelasticity, Springer-Verlag New York, Inc.,New York, 1998
3. O. C. Zienkiewicz and R. L. Taylor, Finite Element Method: Volume 2 Solid Mechanics, Fifth Edition, Butterworth-Heinemann, Oxford, 00

REFERENCE BOOKS:

1. T. Belytschko and W. K. Liu and B. Moran, Nonlinear Finite Elements for Continua and Structures, John Wiley & Sons Ltd., England, 00
2. D. R. J. Owen and E. Hinton, Finite Elements in Plasticity: Theory and Practice, Pineridge Press Ltd., 00
3. Finite Element Analysis Theory and Programming 2nd ed, C.S.Krishnamoorthy, Tata McGraw-Hill 1991

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	2	2	3	1	1	-	-	-	1	1	2	1
CO2	3	3	2	2	2	-	-	-	-	-	1	1	2	-
CO3	3	2	2	3	2	1	2	-	-	-	1	1	2	1

1- Faintly
2- Moderately
3- Strongly

PROGRAMME ELECTIVE – VI

18THE61	BUSINESS ANALYTICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. Understand the role of business analytics within an organization.
2. Analyze data using statistical and data mining techniques and understand relationships between the underlying business processes of an organization.
3. To gain an understanding of how managers use business analytics to formulate and solve business problems and to support managerial decision-making.
4. To become familiar with processes needed to develop, report, and analyze business data
5. Use decision-making tools/Operations research techniques.

UNIT I BUSINESS ANALYTICS AND STATISTICAL TOOLS 9 + 0

Business analytics - Overview - Scope of Business Analytics, Business Analytics Process, Relationship of Business Analytics Process and organization, competitive advantages of Business Analytics. Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modeling, sampling and estimation methods overview.

UNIT II TRENDINESS AND REGRESSION ANALYSIS 9 + 0

Modeling Relationships and Trends in Data, Simple Linear Regression. Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem-solving, Visualizing and Exploring Data, Business Analytics Technology.

UNIT III BUSINESS ANALYTICS & DESCRIPTIVE ANALYTICS & PREDICTIVE ANALYTICS 9 + 0

Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes. Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, Nonlinear Optimization.

UNIT IV FORECASTING TECHNIQUES 9 + 0

Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models. Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model.

UNIT V DECISION ANALYSIS 9 + 0

Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making.

Total =45 Periods

COURSE OUTCOME:

After completion of this course, student will be able to:

CO1 : demonstrate knowledge of data analytics.
CO2 : demonstrate how to think critically in making decisions based on data and deep analytics.
CO3 : demonstrate to use technical skills in predictive and prescriptive modeling to support business decision-making.

CO4 : translate data into clear, actionable insights.

TEXT BOOKS:

1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press.

REFERENCE BOOKS:

1. Business Analytics by James Evans, persons education.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	3	-	1	1	1	2	-	-	-	1	1	3	-
CO2	1	3	1	1	1	1	-	-	-	-	1	1	2	-
CO3	1	1	1	2	3	-	1	-	-	-	1	2	2	1
CO4	1	1	1	-	1	1	-	3	-	2	1	1	2	1

1- Faintly
2- Moderately
3- Strongly

18THE62	INDUSTRIAL SAFETY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To study the requirement for industrial safety and fundamentals of maintenance engineering.
2. To study the fault tracing techniques
3. To understand the maintenance concepts and applying them in industries.

UNIT I INDUSTRIAL SAFETY 9 + 0

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, washrooms, 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 + 0

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

UNIT III WEAR AND CORROSION AND THEIR PREVENTION 9 + 0

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 + 0

Fault tracing-concept and importance, decision tree concept, need and applications, the sequence of fault finding activities, shown decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipments like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. The 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 + 0

Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of the electrical motor, common troubles and remedies of the 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 OUTCOME:

After completion of this course, student will be able to:

CO1 : convey knowledge on safe work practices in offices, industry and construction.
CO2 : to understand the maintenance concept.
CO3 : select suitable techniques to trace faults in industry.
CO4 : select and apply the proper maintenance techniques to industrial equipment.

TEXT BOOKS:

1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.

REFERENCE BOOKS:

1. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.
2. Foundation Engineering Handbook, Winterkorn, Hans, Chapman &Hall London.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	1	2	1	-	-	1	2	-	2
CO2	1	1	1	1	1	1	-	-	-	-	1	-	-	1
CO3	1	1	1	1	3	-	1	-	-	-	1	-	-	2
CO4	1	1	1	-	3	1	-	2	-	2	1	-	-	2

1- Faintly
2- Moderately
3- Strongly

18THE63	OPERATIONS RESEARCH	L	T	P	C
		3	0	0	3

COURSE OBJECTIVE

1. To familiarize how to use variables for formulating complex mathematical models in management science and industrial engineering
2. To familiarize with the use of basic methodology for the solution of linear programs and integer programs.
3. To understand the advanced methods for large-scale transportation and assignment problems

UNIT I **9 + 0**

Optimization techniques, model formulation, models, General L.R Formulation, simplex techniques, sensitivity analysis, inventory control models.

UNIT II **9 + 0**

Formulation of a LPP - Graphical solution revised simplex method - Duality theory - Dual simplex method - Sensitivity analysis - Parametric programming

UNIT III **9 + 0**

Nonlinear programming problem - Kuhn-Tucker conditions min-cost flow problem - Max flow problem - CPM/PERT

UNIT IV **9 + 0**

Scheduling and sequencing - Single server and multiple server models - Deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

UNIT V **9 + 0**

Competitive Models, Single and Multi-channel Problems, sequencing models, dynamic programming, flow in networks, elementary graph theory, game theory simulation

Total =45 Periods

COURSE OUTCOMES:

At the end of the course, the student should be able to

CO1: apply the dynamic programming to solve problems of discrete and continuous variables
CO2: apply the concept of non-linear programming
CO3: carry out sensitivity analysis
CO4: model the real world problem

TEXT BOOKS :

1. H.A. Taha, Operations Research, An Introduction, PHI,2008
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.

REFERENCE BOOKS:

3. J.C. Pant, Introduction to Optimization: Operations Research, Jain Brothers, Delhi,2008
4. Hitler Liebermann Operations Research: McGraw Hill Pub.2009
5. Pannerselvam, Operations Research: Prentice Hall of India2010
6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India2010

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	1	1	-	-	1	2	-	2	-	1	2	2	-
CO2	1	1	1	1	1	-	-	-	2	1	1	2	2	-
CO3	2	3	1	1	1	1	-	-	-	-	1	1	3	-
CO4	1	2	1	1	1	-	1	-	-	1	1	-	-	2

1- **Faintly**
2- **Moderately**
3- **Strongly**

18THE64 COST MANAGEMENT OF ENGINEERING PROJECTS

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

1. To understand the technical concepts of engineering economic analysis
2. To apply appropriate analytical techniques to wide variety of real world problems and data sets.
3. To summarize and present the analysis results in a clear and coherent manner.

UNIT I **9 + 0**

Introduction and Overview of the Strategic Cost Management Process Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.

UNIT II **9 + 0**

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as a conglomeration of technical and non- technical 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. Types and contents. Project execution Project cost control. Bar charts and Network Diagram. Project commissioning: mechanical and process.

UNIT III **9 + 0**

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. Standard Costing and Variance Analysis.

UNIT IV **9 + 0**

Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of the service sector. The just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

UNIT V **9 + 0**

Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

Total =45 Periods

COURSE OUTCOMES:

At the end of the course, the student should be able to

CO1: explain the concepts of cost management and decision making
CO2: explain the concept of projects, its process, objectives and functions of project management
CO3: analyze costing techniques and cost-volume-profit relationships
CO4: apply the pricing strategies and budgetary controls
CO5: select the appropriate quantitative techniques for cost management

TEXT BOOKS :

1. Cost Accounting A Managerial Emphasis, Prentice Hall of India, and New Delhi.
2. Charles T. Horngren and George Foster Advanced Management Accounting.

REFERENCE BOOKS:

1. Robert S Kaplan Anthony A. Alkinson, Management &Cost Accounting.
2. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheelerpublisher.
3. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co.Ltd.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	1	1	-	-	-	1	1	1	1	-	-	1
CO2	1	1	1	1	-	-	-	1	1	-	1	-	-	1
CO3	1	3	2	1	1	-	-	1	1	1	1	-	-	2
CO4	1	1	1	2	1	1	1	-	-	1	1	-	-	1
CO5	1	1	1	1	3	-	-	1	1	-	1	-	-	1

1- Faintly
2- Moderately
3- Strongly

18THE65	WASTE TO ENERGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To study the waste sources of energy and ways to convert biomass into energy.
2. To study the techniques to generate biogas from waste.

UNIT I INTRODUCTION TO ENERGY FROM WASTE 9 + 0

Classification of waste as fuel – Agro-based, Forestresidue, Industrial waste - MSW – Conversion devices – Incinerators, Gasifiers, digesters

UNIT II BIOMASS PYROLYSIS 9 + 0

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 + 0

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 + 0

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.

UNIT V BIOGAS 9 + 0

Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bioenergy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermochemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Biodiesel production - Urban waste to energy conversion - Biomass energy programme inIndia

Total =45 Periods

COURSE OUTCOMES:

After completion of the course students should be able to

CO1: understand the concepts of energy conversion technique from waste.
CO2: understand biogas generation techniques such as pyrolysis, gasification and combustion.
CO3: Identify the suitable method for available waste.

TEXT BOOK:

1. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany.
2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition,2007.

REFERENCE BOOKS:

1. Non-Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2. Biogas Technology - A Practical Hand-Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.

3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Biomass Conversion and Technology, C. Y. WereKo-Bobby and E. B. Hagan, John Wiley &Sons, 1996.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	1	1	1	-	-	1	-	-	2	1	-	-	1
CO2	1	1	1	-	-	-	2	1	-	3	1	-	-	1
CO3	1	1	1	-	-	-	1	-	-	3	1	-	-	1

1- Faintly
2- Moderately
3- **Strongly**

AUDIT COURSES

18AC01	ENGLISH FOR RESEARCH PAPER WRITING	L	T	P	C
		2	-	-	0

COURSE OBJECTIVES:

1. To Understand how to improve writing skills and level of readability
2. To Learn about what to write in each section
3. To Understand the skills needed when writing a title.
4. To Ensure the good quality of paper

UNIT I **4 + 0**

Planning and Preparation, word order, breaking up long sentences, structuring paragraphs and sentences, being concise and removing redundancy, avoiding ambiguity and vagueness

UNIT II **4 + 0**

Clarifying Who Did What, highlighting your findings, hedging and criticizing, paraphrasing and plagiarism, sections of a Paper, abstracts. Introduction

UNIT III **4 + 0**

Review of the Literature, methods, results, discussion, conclusions, the final check

UNIT IV **4 + 0**

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,

UNIT V **4 + 0**

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 VI **4 + 0**

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

Total= 24 Periods

COURSE OUTCOMES:

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

CO1 : practice the unique qualities of a professional writing style
CO2 : recognize, explain, and use the verbal strategies and the formal elements
CO3 : collect, analyze, document, and report research clearly, concisely, logically, and ethically
CO4 : participate actively in writing activities that model effective scientific and technical papers.

TEXT BOOKS

1. Adrian Wallwork (2011) English for Writing Research Papers, Springer New York Dordrecht Heidelberg London.
2. Goldbort R (2006) Writing for Science, Yale University Press

REFERENCE BOOKS:

3. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
4. Highman N (1998) Handbook of Writing for the Mathematical Sciences, SIAM. Highman'sbook.
5. McMurrey,David A. and Joanne Buckley (2008) Handbook for Technical Writing, New Delhi: Cengage Learning, 2008

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	1	1	1	-	-	1	-	-	2	1	1	2	-
CO2	1	1	1	-	-	-	2	1	-	3	1	-	-	-
CO3	1	1	1	-	-	-	1	-	-	3	1	-	-	1
CO4	1	2	1	1	1	-	1	-	-	1	1	-	-	1

1- **Faintly**
2- **Moderately**
3- **Strongly**

18AC02	DISASTER MANAGEMENT	L	T	P	C
		2	-	-	0

COURSE OBJECTIVES:

1. Learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response
2. Critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
3. Develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations
4. Critically understand the strengths and weaknesses of disaster management approaches

UNIT I INTRODUCTION **4 + 0**

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 **4 + 0**

Economic Damage, loss of human and animal life, destruction of ecosystem. Natural Disasters: Earthquakes, volcanism, 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 **4 + 0**

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 **4 + 0**

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 **4 + 0**

Disaster Risk: Concept and elements, disaster risk reduction, global and National disaster risk situation. Techniques of Risk Assessment, global Co-Operation In risk assessment and warning, people's participation in risk assessment. Strategies for Survival.

UNIT VI DISASTER MITIGATION **4 + 0**

Meaning, Concept And Strategies of Disaster Mitigation, emerging trends in Mitigation. Structural Mitigation And Non-Structural Mitigation, Programs of Disaster Mitigation In India.

Total= 24 Periods

COURSE OUTCOMES:

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

CO1 : develop an understanding of the key concepts and the significance of disaster management
CO2 : understand the occurrences, reasons and mechanism for various types of disaster.
CO3 : have a basic understanding of the Disaster Preparedness and Management
CO4 : develop a basic under the understanding of Risk assessment, Prevention, Mitigation, Response and Recovery.

TEXT BOOKS:

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

REFERENCE BOOKS:

3. Goel S. L. 2007 Disaster Administration And Management Text And Case Studies Deep &Deep Publication Pvt. Ltd., New Delhi.
4. Mishra A 2012 New Dimensions of Disaster Management in India: Perspectives Approaches and Strategies (Set of 2 Vols) Serials publications, New Delhi.
5. Sharma, Kadambari C, Avina 2010 Disaster Management in India JnanadaPrakashan [P&D], New Delhi.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	1	1	1	-	-	1	-	-	2	1	-	-	2
CO2	1	1	1	-	-	-	2	1	-	1	1	2	-	1
CO3	1	1	1	-	-	-	1	-	-	1	1	-	-	-
CO4	1	1	1	1	1	-	1	-	-	1	1	-	-	-

1- Faintly
2- Moderately
3- Strongly