PROGRAM OUTCOMES

a) Able to apply advanced thermal engineering concepts in the design of engineering equipment/ systems.

b) Able to utilize non-conventional energy resources for the development of ecofriendly thermal systems.

c) Able to use modern engineering tools and techniques to analyse and interpret the data in fluid flow and thermal engineering problems.

d) Able to Independently carry out research/investigation and development work to solve thermal engineering problems.

e) Able to write and present a substantial technical report/document.

f) Able to learn independently and engage in lifelong learning with understanding of professional, social and ethical responsibility for the need of sustainable development.

VELAGAPUDI RAMAKRISHNA
SIDDHARTHA ENGINEERING COLLEGE
SCHEME OF INSTRUCTIONS FOR TWO YEAR PG PROGRAMME [M. TECH 19]

SEMESTER I **Contact Hours: 23**

S. No	Course Type	Course Code	Title of Course	L	T	P	C	CE	SE	Total
1	Programme Core - I	19METE1001	Advanced Thermodynamics	3	0	0	3	40	60	100
2	Programme Core - II	19METE1002	Advanced Fluid Mechanics	3	0	0	3	40	60	100
3	Programme Core - III	19METE1003	Advanced Heat and Mass Transfer	3	0	0	3	40	60	100
4	Programme Elective - I	19METE1014	A. Advances in I.C. Engines B. Measurements in Thermal Engineering C. Gas Dynamics	3	0	0	3	40	60	100
5	Programme Elective - II	19METE1015	A. Advanced Refrigeration and Air Conditioning B. Environmental Engineering and Pollution Control C. Nuclear Power Plants	3	0	0	3	40	60	100
6	Mandatory Learning Course	19MTMC1026	Research Methodology and IPR	2	0	0	0	40	60	100
7	Laboratory - I	19METE1051	Advanced Thermal Engineering Laboratory	0	0	3	1.5	40	60	100
8	Laboratory - II	19METE1052	Fluid Flow Simulation Laboratory	0	0	3	1.5	40	60	100
			Total:	**17**	**0**	**6**	**18**	**320**	**480**	**800**

L – Lecture, T – Tutorial, P – Practical, C – Credits, CE – Continuous Evaluation, SE – Semester end Evaluation

SEMESTER II **Contact Hours: 25**

S. No	Course Type	Course Code	Title of Course	L	T	P	C	CE	SE	Total
1	Programme Core – IV	19METE2001	Gas Turbines and Jet Propulsion Systems	3	0	0	3	40	60	100
2	Programme Core – V	19METE2002	Finite Element Method for Thermal Engineering	3	0	0	3	40	60	100
3	Programme Core – VI	19METE2003	Computational Fluid Dynamics	3	0	0	3	40	60	100
4	Programme Elective – III	19METE2014	A. Solar Energy Utilization B. Thermal Energy Storage Technologies C. Hydrogen and Fuel Cell Technologies	3	0	0	3	40	60	100
5	Programme Elective – IV	19METE2015	A. Design of Heat Transfer Equipment B. Energy Conservation and Management C. Cryogenic Engineering	3	0	0	3	40	60	100
6	Audit Course	19MTAC2036	Technical Report Writing	2	0	0	-	-	-	-
7	Laboratory - I	19METE2051	Thermal FEM Laboratory	0	0	3	1.5	40	60	100
8	Laboratory - II	19METE2052	Computational Fluid Dynamics Laboratory	0	0	3	1.5	40	60	100
9	Term Paper	19METE2063	Term Paper*	0	0	2	1	40	60	100
			Total:	**17**	**0**	**8**	**19**	**320**	**480**	**800**

L – Lecture, T – Tutorial, P – Practical, C – Credits, CE – Continuous Evaluation,

SE – Semester end Evaluation

***Students should conduct the Literature Survey for the proposed research topic and they need to develop a proto type or simulation based (must be outcome oriented) – the same to be presented in any conference (national or international)**

Semester III **Contact Hours: 24**

S. No	Course Type	Course Code	Title of Course	L	T	P	C	CE	SE	Total
1.	Programme Elective - V	19METE3011	Student Choice course[$]	0	0	0	3	-	100[#]	100
2.	Project	19METE3061	Project – Part A[*]	0	0	20	10	40	60	100
3.	Internship	19METE3052	Internship	0	0	4	2	-	100	100
			Total	**0**	**0**	**24**	**15**	**40**	**260**	**300**

L – Lecture, T – Tutorial, P – Practical, C – Credits, CE – Continuous Evaluation, SE – Semester end Evaluation

[$]Program Elective V may be completed in semester I or II by satisfying the pre-requisites

[#]Evaluation done by MOOCs providers will be considered

[*]To be continued in the IV Semester

Semester IV **Contact Hours: 32**

S. No	Course Type	Course Code	Title of Course	L	T	P	C	CE	SE	Total
1.	Project	19METE4061	Project – Part B	0	0	32	16	40	60	100
			Total	**0**	**0**	**32**	**16**	**40**	**60**	**100**

L – Lecture, T – Tutorial, P – Practical, C – Credits, CE – Continuous Evaluation, SE – Semester end Evaluation

Course Type & Code

Programme Core - 0
Programme Elective - 1
Mandatory Course - 2
Audit Course - 3
Open Elective - 4
Internship/Laboratory - 5
Term Paper/Project- - 6

Semester	Credits
I	**18**
II	**19**
III	**15**
IV	**16**
Total:	**68**

Program Core	**6**
Program Elective	**5 (V is MOOCs)**
Program lab	**4**
MLC	**1**
Audit Course	**1**
Term Paper/Mini Project/Project	**3**

19METE1001 ADVANCED THERMODYNAMICS

Course Category:	Programme Core	**Credits:**	3
Course Type:	Theory	**Lecture-Tutorial-Practice:**	3-0-0
Prerequisites:	Engineering mathematics, Basics of Thermodynamics	**Continuous Evaluation:**	40
		Semester end Evaluation:	60
		Total Marks:	100

Course Outcomes:

At the end of the course the student will be able to:

CO1: Understand the concept of entropy and apply principles of thermodynamics to analyze advanced power cycles.

CO2: Analyze energy systems with Exergy and irreversibility concepts.

CO3: Apply thermodynamic relations for studying the behaviour of ideal and real gasses

CO4: Apply first and second laws of thermodynamics to analyse chemical reactions.

Contribution of Course Outcomes towards achievement of Program Outcomes

	PO a	PO b	PO c	PO d	PO e	PO f
CO1	**H**		**L**	**M**		**M**
CO2	**H**		**L**			
CO3	**H**		**L**			
CO4	**H**		**L**			

(H - High, M - Moderate, L - Low)

Course Content:

UNIT I

Advanced Power Cycles: Binary vapour cycle, cogeneration and combined gas-vapour cycle, Thermodynamics of coupled cycles.

Entropy: Concept of entropy - Entropy principle-Applications of entropy principle, Entropy change of pure substance, Property diagram involving entropy, Entropy generation in daily life, Entropy change of liquids and ideal gasses, Entropy balance for open and closed systems, Third Law of Thermodynamics.

UNIT II

Exergy: Concept of exergy – second law efficiency, exergy change of a system, exergy transfer by heat, work and mass, the decrease of exergy principle and exergy destruction, Exergy balance for open and closed systems.

Irreversibility: Introduction - irreversibility for closed and open system – steady flow process - second law efficiency of steady flow devices.

UNIT III

Thermodynamic Relations: Difference in Heat Capacities- Ratio of Heat Capacities - Energy Equation–Joule-Thomson's Effect, Clausius Clayperon equation-Evaluation of thermodynamic properties from an equation of state, general thermodynamic considerations on an equation of state.

Real Gases: Volume Expansivity and Isothermal & Adiabatic compressibility, Real gas behaviour and Equations of state – Generalized chart for changes of enthalpy & entropy at constant temperature – Property relations for mixtures.

UNIT IV

Chemical Reactions: Combustion, Theoretical and actual combustion processes, Enthalpy of formation, Enthalpy of Combustion, First Law analysis of Reacting Systems, Adiabatic flame temperature – Entropy change of Reacting Mixtures, Second Law analysis of Reacting systems, fuel cells and engineering applications.

Text Books:

1. Basic and Applied Thermodynamics - P.K. Nag, Tata McGraw Hill Education Pvt. Ltd.
2. Thermodynamics - An Engineering Approach - Yunus A. Cengel M. and Michael A. Boles, McGraw Hill Education (I) Pvt. Ltd.

Reference Books:

1. Thermodynamics - Holman, J.P., McGraw-Hill Inc.
2. Engg. Thermodynamics - Gordon Rogers and Yon Mayhew, Addison Wesley Longman.
3. Classical Thermodynamics - Van Wylen, Richard E. Sonntag, Wiley publication.

Web Resources:

- https://nptel.ac.in/courses/112105123/
- http://www.newworldencyclopedia.org/entry/Thermodynamics
- https://www.transtutors.com/

19METE1002 ADVANCED FLUID MECHANICS

Course Category:	Programme Core	**Credits:**	3
Course Type:	Theory	**Lecture-Tutorial-Practice:**	3-0-0
Prerequisites:	Differential Calculus Fluid Mechanics	**Continuous Evaluation:**	40
		Semester end Evaluation:	60
		Total Marks:	100

Course Outcomes:

At the end of the course the student will be able to

CO1: Derive the governing differential equations of fluid flow.

CO2: Determine the laminar flow solutions for flow in pipes, flow between parallel plates and between rotating cylinders.

CO3: Understand the concept of turbulence in pipe flows and analyzing the flows in smooth and rough pipes.

CO4: Analyze laminar and turbulent boundary layer flows on a flat plate.

CO5: Analyze the Drag and Lift forces on submerged bodies.

CO6: Apply the equations of fluid flow for compressible flow in nozzles.

Contribution of Course Outcomes towards achievement of Program Outcomes

	PO a	PO b	PO c	PO d	PO e	PO f
CO1	**M**			**L**		**L**
CO2	**M**		**M**	**L**		**L**
CO3	**H**			**M**		**L**
CO4	**M**		**H**	**L**		**L**
CO5	**H**		**M**	**M**		**L**
CO6	**H**		**H**	**M**		**L**

(H - High, M - Moderate, L - Low)

Course Content:

UNIT I

Fundamental Laws Of Fluid Flow: Derivation of general differential equations of fluid flow– continuity, momentum and energy equations- Navier Stokes and Euler equations, Boundary conditions.

Laminar Internal Flows: Laminar flow between parallel flat plates- Couette-flow, Laminar flow in circular pipes- Hagen–Poiseuille flow, Laminar flow between rotating cylinders. Solutions by elemental approach and solving N-S equations.

UNIT II

Turbulent Internal Flows: Effect of turbulence, types, intensity and scale of turbulence, Reynolds's equations of turbulence, turbulence modeling. Equations for velocity distribution and frictional factor in smooth and rough pipes, friction factor charts - Moody's diagram

Flow Around Submerged Bodies: Drag and Lift coefficients, stream lined and bluff bodies, Drag on a flat plate, cylinder and a sphere, Drag and Lift on an aerofoil.

UNIT III

Laminar Boundary Layer Flows: Boundary layers parameters, Prandtl's Boundary Layer Equations, Von Karman momentum integral equation and solution to Laminar Boundary layer. Separation of Boundary layer

Turbulent Boundary Layer Flows: Solution to turbulent boundary layer flows- Power law form and Empirical form, Solution to combine laminar and turbulent flows, Boundary layer separation.

UNIT IV

Compressible Fluid Flow: Wave Propagation and Sound Velocity, Mach number and Compressible Flow Regimes, Mach Cone, Mach Angle, Mach Line, Basic Equation for One-Dimensional Compressible Flow, Isentropic Flow relations, Compressibility Correction Factor.

Compressible Flow in Nozzles: Area-velocity relations, Nozzles off the design pressure ratio. Effect of viscous friction and heat transfer in compressible flows, in constant area ducts (Fanno equations, Fanno lines, Rayleigh formulae, Rayleigh lines).

Text Books:

1. Fluid Mechanics - Merle C. Potter, David C. Wiggert, Cengage Learning
2. Fluid Mechanics - Fundamentals & Applications - Yunus A Cengel and John M. Cimbala, McGraw Hill Publication.
3. Fluid Mechanics and Fluid power Engineering - D.S Kumar, Kataria & sons.

References:

1. Fluid Mechanics - Frank M. White, McGraw Hill.
2. Fundamentals of Compressible Flow - Yahya S.M., New age publications.
3. Fluid Mechanics - A.K. Mohanty, PHI learning Pvt. Ltd
4. Hydraulics and fluid mechanics - P.N. Modi & S.M. Seth, Rajsons pub.
5. Advanced Engineering Fluid Mechanics - K. Muralidhar & G. Biswas, Narosa pub

Web Resources:

- http://www.nptel.ac.in/courses/112104118/ui/TOC.htm IIT Kanpur
- http://nptel.ac.in/courses/112105171/1 IIT Kharagpur
- http://nptel.ac.in/courses/105101082/ IIT Bombay
- http://nptel.ac.in/video.php?subjectId=105101082
- http://www.nptelvideos.in/2012/11/fluid-mechanics.html
- http://freevideolectures.com/Course/89/Fluid-Mechanics/1

19METE1003 ADVANCED HEAT AND MASS TRANSFER

Course Category:	Programme Core	**Credits:**	3
Course Type:	Theory	**Lecture-Tutorial-Practice:**	3-0-0
Prerequisites:	Thermodynamics, Fluid Mechanics, Differential Calculus	**Continuous Evaluation:**	40
		Semester end Evaluation:	60
		Total Marks:	100

Course Outcomes:

At the end of the course the student will be able to

CO1: Understand principles of conduction heat flow in 2-D steady and unsteady state

CO2: Analyse forced convection problems involving complex geometries and boundary conditions.

CO3: Analyse free convection phenomenon for different geometries and can understand the Radiation heat exchange process

CO4: Apply mass transfer principles to relevant applications

Contribution of Course Outcomes towards achievement of Program Outcomes

	PO a	PO b	PO c	PO d	PO e	PO f
CO1	H	M	H	H		
CO2	H	M	H	H		
CO3	H	H	M	M		
CO4	H	L	H	H		

(H - High, M - Moderate, L - Low)

Course Content:

UNIT I

2-D Steady State Conduction: Analytical Solution-Method of separation of variables, Numerical Solution- FDM

Unsteady Conduction: Lumped Heat Capacity System, Transient heat conduction in infinite plates, long cylinders and spheres, Heisler charts for Transient heat flow and semi-infinite solids, semi-infinite solids, numerical solution for transient heat flow, explicit approach, Implicit approach.

UNIT II

Forced Convection: Mechanism of convective heat transfer, Dimensionless expression of heat transfer coefficient. Laminar Boundary Layer: solution of boundary layer equation for flow over flat plate (Blassius solution), wall shear stress and boundary layer thickness, solution of momentum integral equation (Karman Pohlhauson method), Boundary layer Analogies, Use of empirical correlations for flow over a flat plate, flow across cylinders and spheres, tube banks – inline and staggered arrangement.

UNIT III

Free-Convection: Mechanism of Natural convective heat transfer, Laminar free convection on a vertical surface, approximate solution by the integral method, Use of empirical correlations for vertical plates, cylinders, horizontal plates, cylinders, spheres and enclosed spaces, Combined free and forced convection.

Radiation Heat Exchange: Radiation heat exchange between black and non-black surfaces separated by non-participating media.

Gas Radiation: Radiation transfer in enclosures containing absorbing and emitting media - interaction of radiation with conduction and Convection.

UNIT IV

Diffusion Mass Transfer: Physical Origins and rate reactions, Mass transfer in non-stationary media, stationary media approximation, conservation of spices for a stationary media, Boundary conditions and discontinues concentrations at interfaces, Mass diffusion with homogenous chemical reaction, transient diffusion.

Text Books:

1. Introduction to Heat Transfer – S.K. Som, PHI.
2. Principles of Heat and Mass Transfer – Frank P Incropera, David P. Dewitt, Theodore L Bergman and Adrienne S Lavine, Wiley.
3. Heat and Mass transfer - P.K. Nag, TMH.

Reference Books:

1. Heat Transfer - A Basic Approach - Ozisik M.N., McGraw-Hill.
2. Convective heat and mass transfer - Kays, W.M. and Crawford, M.E., McGraw Hill.
3. Heat and mass transfer - D.S. Kumar, Kataria & sons.

Web Resources:

- http://freevideolectures.com/Course/2366/Heat-and-Mass-Transfer
- http://nptel.ac.in/courses/112101097/
- http://nptel.ac.in/courses/Webcourse contents/IIScBANG/Heat%20and%20Mass%20Transfer/New_index1.html
- http://textofvideo.nptel.iitm.ac.in/112101097/lec1.pdf
- http://www.nptelvideos.in/2012/11/heat-transfer.html
- https://www.wisc-online.com/learn/natural-science/earth-science/sce304/heat-transfer-conduction-convection-radiation
- http://web.mit.edu/lienhard/www/ahtt.html

Note: Heat and Mass Transfer Data Book by Kothandaraman and Subramanian (or) Domkundwar to be allowed in Examination

19METE1014A ADVANCES IN I. C. ENGINES

Course Category:	Programme Elective	**Credits:**	3
Course Type:	Theory	**Lecture-Tutorial-Practice:**	3-0-0
Prerequisites:	I.C. Engines and Pollution	**Continuous Evaluation:**	40
		Semester end Evaluation:	60
		Total Marks:	100

Course Outcomes:

At the end of the course the student will be able to

CO1: Analyse the design and operating parameters of I.C. Engines and fuel Injection systems.

CO2: Evaluate Gas Exchange process and recent engine developments.

CO3: Identify different Alternate fuels based on the need and Properties and different pollution control measures.

CO4: Analyse Hybrid Electric vehicle Technologies,

Contribution of Course Outcomes towards achievement of Program Outcomes

	PO a	PO b	PO c	PO d	PO e	PO f
CO1	**M**					
CO2			**H**	**L**		
CO3				**H**	**M**	**H**
CO4		**H**				**H**

(H - High, M - Moderate, L - Low)

Course Content:

UNIT I

Spark Ignition Engine: mixture requirements – Fuel – Injection systems – Mono-point, Multipoint injection, direct injection – Stages of combustion – Normal and abnormal Combustion – factors affecting knock – Combustion chambers.

Compression Ignition Engines: States of combustion in C.I. Engine – Direct and indirect injection systems – Combustion chambers – Fuel spray behaviour – spray structure, spray penetration and evaporation – air motion.

UNIT II

Scavenging and Super-Charging: Scavenging and supercharging in CI engines - types of scavenging systems in two stroke SI engines – improved and modified scavenging systems – super charging and engine performance – methods of super charging, Turbo charging

Recent Trends: Dual fuel engine, Adiabatic Engines, Variable Compression Ratio Engines, Free Piston Engines, Stratified charge Engines, homogeneous charge compression Ignition engines, Plasma Ignition - Wankel engine, Stirling cycle engine.

UNIT III

Alternative Fuels: Liquid fuels- Alcohol, Methanol, Ethanol, and Bio fuel Gaseous fuels - Hydrogen, Natural Gas and Liquefied Petroleum Gas, Bio gas Properties, Suitability, Merits and Demerits & Engine Modifications.

Pollution Control: Methods of controlling Emissions – Catalytic converters and Particulate Traps – Emission Instrumentation – Non-dispersive infrared gas analyzer, flame ionization detector – chromo-autograph – chemiluminiscent analysis of nitrogen oxides.

UNIT IV

Introduction to Hybrid Electric Vehicles: Types of EVs, Hybrid Electric Drive-train, Tractive effort in normal driving, Energy consumption Concept of Hybrid Electric Drive Trains, Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles: - Battery based energy storage and, Fuel Cell based energy storage and its analysis, Hybridization of different energy storage devices. EV and EV charging standards**,** Indian Roadmap Perspective Policy.

Text Books:

1. Internal Combustion Engines - V. Ganesan, TMH Pub.
2. Fundamentals of Internal Combustion Engines - H.N. Gupta, PHI.
3. Electric and Hybrid Vehicles – Iqbal Husain, Boca Raton, CRC Press.
4. Electric Vehicle Technology Explained - Larminie, James, and John Lowry, John Wiley and Sons.

References:

1. Internal Combustion Engine Fundamentals - K.K. Ramalingam, SciTech Pub.
2. Internal combustion Engines – Mathura & Sharma
3. Internal combustion engines fundamentals - Heywood J.B., McGraw hill Int. editions.
4. Air pollution - Rao M.N., TMH.
5. Environmental pollution control Engg - Rao C.S., Wiley Eastern Ltd.
6. Fuels & Combustion - Sharma S.P., TMH.
7. The complete Idiots guide to Hybrid and Alternative fuel vehicles by Jacj R. Nerad.
8. The automobile in Electric Vehicles: Prospects and Challenges - Tariq Muneer and Irene Illescas García, Elsevier.
9. Hybrid and Alternative Fuel vehicles - James. D. Halderman.

Web Resources:

- https://www.iitk.ac.in/erl/Index_files/ProcSPIE90650B.pdf)
- http://www.ieahev.org/about-the-technologies/hybrid-electric-vehicles/
- https://en.wikipedia.org/wiki/Hybrid_electric_vehicle

19METE1014B MEASUREMENTS IN THERMAL ENGINEERING

Course Category:	Programme Elective	**Credits:**	3
Course Type:	Theory	**Lecture-Tutorial-Practice:**	3-0-0
Prerequisites:	Basics of Thermodynamics, Fluid Mechanics	**Continuous Evaluation:**	40
		Semester end Evaluation:	60
		Total Marks:	100

Course Outcomes:

At the end of the course the student will be able to

CO1: Understand the principles of transducers and analyse the experimental data.

CO2: Identify appropriate pressure and flow measurement devices for different applications.

CO3: Choose appropriate devices for the measurement of temperature and other thermal properties.

CO4: Apply transducers and energy principles to measure air pollution and thermal radiation.

Contribution of Course Outcomes towards achievement of Program Outcomes

	PO a	PO b	PO c	PO d	PO e	PO f
CO1	**M**		**M**			
CO2	**M**		**M**			
CO3	**M**		**M**			
CO4	**M**		**M**			

(H - High, M - Moderate, L - Low)

Course Content:

UNIT I

Analysis of Experimental Data: Causes and types of experimental errors, Error analysis on a common sense basis, Uncertainty analysis, Statistical analysis of experimental data probability distributions, Standard deviation of the mean.

Basic Electrical Measurements and Sensing Devices: Transducers –Variable Resistance, The differential transformer (LVDT), Capacitive, Piezoelectric, Photoelectric effects, Photoconductive transducers, Photovoltaic cells, Hall-effect transducers.

UNIT II

Pressure Measurement: Mechanical pressure - Measurement devices, Dead- weight tester, Bourdon-tube pressure gauge, Diaphragm and bellows gauges, Low- pressure measurement. McLeod gauge, Pirani thermal-conductivity gauge, Knudsen gauge, ionization gauge.

Flow Measurement: Positive displacement methods, flow - Obstruction methods, Practical consideration for obstruction meters, and the sonic nozzle, Flow measurement by Drag Effects, Hot- wire and hot-film anemometers, Magnetic flow meters, Flow visualization methods, smoke methods

UNIT III

Measurement of Temperature: Ideal-gas thermometer, Temperature measurement by mechanical effect. Temperature measurement by electrical effects, Temperature measurement by radiation, Transient response of thermal systems, Thermocouple compensation.

Thermal and Physical Property Measurement: Thermal conductivity measurements, Measurement of viscosity, Gas diffusion, Calorimetry, Humidity measurements, Heat-flux meters.

UNIT IV

Air Pollution Measurements: Air–Pollution Standards, General Air sampling Train, Gas Sampling Techniques, Particulate sampling Techniques, Sulphur-dioxide measurements, Combustion Products Measurements, Opacity Measurements, Odour measurements.

Thermal Radiation Measurements: Detection of thermal Radiation, Measurement of Emissivity, Reflectivity and Transmissivity, Solar radiation measurements.

Text Books:

1. Experimental Methods for Engineers - Holman J.P., TMH.
2. Mechanical Measurements & Control - D S Kumar, Metropolitan Book Co.

References:

1. Mechanical Measurements - Thomas G. Beckwith, N. Newis Buck
2. Mechanical Measurements - R S Sirohi and Radhakrishnan, New Age Intl.
3. Course in Mechanical Measurements and Instrumentation - A K Sawhney, Dhanapat Rai & Sons.

Web resources:

- http://nptel.ac.in/downloads/112104039/
- http://web.iitd.ac.in/~pmvs/course_mel705.php

19METE1014C GAS DYNAMICS

Course Category:	Programme Elective	**Credits:**	3
Course Type:	Theory	**Lecture-Tutorial-Practice:**	3-0-0
Prerequisites:	Fluid Mechanics	**Continuous Evaluation:**	40
		Semester end Evaluation:	60
		Total Marks:	100

Course Outcomes:

At the end of the course the student will be able to

CO1: Understand the physics behind the concepts of wave propagation.

CO2: Formulate and solve problems in 1D steady compressible flows & 2D Compressible flows.

CO3: Analyse the flow parameters through normal shock waves and strength of shock waves on wedge shaped bodies and concave corners.

CO4: Evaluate the flows with friction and heat transfer by Fanno and Rayleigh relations.

Contribution of Course Outcomes towards achievement of Program Outcomes

	PO a	PO b	PO c	PO d	PO e	PO f
CO1	M					
CO2	M			M		
CO3	M		M			
CO4	M		M			

(H - High, M - Moderate, L - Low)

Course Content:

UNIT I

Basic Equation of compressible Flow: Application of general differential equation of continuity, momentum & energy to compressible inviscid fluids; compressible Bernoulli's equation, irrotational flow, velocity potential &stream function.

Wave propagation: Wave propagation, velocity of sound, subsonic and supersonic Flow.

UNIT II

Steady one dimensional Flow: Fundamental equations, discharge from a reservoir, stream-tube, area–velocity relation, De-Laval Nozzle, diffusers, dynamic head, measurement in compressible flow, pressure coefficient.

Two–Dimensional compressible Flow: General linear solution for supersonic flow, flow along wave- shaped Wall.

UNIT III

Normal Shock Waves: Equation of motion for normal shock waves, the normal shock relations, total pressure across the shock wave, Hugoniot equation, propagating shock wave, reflected shock wave, shock tube.

Oblique shock waves: Oblique shock relations, Prandtl's equation, Hugoniot equation, variation of flow parameters, oblique shock relations from the normal shock equation, Mach waves.

UNIT IV

Flow with Friction: Flow in constant area duct with friction, adiabatic, constant – area flow of a perfect gas, Fanno curves, solution of Fanno flow equations, variation of flow properties, tables and charts for Fanno flow.

Flow with Heat Transfer: Flow with heating or cooling in ducts, Rayleigh line, fundamental equations, Rayleigh flow relations, variation of flow properties, maximum heat transfer, tables and charts for Rayleigh flow.

Text Books:

1. Fundamentals of compressible flow - S.M. Yahya, New Age Int.
2. Gas Dynamics – E. Rathakrishnan, PHI Learning Pvt. Ltd.

References:

1. Kinetic Theory and Gas Dynamics - Carlo Cercignani, Springer Verlog.
2. Elements of Gas Dynamics - Liepmann, Dover Publication.
3. Gas Dynamics: Multidimensional Flow Vol-I & II - Zucrow M.J. and Hoffman J.D., John Wiley.

Web Resources:

- http://nptel.ac.in/courses/112106056/
- https://www.youtube.com/playlist?list=PLF1779EDE134553BB
- http://www.learnerstv.com/Free-Engineering-Video-lectures-ltv837-Page1.htm
- http://web.mit.edu/hml/ncfmf.html

19METE1015A ADVANCED REFRIGERATION AND AIR CONDITIONING

Course Category:	Programme Elective	**Credits:**	3
Course Type:	Theory	**Lecture-Tutorial-Practice:**	3-0-0
Prerequisites:	Basics of Thermodynamics	**Continuous Evaluation:**	40
		Semester end Evaluation:	60
		Total Marks:	100

Course Outcomes:

At the end of the course the student will be able to

CO1: Evaluate performance of multi-pressure, multi-load refrigeration systems.

CO2: Analyze the performance of Vapour Absorption Refrigeration system and familiarize with other refrigeration methods.

CO3: Estimate the cooling and heating loads for air conditioning systems in residential, commercial and industrial applications.

CO4: Understand different Low Temperature Production systems.

Contribution of Course Outcomes towards achievement of Program Outcomes

	PO a	PO b	PO c	PO d	PO e	PO f
CO1	**H**			**M**		**M**
CO2	**H**	**M**				
CO3	**H**			**M**		
CO4	**M**					

(H - High, M - Moderate, L - Low)

Course Content:

UNIT I

Vapour Compression System: Classification of refrigerants, coding of refrigerants, Environmental impact – ODP, GWP, Environment friendly refrigerants. Analysis of multi-pressure vapour compression systems – Multi compressor systems and multi evaporator systems.

UNIT II

Vapour Absorption System: Vapour absorption systems – comparison of absorption with compression system - Analysis of Aqua Ammonia system.

Other Refrigeration Methods: Steam jet refrigeration – Thermo electric refrigeration – Vortex tube refrigeration – Pulse Tube refrigeration – Magnetic cooling system- Acoustic refrigeration system.

UNIT III

Cooling Load Calculations: Psychrometry, Comfort air conditioning, Factors affecting human comfort, Cooling Load calculations.

UNIT IV

Low Temperature Production: Low temperature applications, Low temperature Insulations, Hazards in Cryogenic Engineering, Joule Thomson Effect, Cascade system, Liquefication of Air – Linde system & Claude system, Liquefication of Hydrogen and Helium.

Text Books:

1. Refrigeration and Air Conditioning - Arora C.P., Tata McGraw-Hill.
2. Refrigeration and Air conditioning – Arora & Domkundwar, Dhanpatrai & Co.
3. Refrigeration and Air Conditioning – Ramesh Chandra & Arora, PHI.

Reference Books:

1. Refrigeration & Air Conditioning - Stoeker, W.P. Jones, Tata McGraw-Hill.
2. Refrigeration and Air Conditioning - Manohar Prasad, New Age Int.
3. Principles of Refrigeration - Dossat R.J., Pearson Education.
4. Cryogenic systems - Barron R.F., Oxford University press.

Web Resources:

- http://nptel.ac.in/courses/112105128/ IIT Chennai
- http://cosmolearning.org/courses/refrigeration-and-airconditioning/

19METE1015B ENVIRONMENTAL ENGINEERING AND POLLUTION CONTROL

Course Category:	Programme Elective	**Credits:**	3
Course Type:	Theory	**Lecture-Tutorial-Practice:**	3-0-0
Prerequisites:	Environmental Science	**Continuous Evaluation:**	40
		Semester end Evaluation:	60
		Total Marks:	100

Course Outcomes:

At the end of the course the student will be able to

CO1: Understand the sources of Air pollution, Noise pollution and their effects.

CO2: Analyse the methods and principles of waste management and sustainable development.

CO3: Apply the EMS certification procedures and environmental audit.

CO4: Analyse the importance of EIA and understand the environmental protection Laws.

Contribution of Course Outcomes towards achievement of Program Outcomes

	PO a	PO b	PO c	PO d	PO e	PO f
CO1	**M**	**H**				
CO2	**M**	**M**				
CO3		**M**				**L**
CO4		**M**				**M**

(H - High, M - Moderate, L - Low)

Course Content:

UNIT I

Air Pollution: Introduction to air pollution, types of pollutant, types of pollution and their effects, Green house phenomena, Indoor air pollution, Air pollution control, Explains sources of indoor and outdoor pollution. Guidelines and standard of this pollution will be discussed. Air Pollution Index will be calculated

Noise Pollution: Scope of noise including definition of noise, noise standard, level of noise pollution in the environment, definition of noise pollution and noise pollution criteria, effects of noise pollution, method of insulating noise pollution.

UNIT II

Solid Waste Management: The process of generation and handling of Municipal solid waste (MSW), storage, collection, and transport of municipal solid waste (MSW), MSW disposal methods such as landfill, incineration and organic MSW composting. Discuss about waste reduction, reuses, recovery and recycling concepts, Hazardous waste Management, Processing of hazardous waste, Methods of disposal.

Sustainable Development: Definition- elements of sustainable developments-Indicators of sustainable development- Sustainability Strategies- Barriers to Sustainability–Industrialization and sustainable development – Cleaner production in achieving sustainability- sustainable development.

UNIT III

Environmental Management Systems: Introduction, Evolution of ISO 14000: Background step by step preparation of EMS certification, ISO 14001: EMS, Basic ISO 14004 Guidance Document, ISO 14010 Audit standards, ISO 14020 Labeling Standards, Environmental Audit, Introduction – Range of Audit objectives – prevailing practices – Audit Methodology, benefits of E.A.

UNIT IV

Environmental Impact Assessment (E.I.A): Introduction – Methodology of E. I. A. – organizing the job- performing the assessment – preparation of E.I. Statement, 63 Role of E.I.A. in sustainable development, E.I.A. of hazardous waste - Limitations of E.I.A. – case study.

Environmental Legislation: Introduction – Environment Protection Law in India, Water Act 1974 – Air Act 1981 – Wild Life Protection Act 1972 – Indian Forest Act 1927 – Environmental Act 1986 - Motor Vehicle Act 1988. Pollution Control Boards (PCBs) – Activities Current Issues - Miscellaneous Topics – Tragic Incidents.

Text Books:

1. Environmental Engineering - G. N. Pandey & G. C Karney, Tata McGraw Hill.
2. Environmental Engineering by Mackenzie L Davis & David A Cornwell, McGraw Hill Publishing.

Reference Books:

1. Environmental Science & Engineering – Venugopala Rao, Prentice Hall (I) Pvt. Ltd.
2. Waste Water Treatment - G.L. Karia & R. A. Christian, Prentice Hall (I) Pvt. Ltd.
3. Environmental Engineering and Management - Dr. Suresh, K Dhameja, S.K. Kataria & Sons.
4. Environmental Impact Assessment - M. Anji Reddy, B.S. Publications.
5. Environmental Pollution control Engineering - C.S. Rao, New Age Intl. Pvt. Ltd.

Web resources:

- https://civildigital.com/powerpoint-presentations/environmental-engineering-ppts/
- nptel.ac.in/.../Environmental%20Air%20Pollution/air%20pollution%20(Civil)/air%20...

19METE1015C NUCLEAR POWER PLANTS

Course Category:	Programme Elective	**Credits:**	3
Course Type:	Theory	**Lecture-Tutorial-Practice:**	3-0-0
Prerequisites:	Modern physics, Basics of Thermodynamics	**Continuous Evaluation:**	40
		Semester end Evaluation:	60
		Total Marks:	100

Course Outcomes

At the end of the course the student will be able to

CO1: Understand the fundamentals of atomic physics and energy interaction between nuclear particles.

CO2: Comprehend the working of various nuclear reactors.

CO3: Analyze the basic fluidized bed reactors and its relevance to Indian Scenario.

CO4: Evaluate nuclear fuel handling methods with the concern of health, safety and environmental issues.

Contribution of Course Outcomes towards achievement of Program Outcomes

	PO a	PO b	PO c	PO d	PO e	PO f
CO1	**M**					
CO2	**M**		**L**			
CO3	**M**			**L**		
CO4		**M**				**L**

(H - High, M - Moderate, L - Low)

Course Content:

UNIT I

Introduction to Nuclear Engineering: Introduction - Why Nuclear Power for Developing Countries, Atomic Nuclei, Atomic Number and Mass Number, Isotopes, Atomic Mass Unit, Radioactivity and Radioactive Change rate of Radioactive Decay, Mass – Energy Equivalence, Binding Energy, Release of Energy by Nuclear Reaction.

Types of Nuclear Reactions: Initiation of Nuclear Reaction, Nuclear Cross-section, Nuclear Fission, Fission Chain Reaction, moderation, Fertile Materials and Breeding.

UNIT II

Nuclear Reactors: Introduction, General Components of Nuclear Reactor, General Problems of Reactor Operation, Different Types of Reactors, Pressurized Water Reactors (PWR), Boiling Water Reactors (BWR), Heavy Water – cooled and Moderated CANDU (Canadian Deuterium Uranium),Gas-cooled Reactors, Breeder Reactors, Reactor Containment Design.

UNIT III

Fluidized Bed Reactors: Analysis of gas cycle – Steam cycle – Simple and dual pressure cycles – Pebble bed reactors, Liquid metal cooled reactors – Compatibility with materials - Fast reactors – Fluid fuel reactors – types – Corrosion and Erosion characteristics. Location of Nuclear Power Plant, Nuclear Power Stations in India, India’s 3-stage Program for Nuclear Power Development, Comparison Nuclear Plants with Thermal Plants.

UNIT IV

Nuclear Materials: Introduction, Fuels, Cladding and Structural materials Coolants, Moderating and Reflecting materials, Control Rod Materials, Shielding materials.

Nuclear Waste & Its Disposal: Introduction, Unit of Nuclear Radiation, Types of Nuclear Waste, Effects of Nuclear Radiation, Radioactive Waste Disposal System, Gas Disposal System. SAFETY RULES: Personal Monitoring, Radiation Protection, Radiation Dose.

Text Books:

1. Nuclear Power Engineering - El-Wakil M.M., McGraw Hill Co., New York.
2. Power Plant Engineering – Arora & Domkundwar, Dhanpat Rai & Co.
3. Physics of Nuclear Reactors - Suresh, Tata McGraw hill publishing Co. Ltd.

Reference Books:

1. Power Plant Engineering - P.K. Nag, Tata McGraw Hill.
2. Power Plant Engineering - Black/Veatch, CBS Published & Distributors.
3. Combined Power Plants - J.H. Horlock, Pergamon Press.

Web resources:

- www.world-nuclear.org/info/inf32.html
- www.energy-sources.com/
- www.nuclear power plants.com

19MTMC1026 RESEARCH METHODOLOGY AND IPR

Course Category:	Mandatory Learning Course	**Credits:**	0
Course Type:	Theory	**Lecture-Tutorial-Practice:**	2-0-0
Prerequisites:		**Continuous Evaluation:**	40
		Semester end Evaluation:	60
		Total Marks:	100

Course Outcomes:

At the end of the course the student will be able to:

CO1: Acquire an overview of the research methodology and techniques to define research problem.

CO2: Review the literature and identify the problem.

CO3: Analyze the optimum sampling techniques for collected data.

CO4: Understand the significance of Intellectual Property Rights in research work..

Contribution of Course Outcomes towards achievement of Program Outcomes

	PO a	PO b	PO c	PO d	PO e	PO f
CO1				**M**		**H**
CO2				**L**		**H**
CO3						**H**
CO4						**H**

(H - High, M - Moderate, L - Low)

Course Content

UNIT I

Research Methodology: Introduction, Meaning of Research, Objectives of Research, Motivation in Research, Research Approaches, Significance of Research, Research and Scientific Methods, Research Process, Criteria of Good Research, and Problems Encountered by Researchers in India.

Research Problem: Defining the Research Problem, Selecting the Problem, Necessity of Defining the Problem, Technique Involved in Defining a Problem, an Illustration.

UNIT II

Reviewing the literature: Place of the literature review in research, improving research methodology, broadening knowledge base in research area, enabling contextual findings.

Research Design: Meaning of Research Design, Need for Research Design, Features of a Good Design, Important Concepts Relating to Research Design, Basic Principles of experimental Designs, Important Experimental Designs.

UNIT III

Design of Sampling: Introduction, Sample Design, Sampling and Non-sampling Errors, Sample Survey versus Census Survey, Measurement and Scaling: Qualitative and Quantitative Data, Classifications of Measurement Scales, Goodness of Measurement Scales, sources of error in measurement tools.

Data Collection: Experimental and Surveys, Collection of Primary Data, Collection of Secondary Data, Selection of Appropriate Method for Data Collection, Case Study Method

Testing of Hypotheses: Hypothesis, Basic Concepts, Testing of Hypothesis, Test Statistics and Critical Region, Critical Value and Decision Rule, Procedure for Hypothesis Testing.

UNIT IV

Interpretation and Report Writing: Meaning of Interpretation, Technique of Interpretation, Precaution in Interpretation, and Significance of Report Writing

Intellectual Property: The Concept, Intellectual Property System in India, Development of TRIPS Complied Regime in India, Patents Act, 1970, Trade Mark Act, 1999, The Designs Act, 2000, The Geographical Indications of Goods (Registration and Protection) Act1999, Copyright Act, 1957, Trade Secrets, Utility Models WTO, Paris Convention for the Protection of Industrial Property, National Treatment, Right of Priority, Common Rules, Patents, Marks, Industrial Designs, Trade Names, Indications of Source, Unfair Competition, Patent Cooperation Treaty (PCT), Trade Related Aspects of Intellectual Property Rights(TRIPS) Agreement.

Text Books:

1. Research methodology: Methods and Techniques, **C. R. Kothari, Gaurav Garg,** New Age International, 4th Edition, 2018.
2. Research Methodology a step-by-step guide for beginners. **Ranjit Kumar, SAGE Publications** Ltd.,3rd Edition, 2011
3. Study Material, Professional Programme Intellectual Property Rights, Law and Practice, **The Institute of Company Secretaries of India**, Statutory Body under an Act of Parliament, September 2013.

References:

1. An introduction to Research Methodology, Garg B.L et al ,RBSA Publishers 2002
2. An Introduction to Multivariate Statistical Analysis Anderson T.W, Wiley 3rd Edition,
3. Research Methodology, Sinha, S.C, Dhiman, EssEss Publications2002
4. Research Methods: the concise knowledge base, Trochim, Atomic Dog Publishing, 2005
5. How to Write and Publish a Scientific Paper, Day R.A, Cambridge University Press 1992
6. Conducting Research Literature Reviews: From the Internet to Paper, Fink A, Sage Publications, 2009
7. Proposal Writing, Coley S.M. Scheinberg, C.A, Sage Publications, 1990
8. Intellectual Property Rights in the Global Economy, Keith Eugene Maskus, Institute for International Economics.

19METE1051 ADVANCED THERMAL ENGINEERING LABORATORY

Course Category:	Programme Lab	**Credits:**	1.5
Course Type:	Laboratory	**Lecture-Tutorial-Practice:**	0-0-3
Prerequisites:	I.C. Engines, Heat Transfer	**Continuous Evaluation:**	40
		Semester end Evaluation:	60
		Total Marks:	100

Course Outcomes:

At the end of the course the student will be able to

CO1: Evaluate the performance of solar flat plate collector and wind turbine with different orientations.

CO2: Measure heat transfer rates in various heat transfer phenomena.

CO3: Evaluate the performance of bluffed and streamlined bodies.

CO4: Measure the performance of cooling tower equipment.

Contribution of Course Outcomes towards achievement of Program Outcomes

	PO a	PO b	PO c	PO d	PO e	PO f
CO1	**M**	**H**	**M**	**L**	**M**	**M**
CO2	**M**		**M**	**L**	**M**	**M**
CO3	**M**		**M**	**L**	**M**	**M**
CO4	**M**		**M**	**L**	**M**	**M**

(H - High, M - Moderate, L - Low)

Course Content:

Experiments:

1. Performance of a solar flat plate collector (Thermo-Syphonic mode / Forced mode)
2. Coefficient of performance of a wind Turbine.
3. Evaluate Pressure distribution, Lift and Drag force on an Aerofoil (Symmetrical/ Unsymmetrical).
4. Heat transfer coefficient in forced draft cooling tower
5. Heat transfer coefficient for drop-wise and film-wise condensation
6. Critical heat flux in pool boiling
7. Unsteady state heat transfer analysis.
8. Heat transfer coefficient in a shell and tube heat exchanger
9. Humidification and dehumidification capacity of Air-conditioner.
10. Performance test on vapor absorption refrigeration.

19METE1052 FLUID FLOW SIMULATION LABORATORY

Course Category:	Programme Lab	**Credits:**	1.5
Course Type:	Laboratory	**Lecture-Tutorial-Practice:**	0-0-3
Prerequisites:	Fluid Mechanics, Heat Transfer	**Continuous Evaluation:**	40
		Semester end Evaluation:	60
		Total Marks:	100

Course Outcomes:

At the end of the course the student will be able to

CO1: Simulate the different fluid flow concepts using CFD software.

CO2: Apply the convergence techniques to refine the solution.

CO3: Interpret the results to arrive reasonable conclusions.

CO4: Document the results generated in a systematic manner.

Contribution of Course Outcomes towards achievement of Program Outcomes

	PO a	PO b	PO c	PO d	PO e	PO f
CO1			**H**	**L**	**M**	**M**
CO2			**H**	**L**	**M**	**M**
CO3			**H**	**L**	**M**	**M**
CO4			**H**	**L**	**M**	**M**

(H - High, M - Moderate, L - Low)

Course Content:

Experiments:

1. Couette flow and channel flow.
2. Laminar flow through circular and non-circular pipes.
3. Turbulent flow through a circular pipe.
4. Laminar flow over a flat plate (Hydrodynamic and Thermal Boundary layer flows).
5. Turbulent flow over a flat plate.
6. Flow over aerofoil.
7. Flow over a cylinder/sphere.

Web Resources:

- ANSYS V19 reference manual
- http://www.ansys.com/Support/Training+Center/Courses/Introduction+to+ANSYS+FLUENT
- http://iidesign.co.in/ansys_fluent_software_course.php
- http://imechanica.org/node/15400

19METE2001 GAS TURBINES AND JET PROPULSION SYSTEMS

Course Category:	Programme Core	**Credits:**	3
Course Type:	Theory	**Lecture-Tutorial-Practice:**	3-0-0
Prerequisites:	Fluid Mechanics, Basic and Applied Thermodynamics	**Continuous Evaluation:**	40
		Semester end Evaluation:	60
		Total Marks:	100

Course Outcomes:

At the end of the course the student will be able to

CO1: Analyse the performance characteristics of compressors.

CO2: Analyse the performance and applications of gas turbines in power plants.

CO3: Analyse the performance of various jet propulsion systems and devices.

CO4: Understand principle of operation of rocket propulsion systems.

Contribution of Course Outcomes towards achievement of Program Outcomes

	PO a	PO b	PO c	PO d	PO e	PO f
CO1	**H**			**M**		
CO2	**H**			**M**		
CO3	**H**			**M**		
CO4	**M**					

(H - High, M - Moderate, L - Low)

Course Content:

UNIT I

Introduction: Ideal cycles, Ericsson cycle, Practical cycles and their analysis - compressor and turbine efficiency – cycle efficiency – polytropic efficiency - performance of practical cycle.

Axial Flow Compressors: Principle of operation, Momentum analysis and energy transfer in rotors, Losses & coefficients of performance, overall performance, compressor characteristics, surging, choking and stalling.

UNIT II

Axial Flow Gas Turbines: Elementary Theory, Turbine and nozzle efficiencies, Degree of reaction, Impulse turbine analysis, Reaction turbine analysis, comparison of turbine types.

Applications of Gas Turbines: Typical applications of gas turbines-electric power generation applications-marine application locomotive applications -automotive applications-aircraft applications-process applications, additional features of gas turbine engines-trends in future development.

UNIT III

Jet Propulsion: Introduction, Air breathing Jet engines, classification-Ram jet, pulse jet, Turbo jet, Turbo prop, Specific impulse, Thrust, Efficiency-Ram, Thermal, Transmission, overall. Effect of forward speed, altitude, thrust augmentation - After burning, water alcohol mixtures, Bleed burn cycle.

UNIT IV

Rocket Propulsion: Principle, classification-chemical, rocket-solid propellant, liquid propellant, advantages, free radical, Nuclear, Electro dynamic, plasma, photon propulsion.

Text Books:

1. Gas Turbines - Ganesan V., TMH.
2. Gas turbines and propulsive systems - Khajuria P.R., Dubey S.P., Dhanpat rai pub.
3. Gas turbines and jet & rocket propulsion - Mathur M.L., Sharma R.P. Standard Publishers

Reference Books:

1. Gas Turbine Theory - Cohen H, Rogers G and Saravanamuthu H., John Wiley.
2. Turbines, Compressors and Fans - Yahya S.H, Tata McGraw-Hill.
3. Aero-thermodynamics of gas turbine and rocket propulsion - Gordon Oates, AIAA Education series.

Web resources:

- http://nptel.ac.in/courses/101101002/
- http://nptel.ac.in/courses/112104117/13
- https://powergen.gepower.com/plan-build/products/gas-turbines/

19METE2002 FINITE ELEMENT METHOD FOR THERMAL ENGINEERING

Course Category:	Programme Core	**Credits:**	3
Course Type:	Theory	**Lecture-Tutorial-Practice:**	3-0-0
Prerequisites:	Engineering Mathematics, Fluid Mechanics, Heat Transfer	**Continuous Evaluation:**	40
		Semester end Evaluation:	60
		Total Marks:	100

Course Outcomes:

At the end of the course the student will be able to

CO1: Understand the philosophy of interpolation and convergence

CO2: Analyze 1-D steady state and transient heat transfer problems

CO3: Analyze 2-D steady state heat transfer problems

CO4: Formulate 1-D and 2-D fluid kinematics problems

Contribution of Course Outcomes towards achievement of Program Outcomes

	PO a	PO b	PO c	PO d	PO e	PO f
CO1			**M**	**L**		**L**
CO2			**H**	**M**		**L**
CO3			**H**	**M**		**L**
CO4			**H**	**M**		**L**

(H - High, M - Moderate, L - Low)

Course Content:

UNIT I

Basic Concepts of the Finite Element Method: Introduction, working of finite element method, Comparison of Finite Element and Exact Solutions, Comparison of Finite Element and Finite Difference Methods, General Procedure for Finite Element Analysis, Compatibility and Completeness requirements, Polynomial forms for 1-D linear and quadratic elements, geometric isotropy, Polynomial forms for linear triangular elements, Polynomial forms for linear rectangular elements, Iso-parametric formulation.

Numerical Integration: Gauss quadrature formula, One-dimensional Integration with one-point formula, two point formula, three-point formula, Two-dimensional numerical integration with two-point formula for linear triangular and linear quadrilateral regions.

UNIT II

1-D Steady-State Heat Transfer: FE Formulation using Galerkin's approach for one-dimensional heat conduction using linear and quadratic elements, FE Formulation using Galerkin's approach for one-dimensional fins of uniform cross section using linear elements. Numerical problems in composite walls and fins with specified temperature, heat flux and convection boundary conditions.

1-D Transient Heat Transfer: FE Formulation using Galerkin's approach, Derivation of element matrices for linear elements, Application of Finite Difference Methods for the Transient Response-Forward, Central and Backward Difference Schemes, Numerical problems with two linear elements.

UNIT III

2-D Steady-State Heat Transfer: FE Formulation using Galerkin's approach with linear triangle elements, problem modelling and boundary conditions.

2-D Steady-State Axisymmetric Heat Transfer: Finite element formulation using Galerkin's approach with linear triangular elements, problem modelling and boundary conditions.

UNIT IV

Fluid Kinematics: Finite Element formulation for kinematics of 1-D and 2-D Steady, incompressible, inviscid, irrotational fluid flows, Problem modelling and boundary conditions for kinematics part of fluid flow, Heat transfer analogy for fluid kinematics problems.

Text Books:

1. Fundamentals of Finite Element Analysis - David V. Hutton, Tata McGraw Hill.
2. Introduction to Finite elements in Engineering – T. R. Chandraputla & A. D. Belegundu, Prentice Hall / PHI.

Reference Books:

1. Applied Finite Element Analysis – Larry J. Segerlind, John Wiley and Sons.
2. The Finite Element Method in Engineering - Singiresu S. Rao, Butterworth–Heinemann, an imprint of Elsevier.

Web Resources:

- https://www.youtube.com/watch?v=xBgWqy49Z_8
- http://www.nptelvideos.in/2012/11/finite-element-analysis.html
- http://ocw.mit.edu/courses/mechanical-engineering/2-092-finite-element-analysis-of-solids-and-fluids-i-fall-2009/

19METE2003 COMPUTATIONAL FLUID DYNAMICS

Course Category:	Programme Core	**Credits:**	3
Course Type:	Theory	**Lecture-Tutorial-Practice:**	3-0-0
Prerequisites:	Differential Calculus Fluid Mechanics, Heat Transfer	**Continuous Evaluation:** **Semester end Evaluation:**	40 60
		Total Marks:	100

Course Outcomes:

At the end of the course the student will be able to

CO1: Transform Partial Differentials into Finite Difference form and identify grid generation methods.

CO2: Apply different solution methods for solving parabolic PDEs with stability criterion.

CO3: Apply the different solution methods to solve Elliptic and Hyperbolic partial differential equations.

CO4: Formulate the Burger's and incompressible N-S equations.

Contribution of Course Outcomes towards achievement of Program Outcomes

	PO a	PO b	PO c	PO d	PO e	PO f
CO1			**H**	**M**		**M**
CO2			**H**	**M**		**M**
CO3			**H**	**M**		**M**
CO4			**H**	**M**		**M**

(H - High, M - Moderate, L - Low)

Course Content:

UNIT I

Introduction: Areas of Application, Review of Governing equations of Fluid Dynamics, classification of Partial Differential Equations, initial and boundary conditions.

Finite Difference Formulations: First order, higher order and mixed derivatives. Grid generation - Structured grids, algebraic grid generation technique.

UNIT II

Parabolic PDE's: Explicit and Implicit methods, Application to a first order Heat equation, consistency analysis, elementary numerical problems.

Stability Analysis: Von Neumann stability analysis for Heat and first order wave equations, Error Analysis- Numerical dissipation and Dispersion, Modified equation.

UNIT III

Elliptic PDE's: Direct method- Gaussian elimination method, Iterative methods- Jacobi, Gauss-Siedel and Relaxation methods, ADI method, Thomas Algorithm (TDMA), elementary numerical problems.

Hyperbolic PDE's: Explicit and Implicit methods, Multi step methods, Application to a first and second order one dimensional wave equation.

UNIT IV

Scalar Representation of N-S Equations: Model Burgers equation, different numerical schemes for the Solution of Non-linear Burgers equation.

Incompressible N-S Equations: Governing equations, Pressure Correction Method, Staggered Grid, SIMPLE algorithm, Boundary conditions for PCM. Vorticity-Stream function formulation, Boundary conditions, Modeling of Rectangular cavity problem.

Text Books:

1. Computational fluid dynamics - Basics with applications - John. D. Anderson, McGraw Hill.
2. Computational Fluid dynamics - K.A. Hoffmann, S.T. Chiang, Vol-I., EES Publications

References:

1. Introduction to computational fluid mechanics - Niyogi, Chakravarty, Laha, Pearson pub.
2. Numerical heat transfer and fluid flow - S.V. Patankar, Hemisphere Pub.
3. Computational fluid dynamics - T. J. Chung, Cambridge University press
4. Computational Fluid flow and Heat transfer - K. Muralidhar and T. Sundararajan, Narosa Pub.

Web Resources:

- http://ocw.mit.edu/courses/mechanical-engineering/2-29-numerical-fluid-mechanics-fall-2011/
- http://nptel.ac.in/courses/112105045/ (IIT Kharagpur)
- http://nptel.ac.in/courses/112107080/ (IIT Roorkee)
- http://nptel.ac.in/courses/112104030/ (IIT Kanpur)
- http://www.nptelvideos.in/2012/11/computational-fluid-dynamics.html (IIT Madras)
- http://www.cfd-online.com/

19METE2014A SOLAR ENERGY UTILIZATION

Course Category: Programme Elective
Course Type: Theory
Prerequisites: Basics of Thermodynamics

Credits:	3
Lecture-Tutorial-Practice:	3-0-0
Continuous Evaluation:	40
Semester end Evaluation:	60
Total Marks:	100

Course Outcomes:
At the end of the course the student will be able to
CO1: Estimate the solar radiation for utilization.
CO2: Analyze the performance of solar collectors.
CO3: Apply the solar power depending upon application.
CO4: Understand the energy storage, conversion and utilization requirements.

Contribution of Course Outcomes towards achievement of Program Outcomes

	PO a	PO b	PO c	PO d	PO e	PO f
CO1		H		M		
CO2		H	L	M		
CO3		H		M		
CO4		M		L		

(H - High, M - Moderate, L - Low)

Course Content:

UNIT I

Introduction: Solar radiation, Solar constant, basic earth sun angles, beam and diffused radiations, measurement of beam and diffuse radiations
Solar Radiation and Analysis: Estimation of average solar radiation on horizontal and tilted surfaces, numerical problems

UNIT II

Tracking Collectors: Physical principles of collection, types of collectors, liquid flat plate collectors-construction details and performance analysis, selective coatings, Evacuated (or Vacuum) Tubes.
Concentrating Collectors: Compound parabolic collector, linear Fresnel reflector, parabolic trough collector, parabolic dish reflector.

UNIT III

Solar Thermal Domestic Applications: Water heating, solar cooking, solar ponds**,** solar refrigeration & air conditioning, Solar-distillation, solar pumping, Solar power generation.
Solar Thermal Industrial Applications: Solar Thermal Power Production, Solar furnaces, solar drying, Space heating, solar desalination, Solar Industrial process heating.

UNIT IV

Thermal Energy Storage: Introduction, Need for energy storage. Methods of sensible heat storage using solids and liquids, packed bed storage, Latent heat storage, Thermo-chemical storage, solar pond – working principle – construction – application and limitations.

Direct Energy Conversion: Solid-state principles – semiconductors, Photovoltaic cell – characteristics- cell arrays-power electric circuits for output of solar panels-choppers-inverters-batteries-charge regulators, Construction concepts.

Text Books:

1. Solar energy - Sukhatme S.P., TMH.
2. Solar energy utilization - G.D. Rai, Khanna Publishers.
3. Solar Energy - G.N. Tiwari, Narosa Publishing House.
4. Solar engineering of thermal processes - Duffie J.A. and Beckman W.A.

Reference Books:

1. Non-conventional Energy resources - S.K. Dubey, S.K. Bhargava, Dhanpatrai publications.
2. Principles of solar engineering - D.Y. Goswami, F. Kreith and J.F. Kerider, Taylor & Francis publishers, USA.
3. Fundamentals of solar energy conversion - Edward E. Anderson.

Web Resources:

- www.renewable-energy-sources.com/

19METE2014B THERMAL ENERGY STORAGE TECHNOLOGIES

Course Category:	Programme Elective	**Credits:**	3
Course Type:	Theory	**Lecture-Tutorial-Practice:**	3-0-0
Prerequisites:	Heat transfer	**Continuous Evaluation:**	40
		Semester end Evaluation:	60
		Total Marks:	100

Course Outcomes:

At the end of the course the student will be able to

CO1: Understand the basic principles of sensible heat storage systems.

CO2: Analyze the heat transfer process in regenerative devices.

CO3: Probe into the functionality of latent heat thermal storage systems.

CO4: Recognize the use of appropriate thermal storage systems for industrial applications.

Contribution of Course Outcomes towards achievement of Program Outcomes

	PO a	PO b	PO c	PO d	PO e	PO f
CO1	**H**					
CO2	**M**					**M**
CO3	**M**					**M**
CO4	**M**	**M**				**M**

(H - High, M - Moderate, L - Low)

Course Content:

UNIT I

Introduction: Thermal Storage necessity, classification of energy storage devices, various energy storage technologies & their comparison, storage materials, Seasonal thermal energy storage.

Basic Concept of Sensible Heat Storage System: Modelling of heat storage units, simple water and rock bed storage systems- use of TRNSYS packed beds and pressurized water storage system for power plant applications.

UNIT II

Regenerators: Types – parallel flow and counter flow – finite conductivity model & non-linear model, transient performance, step changes in inlet gas temperature, step changes in gas flow rate, parameterization of transient response-recuperative and regenerative heat exchangers.

UNIT III

Latent Heat Storage Systems: Modelling of phase change problems- temperature based model-enthalpy model porous medium approach-conduction dominated phase change-convection dominated phase change.

UNIT IV

Applications: Specific areas of application of energy storage – food storage - food preservation - waste heat recovery.

Solar energy storage - green house heating - power plant applications-drying and heating for process industries

Text Books:

1. Thermal energy storage systems and applications - Ibrahim Dincer & Mark A. Rosen, John Wiley & Sons.
2. Solar Engineering of Thermal Processes - J. Duffie, W. A. Beckman, John Wiley and Sons Inc.
3. Energy Conversion Systems - H.A. Sorenson, John Willey & Sons.

References:

1. Thermal storage and Regeneration - Schmidt F.W. & Willnot A.J., Hemisphere Pub. Corp.
2. Heat Transfer in Cold Climates - Lunadini V.J., John Wiley and sons.
3. Sustainable Thermal Storage Systems: Planning, Design, and Operations - Hyman, Lucas B., New York, McGraw-Hill.
4. Renewable Energy sources & Conversion Technology - Bansal, K. Leeman & Mellis.

Web Resources:

- https://www.irena.org/DocumentDownloads
- http://arena.gov.au/project/advanced-solar-thermal-energy-storage-technologies/

19METE2014C HYDROGEN AND FUEL CELL TECHNOLOGIES

Course Category:	Programme Elective	**Credits:**	3
Course Type:	Theory	**Lecture-Tutorial-Practice:**	3-0-0
Prerequisites:	Basics of Thermodynamics	**Continuous Evaluation:**	40
		Semester end Evaluation:	60
		Total Marks:	100

Course Outcomes:

At the end of the course the student will be able to

CO1: Understand the methods of hydrogen production, storage and its applications.

CO2: Understand the principles and working of fuel cells.

CO3: Analyse and compare merits and demerits of different types of fuel cells.

CO4: Analyse the economics of fuel cell in different applications.

Contribution of Course Outcomes towards achievement of Program Outcomes

	PO a	PO b	PO c	PO d	PO e	PO f
CO1	**L**	**M**			**L**	**L**
CO2	**M**	**H**		**M**	**L**	**H**
CO3	**M**	**M**			**L**	**M**
CO4	**M**	**H**			**L**	**M**

(H - High, M - Moderate, L - Low)

Course Content:

UNIT I

Hydrogen – Basics and Production Techniques: Hydrogen- Physical and chemical properties, Salient characteristics, Production of hydrogen-steam reforming-water electrolysis-gasification and woody biomass conversion-biological hydrogen production-photo dissociation-direct thermal or catalytic splitting of water.

Hydrogen Storage and its Applications: Hydrogen storage options- compressed gas-liquid hydrogen-Hydride-chemical storage-safety and management of hydrogen, applications of hydrogen.

UNIT II

Fuel Cells: History- Principles- working-thermodynamics and kinetics of fuel cell process Performance evaluation of fuel cell – Comparison of battery and fuel cell.

UNIT III

Types of Fuel Cells: AFC, PAFC, SOFC – Relative merits and demerit. MCFC, DMFC, PEMFC – Relative merits and demerits

UNIT IV

Applications of Fuel Cell and Economics: Usage of fuel cell for domestic power systems, large scale power generation, automobile, space Economic and environmental analysis on usage of Hydrogen and Fuel cell Future trends in fuel cells

Text Books:

1. Fuel Cells - Principles and Applications - Viswanathan B. & M. Aulice Scibich, Universities press
2. Hydrogen and Fuel Cells - A comprehensive guide – Rebecca L. and Busby, Premwell corporation

Reference Books:

1. Hydrogen and Fuel cells Emerging Technologies and Applications – Bent Sorensen, Elsevier.
2. Fuel Cell and Their applications - Kordesch. K. & G. Simader, Wiley.
3. Fuel Cells Theory & Applications - Hart A.B. & G.J. Womack, Prentice Hall.

Web Resources:

- NPTEL http://nptel.iitm.ac.in
- www.renewableenergyworld.com/hydrogen/tech.html

19METE2015A DESIGN OF HEAT TRANSFER EQUIPMENT

Course Category:	Programme Elective	**Credits:**	3
Course Type:	Theory	**Lecture-Tutorial-Practice:**	3-0-0
Prerequisites:	Fluid Mechanics, Heat Transfer	**Continuous Evaluation:**	40
		Semester end Evaluation:	60
		Total Marks:	100

Course Outcomes:

At the end of the course the student will be able to

CO1: Apply LMTD and Effectiveness methods in the design of heat exchangers and analyse the performance of double-pipe and shell and tube heat exchanger.

CO2: Understand design of compact heat exchangers and analyse the performance parameters.

CO3: Design condensers and evaporators for various engineering Applications.

CO4: Understand working of different cooling towers and analyse their performance parameters.

Contribution of Course Outcomes towards achievement of Program Outcomes

	PO a	PO b	PO c	PO d	PO e	PO f
CO1	**H**	**L**	**H**	**M**		
CO2	**H**	**L**	**H**	**M**		
CO3	**H**		**H**	**M**		
CO4	**H**		**H**	**M**		

(H - High, M - Moderate, L - Low)

Course Content:

UNIT I

Classification of Heat Exchangers - basic design methods for heat exchangers - LMTD, ε-NTU, double pipe heat exchangers, parallel and counter flow, multi-pass and cross-flow.
Shell and tube heat exchangers - Basic components, design procedure, Heat transfer and pressure drop; TEMA codes.

UNIT II

Flow arrangements for increased heat recovery, design considerations for different plate type heat exchangers. Compact heat exchangers – types, plate fin, tube fin, Heat transfer and pressure drop.

UNIT III

Different Types of Condensers - Shell and tube, Steam Turbine Exhaust, plate, air cooled, direct contact condensers. Thermal design of shell and tube condensers, design and operational considerations, condensers for refrigeration and air conditioning, Evaporators for refrigeration and air conditioning, Thermal Analysis.

UNIT IV

Direct Contact Heat Transfer - Classification of cooling towers, wet-bulb and dew point temperatures, Lewis number, cooling-tower internals, heat balance, heat transfer by simultaneous diffusion and convection; Design and analysis of cooling towers, determination

of the number of diffusion units, performance evaluation of cooling towers, influence of process conditions and operating variables on their design.

Text Books:

1. Heat Exchangers: Selection, Rating, and Thermal Design - Sadik kakac, Hongtan Liu
2. Process heat transfer - Donald Kern.

Reference Books:

1. Heat exchanger design - Press and N. Ozisik.
2. Compact Heat exchangers - Kays, W.M., and A.L. London, McGraw Hill.

Web resources:

- http://nptel.ac.in/courses/103103027/pdf/mod1.pdf
- http://www.ou.edu/class/che-design/design%201-2013/Heat%20Exchangers.pdf

Note: Data books allowed for the examination

- Heat and Mass Transfer Data Book by Kothandaraman and Subramanian (or) by Domkundwar
- Empirical formulae from Heat Exchangers: Selection, Rating, and Thermal Design - Sadik kakac, Hongtan Liu (Approved by Faculty member)
- Refrigeration Tables
- Steam Tables

19METE2015B ENERGY CONSERVATION AND MANAGEMENT

Course Category:	Programme Elective	**Credits:**	3
Course Type:	Theory	**Lecture-Tutorial-Practice:**	3-0-0
Prerequisites:	Industrial Management, Financial Management	**Continuous Evaluation:**	40
		Semester end Evaluation:	60
		Total Marks:	100

Course outcomes:

At the end of the course the student will be able to

CO1: Analyse objectives and Role of Energy Management in Manufacturing & Process industries.

CO2: Identify the need for Energy conservation, networks, materials and, Evaluate Energy Usage Options – analysis, waste heat recovery systems and Applications.

CO3: Evaluate Energy Audits and Analytical techniques.

CO4: Analyse the scope and need of Economic Analysis, Investment Projects, Depreciation, Budget and, Risk analysis.

Contribution of Course Outcomes towards achievement of Program Outcomes

	PO a	PO b	PO c	PO d	PO e	PO f
CO1						**L**
CO2	**M**	**L**	**L**	**H**	**L**	**H**
CO3			**M**		**L**	
CO4					**H**	

(H - High, M - Moderate, L - Low)

Course Content:

UNIT I

Introduction: Principles of Energy management Energy audit, Definitions, Concept, Types of audit, Energy index, Cost index, Pie charts, Sankey diagrams, Load profiles, Energy conservation schemes and energy saving potential, Energy manager, Qualities and functions, Language, Questionnaire, Check list for top management, energy Conservation Act 2003.

UNIT II

Energy Conservation: Technologies for Energy Conservation, Design for Conservation of Energy materials – energy flow networks – critical assessment of energy usage – Waste Heat Recovery - Sources of waste heat and its potential applications, Heat recovery equipment and systems, Heat Exchangers, Incinerators, Regenerators and Recuperates, Waste Heat boilers.

UNIT III

Energy Audit: Definition and Concepts, Types of Energy Audits – Basic Energy Concepts – Resources for Plant Energy Studies – Analytical Techniques, conducting energy audit (pre-audit, audit and post-audit), energy audit instruments, energy audit report, monitoring, evaluating and following up, Need of Energy Consultant – Consultant Selection Criteria.

UNIT IV

Economic Analysis: Scope, Characterization of an Investment Project – Types of Depreciation – Time Value of money – budget considerations, Risk Analysis. Methods of Evaluation of Projects-Payback – Annualized Costs – Investor's Rate of return – Present worth – Internal Rate of Return – Pros and Cons of the common methods of analysis – replacement analysis.

Text Books:

1. Energy Management - W.R. Murphy and G. Mc Kay,
2. Energy Management Principles - CB Smith, Pergamon Press.

Reference Books:

1. Energy Management Hand book - W.C. Turner,
2. Management - H. Koontz and Cyrill O Donnell,
3. Financial Management - C. Kuchhal,
4. Financial Management - I M Panday,
5. Guide to Energy Management - Barney L. Capehart, Wayne C. Turner and William J. Kennedy, Fairmont Press Inc.
6. Design and Management for Energy Conservation - P.W.O Callaghan, Pergamon Press.

Web Resources:

- www1.iitb.ac.in/~cep/about/index.html
- nptel.ac.in/courses/108106022/
- https://www.energyinst.org/training/energy-management-courses/e-learni.
- http://ocw.mit.edu/courses/energy-courses/

19METE2015C CRYOGENIC ENGINEERING

Course Category:	Programme Elective	**Credits:**	3
Course Type:	Theory	**Lecture-Tutorial-Practice:**	3-0-0
Prerequisites:	Basics of Thermodynamics, Heat Transfer, Refrigeration	**Continuous Evaluation:**	40
		Semester end Evaluation:	60
		Total Marks:	100

Course Outcomes:

At the end of the course the student will be able to

CO1: Understand the mechanism of variation of properties of materials at low temperatures.

CO2: Apply the principles of thermodynamics to analyze the low-temperature air separation systems.

CO3: Apply the principles of thermodynamics to analyze cryogenic refrigeration systems.

CO4: Understand use of effective and environmentally safe cryogenic technology for applications in industry, construction, agriculture, medicine and living organisms.

Contribution of Course Outcomes towards achievement of Program Outcomes

	PO a	PO b	PO c	PO d	PO e	PO f
CO1	M					
CO2	H					
CO3	M					
CO4		M				L

(H - High, M - Moderate, L - Low)

Course Content:

UNIT I

Introduction: Historical development – present areas involving cryogenic engineering. Basic thermodynamic as applied to liquefaction and refrigeration process – isothermal, adiabatic and Joule Thomson expansion process.

Low temperature properties of engineering materials: Mechanical and thermal properties of cryogenic fluids.

UNIT II

Gas Liquefaction Systems: Production of low temperatures - general liquefaction systems – liquefaction systems for neon, hydrogen, and helium.

Gas Separation and Purification Systems: Properties of mixtures, principles of mixtures, principles of gas separation, Air separation systems.

UNIT III

Cryogenic Refrigeration Systems: Ideal refrigeration systems – refrigerators using liquids and gases as refrigerants – refrigerators using solids as working media.

Cryogenic Fluid Storage & Transfer Systems: Cryogenic storage systems, Insulation, Fluid transfer mechanisms, Cryostat, Cryo Coolers.

UNIT IV

Applications of Cryogenics: cryogenics in space technology – cryogenics in gas industry, cryogenics in biology, medicine and electronics.

Text Books:

1. Cryogenic Systems - Randall F. Barron, Second edition, McGraw Hill.

Reference Books:

1. Cryogenics Engineering - Scott R.B., D. Van Nostrand Company, Princeton, NJ.
2. Cryogenic Technology - Herald Weinstock, Boston Technical Pub. Inc.
3. Applied Cryogenic Engineering - Vance, R. W. and Duke, W. M., John Wiley.
4. Cryogenic Process Engineering - Timmerhaus K. D. and Flynn T. M., Plenum Press.

Web resources:

- http://nptel.ac.in/courses/112101004/
- https://books.google.co.in/books?isbn=038746896X
- https://books.google.co.in/books?isbn=1461398681

19METE2036 TECHNICAL REPORT WRITING

Course Category:	Audit Course	**Credits:**	-
Course Type:	Theory	**Lecture-Tutorial-Practice:**	2-0-0
		Continuous Evaluation:	0
		Semester end Evaluation:	0
		Total Marks:	0

Course Outcomes:

At the End of the course the student will be able to:

CO1: Understand the significance of Technical Report writing.

CO2: Develop Proficiency in writing technical reports.

CO3: Apply the basic principles to prepare documentation using LATEX.

CO4: Understanding the need of Bibliography and references for quality report writing

Contribution of Course Outcomes towards achievement of Program Outcomes

	PO a	PO b	PO c	PO d	PO e	PO f
CO1					**H**	
CO2					**H**	
CO3					**H**	
CO4					**H**	

(H - High, M - Moderate, L - Low)

Course Content:

UNIT I

Writing scientific and engineering papers-Title, Abstract, Introduction, Materials And Methods, Result, Discussion, Conclusion, References, Acknowledgements, AppEndices, Hedging and Criticizing, Paraphrasing and Plagiarism.

UNIT II

Effective use of charts, graphs and tables-Bar Chart, Line Chart, Pie Chart, Area Chart, Cylindrical Chart, Column Bars, Bubble Chart, Flow Diagram, Screen Capture, Tables

Writing Technical Reports-Objectives Of Technical Report, Types Of Reports, Steps In Writing A Technical Report, Guidelines For Writing A Technical Report.

UNIT III

LATEX - Introduction, Document Structure- Creating a Title, Sections, Labeling, Table of Contents

Typesetting Text- Font Effects, Colored Text, Font Sizes, Lists, Comments & Spacing, Special Characters

UNIT IV

Tables, Figures, Equations- Inserting Equations, Mathematical Symbols, Practical.

Inserting References- Introduction, The BibTeX file, Inserting the bibliography, Citing references, Styles, Practical.

Text Books:

1. Barun K Mitra, Effective Technical Communication-A Guide for Scientists and Engineers,Oxford University Press,2006, ISBN:978019568291.
2. LATEX for Beginners, Workbook Edition 5, March 2014 Document Reference: 3722-2014.

Reference Books:

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books) Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press

19METE2051 THERMAL FEM LABORATORY

Course Category:	Programme Lab	**Credits:**	1.5
Course Type:	Laboratory	**Lecture-Tutorial-Practice:**	0-0-3
Prerequisites:	Heat Transfer	**Continuous Evaluation:**	40
		Semester end Evaluation:	60
		Total Marks:	100

Course Outcomes:

At the end of the course the student will be able to

CO1: Analyse and simulate 1-D, 2-D, 3-D steady state heat conduction problems.
CO2: Analyse and simulate 1-D, 2-D, 3-D Transient problems.
CO3: Analyse and simulate thermal-structural problems.
CO4: Analyse and simulate the phase change phenomenon.

Contribution of Course Outcomes towards achievement of Program Outcomes

	PO a	PO b	PO c	PO d	PO e	PO f
CO1	**M**		**M**	**M**	**M**	**M**
CO2	**M**		**M**	**M**	**M**	**M**
CO3	**M**		**M**	**M**	**M**	**M**
CO4	**M**		**M**	**M**	**M**	**M**

(H - High, M - Moderate, L - Low)

Course Content:

Experiments:

Simulation of different Thermal problems by using ANSYS:

Steady State Heat Conduction

- Variable thermal conductivity,
- Heat generation,
- Mixed mode heat transfer,
- Composite slabs/cylinders/spheres,
- Three Dimensional Problems.

Transient heat conduction in plane wall/cylinders/spheres

- Lumped system Analysis
- Infinite bodies

Structural – Thermal Analysis

- Thermal stresses in structures

Phase change heat transfer

- Casting process

19METE2052 COMPUTATIONAL FLUID DYNAMICS LABORATORY

Course Category:	Programme Lab	**Credits:**	1.5
Course Type:	Laboratory	**Lecture-Tutorial-Practice:**	0-0-3
Prerequisites:	Fluid Mechanics, Heat Transfer, Solid Mechanics	**Continuous Evaluation:**	40
		Semester end Evaluation:	60
		Total Marks:	100

Course Outcomes:

At the end of the course the student will be able to

CO1: Simulate the different fluid flows using CFD software.

CO2: Converge of the results by mesh refinement and setting proper residuals.

CO3: Interpret the results of the problems and arriving at reasonable conclusions.

CO4: Report the results generated in a systematic manner.

Contribution of Course Outcomes towards achievement of Program Outcomes

	PO a	PO b	PO c	PO d	PO e	PO f
CO1			**H**	**L**	**M**	**M**
CO2			**H**	**L**	**M**	**M**
CO3			**H**	**L**	**M**	**M**
CO4			**H**	**L**	**M**	**M**

(H - High, M - Moderate, L - Low)

Course Content:

Experiments:

1. Analysis of Heat exchangers (Double Pipe - PF & CF)
2. Fluid-Thermal coupling analysis (Radiation and Natural Convection)
3. Fluid-Thermal-Structural coupling analysis (Thermal stresses in thick cylinder)
4. Analysis of transient fluid flow (Around a cylinder)
5. Phase change simulation (Solidification)
6. Periodic flow and heat transfer (Tube banks)
7. Compressible flow (Convergent and CD Nozzle)
8. Lid Driven cavity flow (Benchmark problem)

Web Resources:

- ANSYS V19 reference manual
- http://www.ansys.com/Support/Training+Center/Courses/Introduction+to+ANSYS+FLUENT
- http://iidesign.co.in/ansys_fluent_software_course.phphttp://imechanica.org/node/15400

19METE2063 TERM PAPER

Course Category:	Term Paper	**Credits:**	1
Course Type:	Term Paper	**Lecture-Tutorial-Practice:**	0-0-2
Semester End Exam:	Viva-voce	**Continuous Evaluation:**	40
		Semester end Evaluation:	60
		Total Marks:	100

Course Outcomes:

At the end of the course the student will be able to

CO1: Identify simple theoretical and practical problems related to Thermal Engineering area.

CO2: Analyse/Solve theoretical and practical problems for arriving at feasible solutions.

CO3: Prepare an organized report employing elements of technical writing & critical thinking.

CO4: Demonstrate the ability to describe, interpret and analyse technical issues and develop competence in presenting.

Contribution of Course Outcomes towards achievement of Program Outcomes

	PO a	PO b	PO c	PO d	PO e	PO f
CO1	**M**			**H**		**M**
CO2	**M**			**H**		**M**
CO3				**H**	**H**	**M**
CO4				**H**	**H**	**M**

(H - High, M - Moderate, L - Low)

19METE3011 MOOCs COURSE (SELF-LEARING)

Course Category:	Open Elective	**Credits:**	3
Course Type:	Theory	**Lecture-Tutorial-Practice:**	0-0-0
		Continuous Evaluation:	-
		Semester end Evaluation:	100
		Total Marks:	100

Student shall be taking self-learning course from the list of approved MOOCs providers (SWAYAM / NPTEL/ EDX / Others) for minimum duration of 8 weeks. Under MOOCs Platform, student can opt from the following subjects:

- Experimental Methods in Fluid Mechanics
- Multiphase Flows
- Non-Conventional Energy Resources
- Energy Resources, Economics and Environment
- Fundamentals of Nuclear Power Generation
- MATLAB Programming for Numerical Computation
- Membrane Technology
- Plastic Waste Management
- Rocket Propulsion
- Fundamentals of combustion for propulsion

19METE3061 PROJECT – PART A

Course Category:	Project	**Credits:**	10
Course Type:	Project	**Lecture-Tutorial-Practice:**	0-0-20
		Continuous Evaluation:	40
		Semester end Evaluation:	60
		Total Marks:	100

Course Outcomes:

At the end of the course the student will be able to:

CO1: Identify a topic in relevant areas of thermal engineering.

CO2: Review literature to identify gaps and define objectives & scope of the work.

CO3: Understand the methods and processes from literature and apply appropriate research methodologies.

CO4: Develop an analytical/ computational model/ experimental set-up and prepare a report and develop competence in presenting.

Contribution of Course Outcomes towards achievement of Program Outcomes

	PO a	PO b	PO c	PO d	PO e	PO f
CO1	**M**	**M**		**M**		**M**
CO2	**M**	**M**		**M**	**M**	**M**
CO3	**M**	**M**		**M**	**H**	**M**
CO4		**M**		**M**	**H**	**M**

(H - High, M - Moderate, L - Low)

19METE3052 INTERNSHIP

Course Category:	Internship	**Credits:**	2
Course Type:	Summer Training	**Lecture-Tutorial-Practice:**	0-0-4
		Continuous Evaluation:	-
		Semester end Evaluation:	100
		Total Marks:	100

The students shall undergo Internship for a period of six weeks in Industry/Research organizations/ institute of higher learning approved by the Head of the Department during any time after the second semester.

19METE4061 PROJECT - PART B

Course Category:	Project	**Credits:**	16
Course Type:	Project	**Lecture-Tutorial-Practice:**	0-0-32
		Continuous Evaluation:	40
		Semester end Evaluation:	60
		Total Marks:	100

Course Outcomes:

At the end of the course the student will be able to:

CO1: Identify methods and resources to carry out analysis and experiments.

CO2: Reorganize the procedures with a concern for society, environment and ethics.

CO3: Analyze and discuss the results to draw valid conclusions.

CO4: Prepare a report and defend the work and also explore possibility of publishing the work.

Contribution of Course Outcomes towards achievement of Program Outcomes

	PO a	PO b	PO c	PO d	PO e	PO f
CO1	**M**	**H**		**H**		**M**
CO2	**M**	**M**		**H**	**M**	**M**
CO3	**H**	**M**		**H**	**H**	**M**
CO4	**M**	**M**		**H**	**H**	**M**

(H - High, M - Moderate, L - Low)