MAULANA AZAD
NATIONAL INSTITUTE OF TECHNOLOGY, Bhopal - 462003

DEPARTMENT OF MECHANICAL ENGINEERING

M.Tech (Full Time) in Thermal Engineering

PROPOSED SCHEME M.Tech (w.e.f. July 2024)

First Semester:

Course No.	Subject	Schemes of studies periods per week			Total Credits
		L	T	P	
TH24511	Advanced Heat & Mass Transfer	3	-	-	3
TH24512	Fluid Flow & Gas Dynamics	3	-	-	3
TH24513	Computational Fluid Dynamics	3	-	-	3
	Department Elective –1	3	-	-	3
	Department Elective –2	3	-	-	3
TH24514	Thermal Engineering Lab-I	-	-	2	1
TH24515	Computational Fluid Dynamics Lab-I	-	-	2	1
TH24516	Seminar-I	-	-	2	1
TH24517	Minor Project-1(Self Learning)				2
Total Hours: 23 **Total Credits:20**		**Total Semester Credits**			**20**

- **Communication Skill will be Audit Course of 2 credits which will not be counted in SGPA/CGPA calculation**

Second Semester:

Course No.	Subject	Schemes of studies periods per week			Total Credits
		L	T	P	
TH24521	Thermal Environmental Engineering	3	-	-	3
TH24522	Theory and Design of Heat Exchangers	3	-	-	3
	Department Elective –3	3	-	-	3
	Department Elective –4	3	-	-	3
	Open Elective	3	-	-	3
TH24523	Thermal Engineering Lab-II	-	-	2	1
TH24524	Computational Fluid Dynamics Lab-II	-	-	2	1
TH24525	Seminar-II	-	-	2	1
TH24526	Minor Project-2 (Self Learning)				2
Total Hours: 23 **Total Credits: 40**		**Total Semester Credits**			**20**

Third Semester:

Course No.	Subject	Schemes of studies periods per week			Total Credits
		L	T	P	
TH24611	Dissertation Phase-I	-	-	40	20
Total Hours: 40 **Total Credits: 60**		**Total Semester Credits**			**20**

Fourth Semester:

Course No.	Subject	Schemes of studies periods per week			Total Credits
		L	T	P	
TH24621	Dissertation Phase-II	-	-	40	20
Total Hours: 40 **Total Credits:80**		**Total Semester Credits**			**20**

List of Department Electives

TH24551	Renewable Energy
TH24552	Refrigeration System & Component Design
TH24553	Advanced Thermodynamics
TH24554	Theory and Design of Gas Turbines
TH24555	Theory and Design of Turbomachines
TH24556	Design and Simulation of IC Engines
TH24557	Advanced Fluid Mechanics
TH24558	Microfluidics
TH24559	Convective Heat & Mass Transfer
TH24560	Instrumentation for Thermal Engineering
TH24561	Advanced Computational Fluid Dynamics
TH24562	Design of Thermal Systems
TH24563	Thermal Power Plant Engg.
TH24564	Power Generation Systems
SM24564	Finite Element Methods
ME24524	Research Methodology

List of Open Electives

ARP24581	Introduction to Urban Planning
BSE24581	Bioprocess Engineering
BSE24582	Biophysics Tools and Techniques
CHE24581	Analytical Techniques
CHE24582	Green Technology & Processes
CE24581	Solid Waste Management
CE24582	Basic Concept of GIS
CE24583	Road Safety
CSE24581	Machine Learning
CSE24582	Advanced Data Structures and Algorithms
PHY24581	Nanotechnology and Nanoscience
EE24581	Electric Machines & Applications
EE24582	Control and Instrumentation
ECE24581	Introduction to Fuzzy Logic
ECE24582	Neural Networks and its Applications

EC24581	Energy Resource Technologies
HUM24581	Intellectual Property Rights for Engineers
HUM24582	Applied Psychology: Human Centered Design and Engineering
MTH24581	Advanced Operations Research
MTH24582	Computing Technologies
MME24581	Advanced Instrumentation Methods for Material Analysis
MME24582	Smart Materials and their Application
MBA24581	Engineering Startup Management

Name of Program	M. Tech. in Mechanical Engineering with Specialization in Thermal Engineering	Semester: I	Year: I

Name of Course	Advanced Heat & Mass Transfer
Course Code	TH24511
Core / Elective / Other	Core

Prerequisite if any:	
1.	Thermodynamics
2.	Fluid Mechanics

Course Outcomes:	
1.	Able to formulate mechanical engineering problems related to heat transfer and to find solution using basic principles
2.	Able to apply basic laws of heat transfer to solve mechanical engineering problems
3.	Ability to synthesis the information, analysis and interpretation of data to find valid conclusion of the problem.

Description of Contents in brief:	
Unit 1.	**Transient Heat Conduction:** Review of Heat Transfer Fundamentals, Newtonian heating/cooling, sudden temp change in finitely thick slabs & semi-infinite solid, periodic heat flow: graphical solution, Transient heat conduction charts, analysis of thermo couple response.
Unit 2.	**Convection:** Convection heat transfer & boundary layers and development of their equations; approximations and special condition, boundary layer similarity equations Reynolds analogy, similarity solutions for flow over flat plate convection heat transfer in flow through circular pipes, Laminar & Turbulent flows.
Unit 3.	**Heat Transfer by Radiation:** Heat radiation a type of wave motion; concept of a black body, Planck's law of monochromatic radiation of a black body, Kirchhoff's law of radiation, Stefan Boltzmann's law of total radiation Emissivity and absorptivity of different bodies heat exchange between back surfaces - parallel, perpendicular to each other, heat radiation between two black surfaces, heat exchange between planes of different emissivity, heat exchange between and enclosed by and the enclosure.
Unit 4.	**Boiling & Condensation**: Boiling heat transfer, nature of vaporization, nucleate pool boiling and empirical correlations for pool boiling heat transfer, factors affecting pool boiling film coefficients, high heat flux boiling. Physical Mechanisms of Condensation, Laminar film condensation on a vertical plate, Nusselt theory, turbulent film condensation, drop wise condensation, condensation on tubes and tubes banks, deviations from Nusselt theory.
Unit 5.	**Numerical solution of conduction problems:** Introduction finite difference equations method of energy balance, finite difference formulation of unidirectional for cartesian cylindrical coordinate of various kinds of boundary conditions, heat conduction problems, numerical methods of solutions, numerical solution of transient heat diffusion problem.
Unit 6.	**MASS TRANSFER:** Mass transfer fundamentals, Convective mass transfer, equation for convective mass transfer, boundary layer mass transfer, empirical correlation for convective mass transfer. Overall Mass Momentum and Energy Balance.

List of Text Books:	
1.	Frank Kreith, Raj M. Manglik, Mark S. Bohn. Principles of Heat Transfer, Cengage Learning, 2010
2.	Jack Philip Holman. Heat Transfer, Tata-McGraw-Hill, 2012
3.	P.K. Nag. Heat and Mass Transfer, Tata-McGraw-Hill, 2011

List of Reference Books:	
1.	L.S. Tong, Y.S. Tang. Boiling Heat Transfer and Two-Phase Flow, CRC Press, 2008

URLs:		
1.	https://swayam.gov.in	
2.	http://www.nptel.ac.in	
Lecture Plan (about 40-50 Lectures):		
***Lecture No.**	**Topic**	**Remarks**
1.	Review of Heat Transfer Fundamentals	
2.	Newtonian heating/cooling	
3.	Unsteady state heating of bodies with known temperature distribution	
4.	Unsteady state heating of bodies with negligible internal resistance	
5.	Unsteady state heating of bodies with negligible surface resistance	
6.	Sudden temp change in finitely thick slabs	
7.	Sudden temp change in semi-infinite solid	
8.	Periodic heat flow	
9.	Analysis of thermo couple response	
10.	Graphical solution	
11.	Transient heat conduction charts	
12.	Numerical on above topic	
13.	Numerical on above topic	
14.	Convection heat transfer	
15.	Development of boundary layers, Laminar & Turbulent flows	
16.	Boundary layers equations; approximations and special condition	
17.	Boundary layer similarity equations	
18.	Reynolds analogy	
19.	Similarity solutions for flow over flat plate	
20.	Convection heat transfer in flow through circular pipes	
21.	Numerical on above topic	
22.	Introduction to Heat radiation a type of wave motion	
23.	Concept of a black body	
24.	Planck's law of monochromatic radiation of a black body	
25.	Kirchhoff's law of radiation	
26.	Stefan Boltzmann's law of total radiation	
27.	Emissivity and absorptivity of different bodies	
28.	Heat exchange between back surfaces - parallel, perpendicular to each other	
29.	Heat radiation between two black surfaces, heat exchange between planes of different emissivity and between and enclosed by and the enclosure	
30.	Numerical on above topic	
31.	Introduction to Boiling heat transfer	
32.	Nature of vaporization	
33.	Empirical correlations for pool boiling heat transfer	
34.	Nucleate pool boiling and factors affecting pool boiling film coefficients	
35.	High heat flux boiling	
36.	Physical Mechanisms of Condensation	
37.	Laminar film condensation on a vertical plate, Nusselt theory	
38.	Turbulent film condensation, drop wise condensation	
39.	Condensation on tubes and tubes banks	
40.	Numerical solution of conduction problems**:** Introduction	
41.	Introduction finite difference equations method of energy balance	
42.	finite difference formulation of unidirectional for cartesian cylindrical coordinate of various kinds of boundary conditions	

43.	Heat conduction problems, numerical methods of solutions, numerical solution of transient heat diffusion problem	
44.	Mass transfer fundamentals	
45.	Convective mass transfer, equation for convective mass transfer	
46.	Boundary layer mass transfer, empirical correlation for convective mass Transfer	
47.	Overall Mass Momentum and Energy Balance	
48.	Revision	

***Min 48 (for four credit course)**

Evaluation Criteria:

Sl. No.	Name of Examination	Marks Allotted	Remarks
1	Mini Test	10	
2	Mid Semester Test	20	
3	Assignment if any	10	
4	Tutorial if any	10	
5	Quiz if any	-	
6	Seminar, Viva voce if ay	-	
7	End Semester Examination	50	
8	Experiments if any (for practical courses)	-	
9	Any other	-	

Name of Program	M. Tech. in Mechanical Engineering with Specialization in Thermal Engineering	Semester: I	Year: I

Name of Course	Fluid Flow & Gas Dynamics
Course Code	TH24512
Core / Elective / Other	Core

Prerequisite if any:	
1.	Engineering Thermodynamics
2.	Fluid Mechanics

Course Outcomes:	
1.	Understand basic laws of conservation and apply them to seek solutions to fluid and heat flow problems in engineering applications
2.	Familiarize with governing equations of ideal flows and apply them to develop flow pattern over immersed bodies
3.	Apply concepts of boundary layer to understand behavior of flows over flat plate and flow through pipes
4.	Analyze variation in properties of compressible flows and normal shock
5.	Formulate and solve one dimensional compressible fluid flow problems

Description of Contents in brief:	
Unit 1.	**Fundamental Equations of Fluid and Heat Flow:** Governing equations and applications to find solutions to simple fluid and thermal systems
Unit 2.	**Potential Flow:** Elementary flows, superposition of flow patterns, flow over immersed bodies
Unit 3.	**Viscous Flow:** Flow over flat plates-laminar and turbulent boundary layers, displacement and momentum thickness, velocity distribution in turbulent flows in smooth and rough boundaries - laminar sub layer
Unit 4.	**Compressible Flow of Gases-I:** Isentropic and adiabatic flow, stagnation and critical properties, flow through ducts of constant area, Fanno-line and Rayleigh line flows. Fundamental equations and variation in flow properties
Unit 5.	**Compressible Flow of Gases-II:** Flow with normal shock waves governing equations, Prandtl- Meyer and Rankine-Hugoniot relations

List of Text Books:	
1.	S.M. Yahya. Fundamentals of Compressible Flows, New Age International (P) Limited, 2009
2.	R.W. Fox, A.T. Donald, Philip J. Pritchard. Introduction to Fluid Mechanics, Wiley, 2002
3.	P. Balachandran. Fundamentals of Compressible Fluid Dynamics, PHI Learning, 2009

List of Reference Books:	
1.	Michel A. Saad. Compressible Fluid Flow, Prentice Hall, 2nd Edition, 1993
2.	A. Alexandrou. Fluid Mechanics, Prentice Hall, 2001

URLs:	
1.	http://www.nptel.ac.in
2.	https://swayam.gov.in/nc_details/NPTEL

Lecture Plan (about 40-50 Lectures):

*Lecture No.	Topic	Remarks
1.	Continuity equation	
2.	Equations of motion	

3.	Equations of motion (Continued)	
4.	Euler's equation	
5.	Bernoulli's equation	
6.	Energy equation	
7.	Stream function and velocity potential	
8.	Applied numerical problems	
9.	Applied numerical problems	
10.	Applied numerical problems	
11.	Elementary potential flows: Uniform flow, source, sink, vortex and doublet	
12.	Superposition of flow patterns: Flow over the cylinder, velocity distribution, stagnation points, determination of pressure distribution	
13.	Flow over the cylinder: Determination of the lift and drag, Kutta-Joukowski Profile	
14.	Superposition of flow patterns: Flow over the cylinder with circulation using velocity distribution, stagnation points, determination of pressure distribution	
15.	Flow over the cylinder with circulation: Determination of the lift and drag	
16.	Flow over the cylinder with circulation: Determination of the lift and drag	
17.	Rankine Body: Velocity Distribution, stagnation points, determination of pressure distribution	
18.	Related numerical problems	
19.	Related numerical problems	
20.	Boundary Layers - Laminar and turbulent boundary layers in flat plates, displacement and momentum thickness	
21.	Flow over flat plates - Characteristics equations, boundary layer Approximations	
22.	Velocity distribution in turbulent flows in smooth and rough boundaries - Laminar sub layer	
23.	Boundary layer equations - Order of magnitude analysis	
24.	Solution to boundary layer equations - Blasius solution	
25.	Solution to boundary layer equations - Blasius solution	
26.	Approximate solution to boundary layer equations for flat plates	
27.	Related numerical problems	
28.	Related numerical problems	
29.	Related numerical problems	
30.	Flow through ducts of constant area	
31.	Isentropic flow through converging nozzle	
32.	Isentropic flow through converging - diverging nozzle	
33.	Numerical problems on isentropic flow	
34.	Numerical problems on isentropic flow – continued	
35.	Fanno-line flow: Effects of friction on adiabatic flow through constant area Duct	
36.	Rayleigh line flows: Effects of heat exchange on friction-less flow through constant area duct	
37.	Related numerical problems	
38.	Related numerical problems	
39.	Related numerical problems	
40.	Flow with normal shock waves: Governing equations	
41.	Derivation of equations for normal shock	
42.	Derivation of equations for normal shock	
43.	Derivation of equations for normal shock	
44.	Rankine-Hugonoit Relation	

45.	Prandtl-Meyer Relation	
46.	Numerical problems related to normal shock	
47.	Numerical problems related to normal shock	
48.	Numerical problems related to normal shock	

***Min 48 (for four credit course)**

Evaluation Criteria:

Sl.No.	Name of Examination	Marks Allotted	Remarks
1	Mini Test	10	
2	Mid Semester Test	20	
3	Assignment if any	10	
4	Tutorial if any	-	
5	Quiz if any	10	
6	Seminar, Viva voce if ay	-	
7	End Semester Examination	50	
8	Experiments if any (for practical courses)	-	
9	Any other	-	

Name of Program	M. Tech. in Mechanical Engineering with Specialization in Thermal Engineering	Semester: I	Year: I

Name of Course	Computational Fluid Dynamics
Course Code	TH24513
Core / Elective / Other	Core

Prerequisite if any:	
1.	Engineering Thermodynamics
2.	Fluid Mechanics
3.	Heat & Mass Transfer

Course Outcomes:	
1.	Discretize the governing equations along with boundary condition using different Techniques
2.	Evaluate the grid sensitivity, analyze the accuracy and stability of a numerical solution.
3.	Develop an algorithm and numerical code for fluid flow and heat transfer problems.

Description of Contents in brief:	
Unit 1.	**Governing Differential Equations & Discretization Techniques:** Basics of Heat Transfer, Fluid flow – Mathematical description of fluid flow and heat transfer – Conservation of mass, momentum, energy and chemical species - Classification of partial differential equations – Initial and Boundary Conditions – Discretization techniques using finite difference methods – Taylor's Series - Uniform and non-uniform Grids, Numerical Errors, Grid Independence Test.
Unit 2.	**Heat Diffusion:** Steady one-dimensional diffusion, Discretization of unsteady diffusion problems – Explicit, Implicit and Crank-Nicholson's schemes, Stability of schemes.
Unit 3.	**Convection – Diffusion Processes:** Finite difference technique for one dimensional convection – diffusion problem, central difference scheme, upwind scheme – Hybrid and power law discretization techniques – QUICK scheme.
Unit 4.	**Flow Processes:** Discretization of incompressible flow equations – Pressure based algorithms, SIMPLE, PISO algorithms.
Unit 5.	**Turbulence And Its Modeling:** Description of turbulent flow, free turbulent flows, flat plate boundary layer and pipe flow. Algebraic Models, One equation model, $k - \varepsilon$ & $k - \omega$ models Standard and High and Low Reynolds number models. Transport method.

List of Textbooks:	
1.	P.S. Ghoshdastidar. Computer Simulation of Flow and Heat Transfer, Tata McGraw-Hill Publishing Company Limited, 1998
2.	Versteeg, N. Malalasekera. An Introduction to Computational Fluid Dynamics The Finite Volume Method, Pearson Education Limited, 2007
3.	S.V. Patankar. Numerical Heat Transfer, Hemisphere Publishing Corporation, 1980

List of Reference Books:	
1.	D.A. Anderson, J.I. Tannehill, R.H. Pletcher. Computational Fluid Mechanics and Heat Transfer, Hemisphere Publishing Corporation, 2012
2.	K. Muralidhar, T. Sundararajan. Computational Fluid Flow and Heat Transfer, Narosa Publishing House, 2003
3.	T.K. Bose. Numerical Fluid Dynamics, Narosa Publishing House, 1997

URLs:	
1.	http://www.nptel.ac.in
2.	https://swayam.gov.in/nc_details/NPTEL

Lecture Plan (about 40-50 Lectures):		
***Lecture No.**	**Topic**	**Remarks**
1.	Mathematical description of fluid flow and heat transfer – conservation of mass, momentum	
2.	Mathematical description of fluid flow and heat transfer –energy and chemical species	
3.	Classification of partial differential equations	
4.	Initial and boundary conditions	
5.	Discretization techniques using finite difference methods – Taylor's Series	
6.	Discretization techniques using finite difference methods – Taylor's series (Continued)	
7.	Uniform and non-uniform grids, numerical errors, grid independence test	
8.	Uniform and non-uniform grids, numerical errors, grid independence test (Continued)	
9.	Steady one-dimensional heat diffusion: Discretization	
10.	Numerical solution of sample problem	
11.	Explicit formulation : Numerical solution of sample problem	
12.	Numerical solution of sample problem	
13.	Numerical solution of sample problem	
14.	Implicit formulation: Numerical solution of sample problem	
15.	Numerical solution of sample problem	
16.	Numerical solution of sample problem	
17.	Crank-Nicolson formulation, comparison of three formulation	
18.	Stability of schemes	
19.	One dimensional convection – diffusion problem: Finite volume Formulation	
20.	Central difference scheme for convection term	
21.	Central difference scheme for convection term (Continued)	
22.	Upwind scheme	
23.	Hybrid discretization techniques	
26.	Hybrid discretization techniques (Continued)	
27.	Power law discretization techniques	
28.	Power law discretization techniques (Continued)	
29.	Quick Scheme: formulation	
30.	Discretization of incompressible flow equations – Pressure based Algorithms	
31.	Discretization of incompressible flow equations – Pressure based Algorithms	
32.	Discretization of incompressible flow equations – Pressure based Algorithms	
33.	SIMPLE scheme	
34.	SIMPLE scheme	
35.	PISO algorithms	
36.	PISO algorithms	
37.	Description of turbulent flow	
38.	Description of turbulent flow	
39.	Free turbulent flows	
40.	Flat plate boundary layer and pipe flow	
41.	Flat plate boundary layer and pipe flow	

42.	Algebraic Models, one equation model	
43.	$k - \varepsilon$ & $k - \omega$ models	
44.	$k - \varepsilon$ & $k - \omega$ models	
45.	$k - \varepsilon$ & $k - \omega$ models	
46.	Standard and high and low Reynolds number models.Transport method.	
47.	Standard and high and low Reynolds number models. Transport method.	
48.	Standard and high and low Reynolds number models. Transport method.	

***Min 48 (for four credit course)**

Evaluation Criteria:

Sl.No.	Name of Examination	Marks Allotted	Remarks
1	Mini Test	10	
2	Mid Semester Test	20	
3	Assignment if any	20	
4	Tutorial if any	-	
5	Quiz if any	-	
6	Seminar, Viva voce if ay	-	
7	End Semester Examination	50	
8	Experiments if any (for practical courses)	-	
9	Any other	-	

Name of Program	M. Tech. in Mechanical Engineering with Specialization in Thermal Engineering	Semester: I	Year: I

Name of Course	Thermal Engineering Lab-I
Course Code	TH24514
Core / Elective / Other	Core

Prerequisite if any:	
1.	Heat and Mass Transfer
Course Outcomes:	
1.	Practical knowledge about functioning of different types of heat exchangers
2.	Learning about different types of heat transfer processes and measurement of their evaluation Parameters
3.	Physical Observation of Heat Transfer Phenomena
Description of Contents in brief:	
Exp. 1.	Determination of LMTD, Overall Heat Transfer Coefficient and Effectiveness of Double Pipe Heat Exchanger in Parallel Flow and Counter Flow Configuration
Exp. 2.	Determination of Thermal Conductivity of Metal Rod
Exp. 3.	Determination of Heat Transfer in Free and Forced Convection
Exp. 4.	Determination of Heat Transfer Rate in Drop wise and Film wise Condensation
Exp. 5.	Performance Testing of Air Conditioning Cycle Test Rig.
Exp. 6	Determination of COP and Tonnage Capacity of a Mechanical Heat Pump
List of Text Books:	
1.	D.S. Kumar. Heat and Mass Transfer, S.K. Kataria and Sons, 2009
2.	S.P. Sukhatme. A Textbook on Heat Transfer, Universities Press, 2005
3.	S.C. Arora, S. Domkundwar, Anand V. Domkundwar. A Course in Heat and Mass Transfer, Dhanpat Rai & Co. Pvt. Ltd., 2007
List of Reference Books:	
1.	Frank P. Incropera. Introduction to Heat Transfer, Wiley, 2001
2.	Yunus Cengel, Afshin Ghajar. Heat and Mass Transfer, McGraw Hill Education, 2011
URLs:	
1.	http://www.nptel.ac.in
2.	https://swayam.gov.in/nc_details/NPTEL

Lecture Plan (about 40-50 Lectures):
It is an experimental course

Evaluation Criteria:

Sl. No.	Name of Examination	Marks Allotted	Remarks
1	Mini Test	-	
2	Mid Semester Test	-	
3	Assignment/Lab Record if any	30	
4	Tutorial if any	-	
5	Quiz if any	10	

6	Seminar, Viva voce if any	20	
7	End Semester Examination	-	
8	Experiments if any (for practical courses)	40	
9	Any other	-	

Name of Program	M. Tech. in Mechanical Engineering with Specialization in Thermal Engineering	Semester: I	Year: I

Name of Course	Computational Fluid Dynamics Lab-I
Course Code	TH24515
Core / Elective / Other	Core

Prerequisite if any:	
1.	Heat and Mass Transfer
2.	Computational Fluid Dynamics

Course Outcomes:	
1.	Generate meshes for various geometries.
2.	Analyze the fluid flow and heat transfer for internal flows.
3.	Visualize the flow and heat transfer characteristics using post-processing software.

Description of Contents in brief:	
Exp. 1.	Generation of grids for simple 2-D geometry
Exp. 2.	Grid generation for 3-D geometry
Exp. 3.	Solution of the one-dimensional steady-state diffusion
Exp. 4.	One-dimensional steady-state diffusion with volume source
Exp. 5.	One-dimensional transient heat conduction
Exp. 6	Laminar pipe flow
Exp. 7	Turbulent pipe flow
Exp. 8	External flow over a flat plate

List of Text Books:	
1.	M.Veeramanikandan and D. Satish, Computational Fluid Dynamics Laboratory Manua, CBS Publishers & Distributors, 2021.
2.	P.S. Ghoshdastidar. Computer Simulation of Flow and Heat Transfer, Tata McGraw-Hill Publishing Company Limited, 1998.

List of Reference Books:	
1.	D.A. Anderson, J.I. Tannehill, R.H. Pletcher. Computational Fluid Mechanics and Heat Transfer, Hemisphere Publishing Corporation, 2012

URLs:	
1.	https://nptel.ac.in/courses/112105045

Lecture Plan (about 40-50 Lectures): It is an experimental course

Evaluation Criteria:

Sl. No.	Name of Examination	Marks Allotted	Remarks
1	Mini Test	-	
2	Mid Semester Test	-	
3	Assignment/Lab Record if any	30	
4	Tutorial if any	-	
5	Quiz if any	10	
6	Seminar, Viva voce if any	20	
7	End Semester Examination	-	
8	Experiments if any (for practical courses)	40	
9	Any other	-	

Name of Program	M. Tech. in Mechanical Engineering with Specialization in Thermal Engineering	Semester: I	Year: I

Name of Course	Seminar – I
Course Code	TH24516
Core / Elective / Other	Core

Prerequisite if any:	
1.	Nil
Course Outcomes:	
1.	Familiar with the research articles.
2.	Develop communication and presentation skills.
Description of Contents in brief:	
1.	Students have to collect an International Journal paper on the topics of their interest, prepare a write up and present with suitable demonstration by software or experimental work.

List of Text Books: Nil

List of Reference Books: Nil

URLs:	
1.	https://www.sciencedirect.com/
2.	https://www.tandfonline.com/
3.	https://www.google.com/

Lecture Plan (about 40-50 Lectures): It is a seminar course

Evaluation Criteria:

Sl. No.	Name of Examination	Marks Allotted	Remarks
1	Mini Test	-	
2	Mid Semester Test/Evaluation	20	
3	Assignment if any	-	
4	Tutorial if any	-	
5	Quiz if any	-	
6	Seminar, Viva voce if any	20	
7	End Semester Examination	60	
8	Experiments if any (for practical courses)	-	
9	Any other	-	

Name of Program	**M. Tech. in Mechanical Engineering with Specialization in Thermal Engineering**	**Semester: I**	**Year: I**
Name of Course	Minor Project -1 (Self Learning)		
Course Code	TH24517		
Core / Elective / Other	Core		
Prerequisite if any:			
1.	Nil		
Course Outcomes:			
1.	Enhance research skills and thinking.		
2.	Apply the fundamentals of subjects to analyse the real engineering problem.		
Description of Contents in brief:			
1.	Students will choose a topic of his/her interest (either numerical or experimental) and will the conduct analysis		
List of Text Books: Nil			
List of Reference Books: Nil			
URLs:			
1.	Nil		
2.	Nil		
3.	Nil		
Lecture Plan (about 40-50 Lectures): It is a seminar course			

Evaluation Criteria:

Sl. No.	Name of Examination	Marks Allotted	Remarks
1	Mini Test	-	
2	Mid Semester Test/Evaluation	20	
3	Assignment if any	-	
4	Tutorial if any	-	
5	Quiz if any	-	
6	Seminar, Viva voce if any	20	
7	End Semester Examination	60	
8	Experiments if any (for practical courses)	-	
9	Any other	-	

Name of Program	M. Tech. in Mechanical Engineering with Specialization in Thermal Engineering	Semester: I	Year: I

Name of Course	Communication Skills
Course Code	HUM24511
Core / Elective / Other	Other

Prerequisite: Nil

Course Outcomes:

1.	To help postgraduate students improve their technical communication skills related to listening, speaking, reading, writing
2.	To enable students to organize, comprehend, write, and present short and long forms of any technical work within the broad framework of the scientific method
3.	To help students adhere to ethical norms of scientific communication

Description of Contents in brief:

Unit 1.	**Scientific Method and its Relationship to Technical Communication** Basics of technical communication, formulation of hypothesis, paragraph organisation, argument development, evidence and elaboration
Unit 2.	**Listening and Reading Skills** Note taking, survey of literature, different reading strategies
Unit 3.	**Writing Skills** Report writing, peer review skills, summary and abstract writing, bibliography and references, data analysis and presentation, visual communication
Unit 4.	**Speaking Skills** Elevator pitch, oral presentation, slides for presentation, group discussions, interview skills
Unit 5.	**Ethics in Communication** Ethics in education and research, copyrights and plagiarism, authorship, gender and diversity, net etiquettes and workplace communication

List of Text Books:

1.	V.N. Arora, Lakshmi Chandra. Improve Your Writing, Oxford University Press, 2013
2.	Graff Gerald, Birkenstein Cathy. They Say I Say-The Moves That Matter in Academic Writing, Fourth Edition, W. W. Norton and Company, 2018
3.	V. Raymond, E. Marie, Flatley Lesikar. Basic Business Communication Skills for Empowering the Internet Generation, Ninth Edition, McGraw-Hill, 2002

List of Reference Books:

1.	Graff Gerald, Birkenstein Cathy. They Say I Say-The Moves That Matter in Academic Writing, Fourth Edition, W. W. Norton and Company, 2018
2.	Sanjay Kumar, Pushp Lata. Communication Skills, Oxford University Press, 2011
3.	Meenakshi Raman, Sangeeta Sharma. Technical Communication: Principles and Practice, Oxford University Press, 2015

URLs: Nil

Lecture Plan (about 40-50 Lectures):

Lecture No.	Topic
1-2	Basics of technical communication
3.	Formulation of hypothesis

4-5	Paragraph organization
6.	Argument development
7.	Evidence and elaboration
8.	Note taking
9-10	Survey of literature
11.	Different reading strategies
12-13	Report writing
14-16	Peer review skills
17-18	Summary and abstract writing
19-20	Bibliography and references
21-25	Data analysis and presentation
26-27	Visual communication
28.	Elevator pitch
29-33	Oral presentation
34.	Slides for presentation
35-37	Group discussions
38-40	Interview skills
41.	Ethics in education and research
42-43	Copyrights and plagiarism
44.	Authorship
45.	Gender and diversity
46.	Net etiquettes
47- 48	Workplace communication

Evaluation Criteria:

Sl. No.	Name of Examination	Marks Allotted	Remarks
1	Mini Test	10	
2	Mid Semester Test	20	
3	Assignment if any	20	
4	Tutorial if any	-	
5	Quiz if any	-	
6	Seminar, Viva voce if any	-	
7	End Semester Examination	50	
8	Experiments if any (for practical courses)	-	
9	Any other	-	

Name of Program	M. Tech. in Mechanical Engineering with Specialization in Thermal Engineering	Semester: II	Year: I

Name of Course	Thermal Environmental Engineering
Course Code	TH24521
Core / Elective / Other	Core

Prerequisite if any:	
1.	Engineering Thermodynamics
2.	Heat Transfer

Course Outcomes:	
1.	Understand principles of comfort air conditioning
2.	Understand different air conditioning systems, equipment, components and controls
3.	Understand air distribution systems and duct design
4.	Understand load calculations and applied psychrometrics
5.	Understand various systems of refrigeration and their application to environmental control

Description of Contents in brief:	
Unit 1.	**Introduction:** Thermal exchanges of body with environment, comfort air conditioning and effective temperature
Unit 2.	**Air Conditioning Systems:** Elements of air conditioning systems, classification, air conditioning equipments, filters, fans and air conditioning controls
Unit 3.	**Air Distribution:** Principles of air distribution, air distribution systems, flow through ducts, static and dynamic losses, duct design
Unit 4.	**Applied Psychrometrics:** Moist air properties, various psychrometric processes, summer air conditioning, winter air conditioning, bypass factor, RSHF, use of ERSHF, application with low latent heat loads and high latent heat loads. Solar radiation, heat gain through glasses, heat transfer through roofs and walls, total cooling load estimation
Unit 5.	**Environmental Control Systems**: Vapour compression refrigeration system, multi-evaporator multi-compressor systems, vapour absorption system, evaporative cooling, desiccant cooling systems, vapour adsorption system

List of Text Books:	
1.	C.P. Arora. Refrigeration and Air Conditioning, Tata McGraw Hill Education, 2000
2.	R.C. Arora. Refrigeration and Air Conditioning, PHI Learning, 2010
3.	S.N. Sapali. Refrigeration and Air Conditioning, PHI Learning, 2009

List of Reference Books:	
1.	Roy J. Dossat, Thomas J. Horan. Principles of Refrigeration, Pearson, 2001
2.	W.F. Stoecker, J. W. Jones. Refrigeration and Air Conditioning, McGraw Hill, 1982
3.	Carter Stanfield, David Skaves. Fundamentals of HVACR, Pearson, 2009

URLs:	
1.	https://nptel.ac.in/courses/112/105/112105129/
2.	https://nptel.ac.in/courses/112/107/112107208/

Lecture Plan (about 40-50 Lectures):

***Lecture No.**	**Topic**	**Remarks**

1-2	Thermal exchanges of body with environment	
3-4	Comfort air conditioning and effective temperature	
5-6	Elements of air conditioning systems	
7-8	Classification of air conditioning systems	
9-10	Air conditioning equipment's	
11-13	Filters, fans and air conditioning controls	
14-16	Principles of air distribution	
17-19	Air distribution systems	
20-21	Flow through ducts, static and dynamic losses	
22-24	Duct design	
25-26	Moist air properties	
27-29	Various psychrometric processes	
30-31	Summer air conditioning, winter air conditioning	
32-33	Bypass factor, RSHF, use of ERSHF	
34-36	Application with low latent heat loads and high latent heat loads	
37-38	Solar radiation	
39-40	Heat gain through Glasses, heat transfer through roofs and walls, total cooling load estimation	
41-42	Vapour compression refrigeration system	
43-44	Multi-evaporator and multi-compressor systems	
45-46	Vapour absorption system	
47-48	Evaporative cooling, desiccant cooling systems	
49-50	Vapour adsorption system	

***Min 48 (for four credit course)**

Evaluation Criteria:

Sl. No.	Name of Examination	Marks Allotted	Remarks
1	Mini Test	10	
2	Mid Semester Test	20	
3	Assignment if any	20	
4	Tutorial if any	-	
5	Quiz if any	-	
6	Seminar, Viva voce if ay	-	
7	End Semester Examination	50	
8	Experiments if any (for practical courses)	-	
9	Any other	-	

Name of Program	M. Tech. in Mechanical Engineering with Specialization in Thermal Engineering	Semester: II	Year: I

Name of Course	Theory and Design of Heat Exchangers
Course Code	TH24522
Core / Elective / Other	Core

Prerequisite if any:

1.	Heat & Mass Transfer
2.	Fluid Mechanics

Course Outcomes:

1.	Able to apply knowledge of engineering fundamentals for solving mechanical engineering Problems
2.	Able to formulate mechanical engineering problems and to find solution using principles of Engineering
3.	Ability to design and develop mechanical component /system and processes that meets specific needs

Description of Contents in brief:

Outline: The subject aimed to detail design of heat exchangers used in process industries and other industrial applications. The design should include practical approach of material available as per Indian & International Standards, considering variable effect of various parameters like temperature, viscosity, density, specific heat, pressure, Reynolds no. etc. in details

Note:

1) The calculation data tables of international and Indian standards, property tables, charts and figures and design approach will be allowed in examination

2) The question paper should have total three questions, include two details design problems one each from unit 3,4 and unit 5,6 and theoretical questions from unit 1,2 of equal weightage

Unit 1. **Unit 2.**	**Introduction and Basic concepts to Heat Exchanger Design:** Types of heat exchangers based on construction details of double pipe, shell and tube heat exchangers, TEMA Standards, classification as per manufactures association, flow arrangements, regenerators and recuperators, vaporizers and standards. Industrial applications. Temperature distribution and its implications. Overall heat transfer coefficient, dirt factor. Basic design equation. Mean temperature difference concept: LMTD. Effectiveness-NTU method for heat exchanger of design/analysis. Concept of caloric temperature. Rating and sizing problem. Correlations for tube side pressure drop and heat transfer coefficients. Construction Details and Heat Flow Distribution and Stress Analysis –Effect of turbulence, friction factor, pressure loss, channel divergence. Thermal stress, types of failures. Design aspects –Heat transfer and pressure loss, Flow configuration, effect of baffles, effect of deviations from ideality, Indian and International Standards of heat exchangers types and components. Standards data table & charts for design parameters. Testing evaluation and maintenance of heat exchanger
Unit 3. **Unit 4.**	**Detail design of double pipe heat exchangers:** Constructional details of double pipe heat exchangers and their fittings, film coefficients for fluids in pipes & annuli, fouling factor for pipes & annuli. Design calculations of flow area, mass velocity, viscosity, heat transfer factor, specific heat, over all heat transfer coefficient and their corrections. Checking pressure drop and adjusting flow arrangement accordingly, series and parallel arrangement of double pipe heat exchanger. Net working of heat exchangers.
Unit 5. **Unit 6.**	**Design of Shell and tube heat exchangers:** Flow arrangement for increased heat recovery, different tube pitch arrangements, effect of baffles pitch, packed band & u-head arrangements. Calculations of shell and tube heat exchangers. Liquid to gases, and gases to gases heat exchangers design. Evaporation and phase change, calculation of process conditions, design of condensers and evaporators.

List of Text Books:	
1.	D.Q. Kern, Process Heat Transfer, Mc Graw Hill, 2013
2.	G.F. Hewuttm, G.L. Shires, T.R. Bott. Process Heat Transfer, CRC Press, 1994
3.	R.K. Shah, D.P. Sekulic. Fundamentals of Heat Exchanger Design, John Wiley & Sons, 2003
List of Reference Books:	
1.	A. Kakac, H. Liu. Heat Exchangers, CRC Press, 2002
2.	D. Annaratone. Handbook for Heat Exchangers and Tube Banks Design, Springer Verlag, 2010
3.	Eric M. Smith. Advances in Thermal Design of Heat Exchangers, John Wiley & Sons Limited, 2005
URLs:	
1.	http://www.nptel.ac.in
2.	https://swayam.gov.in

Lecture Plan (about 40-50 Lectures):

*Lecture No.	Topic	Remarks
1.	Introduction & types of heat exchangers, industrial applications	
2.	Classification of heat exchangers	
3.	Use of standard tables & charts	
4.	Shell & tube type heat exchanger, TEMA Standards selection of shell & tube type heat exchanger	
5.	Construction details of double pipe and shell & tube type heat exchanger	
6.	Flow arrangements	
7.	Regenerators and recuperators, vaporizers	
8.	Temperature distribution and its implications. Overall heat transfer coefficient, dirt factor	
9.	Basic design equation. Mean temperature difference Concept: LMTD	
10.	Effectiveness-NTU method for heat exchanger of design/ analysis	
11.	Concept of caloric temperature	
12.	Rating and sizing problem	
13.	Correlations for tube side pressure drop and heat transfer coefficients	
14.	Design –Tutorials	
15.	Design –Tutorials	
16.	Design –Tutorials	
17.	Constructional details of double pipe heat exchangers and their fittings	
18.	Film coefficients for fluids in pipes & annuli	
19.	Fouling factor for pipes & annuli	
20.	Design calculations of flow area, mass velocity, viscosity, heat transfer factor, specific heat, over all heat transfer coefficient and their corrections	
21.	Checking pressure drop and adjusting flow arrangement accordingly	
22.	Series and parallel arrangement of double pipe heat exchanger	
23.	Net working of Heat exchangers	
24.	Design –Tutorials	
25.	Design –Tutorials	
26.	Design –Tutorials	
27.	Design –Tutorials	
28.	Design –Tutorials	
29.	Constructional details of shell & tube type heat exchanger with fittings	
30.	Different tuTo determine the COP and tonnage capacity of a Mechanical Heat Pumpbe pitch arrangements	

31.	Effect of baffles pitch	
32.	Effect of baffles pitch, packed band & u-head arrangements	
33.	Design of shell and tube heat exchangers, design Calculations of flow area, mass velocity, viscosity, heat transfer factor, specific heat, over all heat transfer coefficient and their corrections	
34.	Flow arrangement for increased heat recovery	
35.	Liquid to gases heat exchangers design.	
36.	Liquid to gases heat exchangers design- Continued	
37.	Gases to gases heat exchangers design	
38.	Gases to gases heat exchangers design-Continued	
39.	Evaporation and phase change, calculation of process conditions	
40.	Design of condensers	
41.	Design of condensers-Continued	
42.	Design of evaporators	
43.	Design of evaporators-Continued	
44.	Design –Tutorials	
45.	Design –Tutorials	
46.	Design –Tutorials	
47.	Revision	
48.	Revision	

***Min 48 (for four credit course)**

Evaluation Criteria:

Sl. No.	Name of Examination	Marks Allotted	Remarks
1	Mini Test	10	
2	Mid Semester Test	20	
3	Assignment if any	20	
4	Tutorial if any	-	
5	Quiz if any	-	
6	Seminar, Viva voce if any	-	
7	End Semester Examination	50	
8	Experiments if any (for practical courses)	-	
9	Any other	-	

Name of Program	M. Tech. in Mechanical Engineering with Specialization in Thermal Engineering	Semester: II	Year: I

Name of Course	Thermal Engineering Lab-II
Course Code	TH24523
Core / Elective / Other	Core

Prerequisite if any:	
1.	Thermodynamics
2.	Heat Transfer
3.	Fluid Mechanics

Course Outcomes:	
1.	Analyze performance of IC Engines
2.	Understand Steam Turbine, Gas Turbine and Wind Tunnel
3.	Analyze performance of Thermal Power Plant
4.	Understand fluid flow and heat transfer processes

Description of Contents in brief:	
Exp. 1.	Determination of Heat Balance for Compression Ignition Engine
Exp. 2.	To Find Effect of Compression Ratio on I.C. Engine Performance
Exp. 3.	Determination of Isentropic Efficiency of Steam Turbine
Exp. 4.	Determination of Efficiency Enhancement in Solar Air Heater
Exp. 5.	Determination of Heat Removal Factor of Solar Water Heater
Exp. 6	Study of Cold Storage

List of Text Books:	
1.	V. Ganesan. Internal Combustion Engines, Tata McGraw-Hill, 2004
2.	R. Yadav. Steam and Gas Turbines, Central Publishing House, Allahabad, 1997
3.	P.S. Ghoshdastidar. Computer Simulation of Flow and Heat Transfer, Tata McGraw-Hill Publishing Company Limited, 1998

List of Reference Books:	
1.	John B. Heywood. Internal Combustion Engine Fundamentals, Mc Graw Hill Education, 2017
2.	Frank P. Incropera. Introduction to Heat Transfer, Wiley, 2001
3.	K. Muralidhar, T. Sundararajan. Computational Fluid Flow and Heat Transfer, Narosa Publishing House, 2003

URLs:	
1.	https://nptel.ac.in/courses/112/104/112104033/
2.	https://nptel.ac.in/courses/112/104/112104117/

Lecture Plan (about 40-50 Lectures):
It is an experimental course

Evaluation Criteria:

Sl. No.	Name of Examination	Marks Allotted	Remarks
1	Mini Test	-	
2	Mid Semester Test	-	
3	Assignment/Lab Record if any	30	
4	Tutorial if any	-	
5	Quiz if any	10	
6	Seminar, Viva voce if any	20	
7	End Semester Examination	-	
8	Experiments if any (for practical courses)	40	
9	Any other	-	

Name of Program	M. Tech. in Mechanical Engineering with Specialization in Thermal Engineering	Semester: II	Year: I

Name of Course	Computational Fluid Dynamics Lab-II
Course Code	TH24524
Core / Elective / Other	Core

Prerequisite if any:	
1.	Heat and Mass Transfer
2.	Computational Fluid Dynamics
3.	Fluid Flow & Gas Dynamics

Course Outcomes:	
1.	Able to generate multi-block structured & unstructured mesh.
2.	Develop numerical code using programming language for simple heat conduction problem.
3.	Simulate fluid flow and heat transfer analysis for laminar and turbulent flow in various geometrical configurations.

Description of Contents in brief:	
Exp. 1.	Structured mesh generation for the circular bend.
Exp. 2.	Unstructured mesh generation for complex geometry.
Exp. 3.	Fluid flow simulation in 3-D circular pipe at different Reynolds numbers.
Exp. 4.	Estimation of Nusselt number in 3-D rectangular duct.
Exp. 5.	Basic file structure of Open Source CFD software
Exp. 6	Laminar flow analysis using Open Source CFD software
Exp. 7	Write a computer program for a steady-state 1-D heat conduction problem.
Exp. 8	Write a computer program for an unsteady-state 1-D heat conduction problem.

List of Text Books:	
1.	M.Veeramanikandan and D. Satish, Computational Fluid Dynamics Laboratory Manua, CBS Publishers & Distributors, 2021.
2.	P.S. Ghoshdastidar. Computer Simulation of Flow and Heat Transfer, Tata McGraw-Hill Publishing Company Limited, 1998.

List of Reference Books:	
1.	D.A. Anderson, J.I. Tannehill, R.H. Pletcher. Computational Fluid Mechanics and Heat Transfer, Hemisphere Publishing Corporation, 2012

URLs:	
1.	https://openfoam.org/
2.	https://doc.cfd.direct/openfoam/user-guide-v11/index

Lecture Plan (about 40-50 Lectures):
It is an experimental course

Evaluation Criteria:

Sl. No.	Name of Examination	Marks Allotted	Remarks
1	Mini Test	-	
2	Mid Semester Test	-	
3	Assignment/Lab Record if any	30	
4	Tutorial if any	-	

5	Quiz if any	10	
6	Seminar, Viva voce if any	20	
7	End Semester Examination	-	
8	Experiments if any (for practical courses)	40	
9	Any other	-	

Name of Program	**M. Tech. in Mechanical Engineering with Specialization in Thermal Engineering**	**Semester: II**	**Year: I**
Name of Course	Seminar - II		
Course Code	TH24525		
Core / Elective / Other	Core		
Prerequisite if any:			
1.	Nil		
Course Outcomes:			
1.	Able to understand the pattern of research articles.		
2.	Develop a communication and presentation skills.		
Description of Contents in brief:			
1.	Students have to collect an International Journal paper on the topics of their interest, prepare a write up and present with suitable demonstration on numerical or experimental work.		
List of Text Books: Nil			
List of Reference Books: Nil			
URLs:			
1.	https://www.sciencedirect.com/		
2.	https://www.tandfonline.com/		
3.	https://www.google.com/		
Lecture Plan (about 40-50 Lectures): It is a seminar course			

Evaluation Criteria:

Sl. No.	Name of Examination	Marks Allotted	Remarks
1	Mini Test	-	
2	Mid Semester Test/Evaluation	20	
3	Assignment if any	-	
4	Tutorial if any	-	
5	Quiz if any	-	
6	Seminar, Viva voce if any	20	
7	End Semester Examination	60	
8	Experiments if any (for practical courses)	-	
9	Any other	-	

Name of Program	**M. Tech. in Mechanical Engineering with Specialization in Thermal Engineering**	**Semester: II**	**Year: I**
Name of Course	Minor Project -2 (Self Learning)		
Course Code	TH24526		
Core / Elective / Other	Core		

Prerequisite if any:	
1.	Nil
Course Outcomes:	
1.	Learn the experimental/numerical technique.
2.	Apply the fundamentals of core subjects to analyse the real engineering problem.
Description of Contents in brief:	
1.	Students will be able to extend project phase to get more insight.
List of Text Books: Nil	
List of Reference Books: Nil	
URLs:	
1.	Nil
2.	Nil
3.	Nil
Lecture Plan (about 40-50 Lectures): It is a seminar course	

Evaluation Criteria:

Sl. No.	Name of Examination	Marks Allotted	Remarks
1	Mini Test	-	
2	Mid Semester Test/Evaluation	20	
3	Assignment if any	-	
4	Tutorial if any	-	
5	Quiz if any	-	
6	Seminar, Viva voce if any	20	
7	End Semester Examination	60	
8	Experiments if any (for practical courses)	-	
9	Any other	-	

Name of Program	M. Tech. in Mechanical Engineering with Specialization in Thermal Engineering	Semester: I/II	Year: I

Name of Course	Renewable Energy
Course Code	TH24551
Core / Elective / Other	Elective

Prerequisite if any: Nil

Course Outcomes:

1.	Understanding the physics of solar radiation. Ability to classify the solar energy collectors and methodologies of storing solar energy.
2.	Knowledge in applying solar energy, wind energy and biomass with its economic aspects.
3.	Knowledge in capturing and applying other forms of energy sources like wind, biogas, geothermal, tidal, wave, small hydro etc.

Description of Contents in brief:

Unit 1.	Energy Resources and their Utilization, Types of Energy Resources, Energy Parameters, India & Global Energy Resources, Environment Aspects of Energy, Solar Radiation Geometries and Solar Radiation Measuring Instruments
Unit 2.	Solar Energy: Introduction, Solar collectors, Classification of Solar collectors, Performance Analysis of Liquid flat-plate collector, Overall loss coefficient and Heat transfer correlations, collector efficiency factor, Collector heat removal factor, Efficiency of flat plate collectors, Evacuated tube collectors, Modified flat plate collectors, Selective coatings, Solar Air heaters
Unit 3.	Solar concentrating collectors, types of concentrating collectors, thermal analysis of concentrating collectors ,Orientation and tracking modes, performance Analysis, Overall loss coefficient and Heat transfer correlations .Thermal Energy storage.
Unit 4.	Wind Energy, Origin of winds, wind turbine siting, Types of Wind turbine, Wind turbine sizing and system design, Environmental impacts of wind turbine.
Unit 5.	Other Renewable energy sources, Biomass energy, geothermal energy, Wave energy, Ocean thermal energy, Economic Analysis, Solar photovoltaic system, Solar PV Sustainability

List of Text Books:

1.	John Twidell, Tony Weir. Renewable Energy Resources, Routledge, 2015
2.	S.P. Sukhatme, J.K. Nayak. Solar Energy, McGraw Hill Education, 2017
3.	Godfrey Boyle. Renewable Energy, OUP Oxford, 2009

List of Reference Books:

1.	G.D. Rai. Non-Conventional Energy Sources, Khanna Publishers, 1999
2.	H.P. Garg, J. Prakash. Solar Energy Fundamentals and Applications, Tata McGraw Hill Education, 2000
3.	G.N. Tiwari. Solar Energy: Fundamentals, Design, Modelling and Applications, CRC Press, 2002

Lecture Plan

Lecture No.	Topic	Remarks
1	Energy Resources and their Utilization, Types of Energy Resources,	
2	Energy Parameters, India & Global Energy Resources,	
3	Instruments Environment Aspects of Energy	

4	Solar Radiation Geometries	
5	Solar Radiation Measuring	
6	Solar Energy: Introduction, Solar collectors,	
7	Classification of Solar collectors,	
8	Performance Analysis of Liquid flat-plate collector,	
9	Overall loss coefficient	
10	Heat transfer correlations	
11	collector efficiency factor,	
12	Collector heat removal factor,	
13	Efficiency of flat plate collectors,	
14	Evacuated tube collectors,	
15	Modified flat plate collectors,	
16	Selective coatings, Solar Air heaters	
17	Solar concentrating collectors,	
18	types of concentrating collectors,	
19	thermal analysis of concentrating collectors	
20	Orientation and tracking modes	
21	performance Analysis,	
22	Overall loss coefficient.	
23	Heat transfer correlations	
24	Thermal Energy storage	
25	Wind Energy, Origin of winds,	
26	wind turbine siting,	
27	Types of Wind turbine	
28	Wind turbine sizing and system design	
29	Environmental impacts of wind turbine.	
30	Other Renewable energy sources,	
31	Biomass energy,	
32	geothermal energy,	
33	Wave energy,	
34	Ocean thermal energy,	
35	Economic Analysis,	
36	Solar photovoltaic system	
37	Solar PV Sustainability	

***Min 36 (for three credit course)**

Evaluation Criteria:

Sl. No.	Name of Examination	Marks Allotted	Remarks
1	Mini Test	10	
2	Mid Semester Test	20	
3	Assignment if any	10	
4	Tutorial if any	-	
5	Quiz if any	10	
6	Seminar, Viva voce if ay	-	
7	End Semester Examination	50	

8	Experiments if any (for practical courses)	-	
9	Any other	Nil	

Name of Program	M. Tech. in Mechanical Engineering with Specialization in Thermal Engineering	Semester: I/II	Year: I

Name of Course	Refrigeration System and Component Design
Course Code	TH24552
Core / Elective / Other	Elective

Prerequisite if any:	
1.	Refrigeration and Air Conditioning
Course Outcomes:	
1.	Able to apply knowledge of refrigeration and air conditioning engineering fundamentals for solving problems
2.	Able to formulate refrigeration and air conditioning problems for different applications and to find solution using principles engineering sciences, mathematics and literature
3.	Ability to design and develop refrigeration and air conditioning component /system and processes that meets specific needs
Description of Contents in brief:	
Unit 1.	Review of basic of refrigeration machine, coefficient of performance, ton of refrigeration, various types of refrigeration systems. Basics of vapour compression refrigeration system, multi stage compression system, multi evaporator system, cascade system
Unit 2.	Various components of refrigeration system: Types of compressor, condensers, evaporators, expansion devises used for used for refrigeration system, thermal design of reciprocating compressor, principle dimensions of reciprocating compressor, performance characteristic of reciprocating compressor, capacity control of reciprocating compressor. Construction feature of rotary, screw, scroll and centrifugal compressors
Unit 3.	Thermal design of condensers: Water-cooled and air-cooled, heat rejection ratio, heat transfer in condenser, condensing heat transfer coefficient for outside and inside surfaces, Wilson's plot
Unit 4.	Thermal design of different evaporators: Direct expansion chiller, direct expansion cooling coil for air with forced convection, direct expansion etc. Extended surface evaporator, heat Transfer in evaporators, augmentation of boiling heat transfer
Unit 5.	Selection of expansion valves and other refrigerant control devices, components balancing, testing and charging methods
Unit 6.	Design of cold storages: Construction details of cold storage, storage parameters for different food items, transmission heat load, air change load and product load calculation. Construction details and application of transport refrigeration system
List of Text Books:	
1.	C.P. Arora. Refrigeration and Air Conditioning, Tata McGraw-Hill Education, 2000
2.	W.F. Stoecker. Design of Thermal Systems, McGraw Hill, 1980
3.	R.S. Khurmi. Refrigeration and Air Conditioning, S. Chand Publication, 2006
List of Reference Books:	
1.	R.J. Dossat. Principles of Refrigeration, Pearson Education India, 1996
2.	Whitman, Johnson & Tomczyk. Refrigeration and Air Conditioning Technology, Cengage Learning, 2009
3.	Hundy, Trott &Welch. Refrigeration and Air Conditioning, Butterworth-Heinemann, 2008
URLs:	
1.	https://www.ashrae.org/
2.	https://ishrae.in/

Lecture Plan (about 40-50 Lectures):		
Lecture No.	**Topic**	**Remarks**
1-6	Review of basic of refrigeration machine, coefficient of performance, ton of refrigeration, various types of refrigeration systems. Basics of vapour compression refrigeration system, multi stage compression system, multi evaporator system, cascade system	
7-10	Types of compressor, condensers, evaporators expansion devises used for used for Refrigeration system	
11-16	Principle dimensions of reciprocating compressor, performance characteristic of reciprocating compressor, capacity control of reciprocating compressor. Construction feature of rotary, screw, scroll and centrifugal compressors	
17-22	Thermal design of condensers–water-cooled and air-cooled, heat rejection ratio, heat transfer in condenser, condensing heat transfer coefficient for outside and inside surfaces. Wilson's plot	
23-28	Thermal design of different evaporators–Direct expansion chiller, direct expansion cooling coil for air with forced convection, direct expansion etc. Extended surface evaporator	
29-30	Heat transfer in evaporators. Augmentation of boiling heat transfer	
31-38	Selection of expansion valves and other refrigerant control devices, components balancing, testing and charging methods	
39-48	Design of cold storages: Construction details of cold storage, storage parameters for different food items, transmission heat load, air change load and product load calculation	
49-50	Construction details and application of transport refrigeration system	

***Min 48 (for four credit course)**

Evaluation Criteria:

Sl. No.	Name of Examination	Marks Allotted	Remarks
1	Mini Test	10	
2	Mid Semester Test	20	
3	Assignment if any	10	
4	Tutorial if any	-	
5	Quiz if any	10	
6	Seminar, Viva voce if ay	-	
7	End Semester Examination	50	
8	Experiments if any (for practical courses)	-	
9	Any other	-	

Name of Program	M. Tech. in Mechanical Engineering with Specialization in Thermal Engineering	Semester: I/II	Year: I

Name of Course	Advanced Thermodynamics
Course Code	TH24553
Core / Elective / Other	Elective

Prerequisite if any:	
1.	Thermodynamics
2.	Chemical Reactions and Chemical equilibrium
Course Outcomes:	
1.	Apply the concepts of basic thermodynamics, entropy and exergy for analysis of thermal energy systems
2.	Understand properties of pure substance and thermodynamic properties of real gases
3.	Apply energy balances to reacting systems for both closed and open system
4.	Define the chemical equilibrium constant and apply the general criteria for chemical equilibrium analysis to reacting ideal-gas mixtures
Note:	Use of Steam Tables, Molier diagram and Charts will be allowed in examination
Description of Contents in brief:	
Unit 1.	Laws of thermodynamics, and its applications to different systems, entropy and exergy, differential Equations of thermodynamics and their applications
Unit 2.	P-V-T surfaces, phase diagram, phase changes, Gibbs phase rule, various properties diagram
Unit 3.	Thermodynamic relations. Throttling process. Joule Thomson effect. Clayperon's equations
Unit 4.	Equations of states for real gases - Vander Waal's equation of state. Law of corresponding states. Mixtures of ideal & real gases
Unit 5.	Fundamentals of chemical thermodynamics, First law of thermodynamics in thermo chemistry, heat effects of reaction. Hess's law. Kirchhoff's law. Chemical equilibrium. Bond energy
List of Text Books:	
1.	Gordon Rogers, Yon Mayhew. Engineering Thermodynamics: Work and Heat Transfer, Pearson Education, 2002
2.	P.K. Nag. Basic and Applied Thermodynamics, Tata McGraw-Hill Publishing Co. Ltd., 2010
3.	Yonus A. Cengel, Michale A. Boles. Thermodynamics: An Engineering Approach, McGraw Hill, 2002
4.	A. Bejan. Advanced Engineering Thermodynamics, John Wiley & Sons, 2006
List of Reference Books:	
1.	M.J. Moran, H.N. Shapiro. Fundamentals of Engineering Thermodynamics, John Wiley and Sons, 1999
2.	M. W. Zemansky. Heat and Thermodynamics, 8th Edition, Tata Mc Graw Hill Education Private Limited, 2011
3.	Edward F. Obert. Concepts of Thermodynamics, Mc Graw Hill, 1960
4.	V. Wylen, E. Sonntag. Fundamentals of Classical Thermodynamics, 4th Edition, John Wiley and Sons,1994
5.	J.P. Holman. Thermodynamics (ISE Editions), Mc Graw-Hill Education, 1988
URLs:	
1.	www.nptel.ac.in

2.	https://swayam.gov.in/nc_details/NPTEL	
Lecture Plan (about 40-50 Lectures):		
***Lecture No.**	**Topic**	**Remarks**
1.	Equation of the first law of the thermodynamics	
2.	Application of the first law to flow & non flow system	
3.	Reversible & irreversible processes with ideal and real gases	
4.	Problems onflow & non flow system	
5.	Statement of Second law and its applications	
6.	Entropy & exergy	
7.	Thermodynamic potential functions	
8.	Availability, losses of maximum useful work	
9.	Nerst's heat theorem	
10.	Problems on Second law and availability	
11.	Problems on availability and irreversibility	
12.	Formulae of partial derivatives for internal energy	
13.	Differential equations for heat , enthalpy, entropy	
14.	Free energy and isobaric potential	
15.	Equations of heat capacities, thermal coefficients	
16.	Application of general differential equations of thermodynamics	
17.	Problems on differential equations of thermodynamics	
18.	Pure substances	
19.	Phase diagram	
20.	Phase changes	
21.	Triple point, critical point	
22.	Temperature-Entropy diagram	
23.	Enthalpy-Entropy charts	
24.	Gibbs phase rule	
25.	Problems on pure substances	
26.	Problems on pure substances	
27.	Thermodynamic relations	
28.	Throttling process	
29.	Joule Thomson effect	
30.	Clayperon's equation, Clausius Clayperon's equation	
31.	Problems on Clayperon's equations	
32.	Introduction to real gases and their deviation from ideal behaviour	
33.	Real substances & their properties	
34.	Equations of states for real gases Vander Waal's equation of state	
35.	Law of corresponding states	
36.	Compressibility chart	
37.	Problems on real gases	
38.	Introduction to mixtures of ideal & real gases	
39.	Laws regulating mixtures of ideal & real gases	
40.	Adiabatic mixing of flowing gases	
41.	Mixing of gases at constant volume	
42.	Problems on mixtures of ideal & real gases	
43.	Application of First law of thermodynamics in thermo chemistry	
44.	Heat effects of reaction	
45.	Hess's law	

46.	Kirchhoff's law	
47.	Chemical equilibrium	
48.	Bond energy	
49.	Problems on Hess's law	
50.	Problems on chemical equilibrium	

***Min 48 (for four credit course)**

Evaluation Criteria:

Sl. No.	Name of Examination	Marks Allotted	Remarks
1	Mini Test	10	
2	Mid Semester Test	20	
3	Assignment if any	10	
4	Tutorial if any	-	
5	Quiz if any	10	
6	Seminar, Viva voce if any	-	
7	End Semester Examination	50	
8	Experiments if any (for practical courses)	-	
9	Any other	-	

Name of Program	M. Tech. in Mechanical Engineering with Specialization in Thermal Engineering	Semester: I/II	Year: I

Name of Course	Theory and Design of Gas Turbines
Course Code	TH24554
Core / Elective / Other	Elective

Prerequisite if any:	
1.	Engineering Thermodynamics
2.	Turbo Machines

Course Outcomes:	
1.	To analyze gas turbines cycles
2.	To understand the working and design principles of gas turbines
3.	Design of compressor of gas turbine cycle
4.	Design of combustion chamber

Description of Contents in brief:	
Unit 1.	**Gas Turbines:** Gas turbines classification, thermodynamic analysis, open and closed cycles, cycle analysis, losses and efficiency. Introduction to codes and standards used in turbine design. Introduction to turbine testing methods
Unit 2.	**Two Dimensional Cascades:** Cascade nomenclature, lift and drag, circulation and lift, losses and efficiency, compressor and turbine cascade performance, axial compressor cascades , nominal deflection, fluid deviation
Unit 3.	**Axial Flow Compressor:** Principle of operation, velocity triangles, design procedure for single and multistage compressors. Three dimensional effect compressor performance. Description and problems of transonic and supersonic compressors
Unit 4.	**Axial Flow Turbines:** Velocity diagram, multistage turbines, stage losses and efficiency, stage reaction, diffusion within blade rows, efficiencies and characteristics, Blade design & manufacture, blade material and blade cooling, limiting factors in turbine design
Unit 5.	**Combustion Chambers:** Combustion chambers of gas turbines requirements, factors affecting design and performance, combustion process, geometry, combustion zones, combustion chamber arrangements, limiting factors in combustion chambers

List of Text Books:	
1.	R. Yadav. Steam and Gas Turbines, Central Publishing House, Allahabad, 1997
2.	V. Ganesan. Gas Turbines, McGraw Hill, 2010
3.	A.V. Arasu. Turbo Machines, Vikas Publishing House, 2013

List of Reference Books:	
1.	Meinhard T. Schobeiri. Gas Turbine Design, Components and System Design Integration, Springer, 2018
2.	H.I.H. Saravanamuttoo, G.F.C. Rogers, H. Cohen, Paul Straznicky. Gas Turbine Theory, Pearson Education Canada, 2008
3.	Gregory K. McMillan. Centrifugal and Axial Compressor Control, Momentum Press, 2010

URLs:	
1.	https://nptel.ac.in/noc/courses/noc18/SEM1/noc18-me34/
2.	https://nptel.ac.in/content/storage2/courses/112104117/ui/TOC.htm
3.	https://nptel.ac.in/courses/112/104/112104117/

Lecture Plan (about 40-50 Lectures):		
***Lecture No.**	**Topic**	**Remarks**
1-3	Gas turbines classification, thermodynamic analysis, open and closed cycles	
4-6	Cycle analysis, losses and efficiency	
7-9	Introduction to codes and standards used in turbine design	
10-11	Introduction to turbine testing methods	
12-14	Cascade nomenclature, lift and drag, circulation and lift, losses and Efficiency	
15-17	Compressor and turbine cascade performance	
18-20	Axial compressor cascades, nominal deflection, fluid deviation	
21-23	Axial compressor principle of operation, velocity triangles for axial flow Compressors	
24-26	Design procedure for single and multistage compressors	
27-28	Three dimensional effect compressor performance	
29-30	Description and problems of transonic and supersonic compressors.	
31-33	Velocity diagram of axial flow turbines, multistage turbines, stage losses and efficiency, stage reaction	
34-36	Diffusion within blade rows, efficiencies and characteristics	
37-39	Blade design & manufacture, blade material and blade cooling	
40-42	Limiting factors in turbine design	
43-45	Combustion chambers of gas turbines requirements, factors affecting design and performance	
46-48	Combustion process, geometry, combustion zones	
49-50	Combustion chamber arrangements, limiting factors in combustion chambers	

***Min 48 (for four credit course)**

Evaluation Criteria:

Sl. No.	Name of Examination	Marks Allotted	Remarks
1	Mini Test	10	
2	Mid Semester Test	20	
3	Assignment if any	20	
4	Tutorial if any	-	
5	Quiz if any	-	
6	Seminar, Viva voce if ay	-	
7	End Semester Examination	50	
8	Experiments if any (for practical courses)	-	
9	Any other	-	

Name of Program	M. Tech. in Mechanical Engineering with Specialization in Thermal Engineering	Semester: I/II	Year: I

Name of Course	Theory and Design of Turbomachines
Course code	TH24555
Core/ Elective/other	Elective

Prerequisite:	
1.	Fluid Mechanics
2.	Thermodynamics
3.	Hydraulic Machinery

Course Outcomes:	
1.	Identify the fundamental concepts of energy balance in a turbine system
2.	Integrate the fundamentals of thermodynamics into turbomachinery
3.	Demonstrate skills required for design of Turbomachines
4.	The capability to design, analyse and troubleshoot systems involving turbomachines
5.	Suggest advanced and innovative solutions for efficient turbomachines

Description of Contents in brief:	
Unit 1.	**Introduction:** The equations of motion in rotating frame of reference, Coriolis effect and centrifugal forces, momentum and energy equation, Euler equation, similarity rules and Cordier diagram, streamline theory, mass-momentum principle, circulation
Unit 2.	**Classification of impellers & diffuser:** Axial flow, radial flow and mixed flow machines, prerotation vortex theory, classification of casing, diffuser, principle and characteristics of turboblowers
Unit 3.	**Cascade Analysis:** Two-dimensional cascade theory, lift and drag, blade efficiency, estimation of loss, cascade nomenclature, compressor and turbine cascade, cascade testing and curves, losses in cascade, correlation of low speed
Unit 4.	**Axial flow Compressor:** Stage characteristics, blading efficiency, design parameters, three dimensional flow considerations, radial equilibrium design approach procedure and calculations, losses, Mach and Reynolds number
Unit 5.	**Steam turbine & Compressor:** Transonic and supersonic compressor, industrial steam turbines classification, characteristics and properties. Stresses in discs and blades-Interstage traversing, total pressure, static pressure, vane angles, turbine performance

List of Text Books:	
1.	Budugur Lakshminarayana. Fluid Dynamics and Heat Transfer of Turbomachinery, Wiley Interscience, 1995
2.	E.J. Finnemore, J.B. Franzini. Fluid Mechanics with Engineering Applications, 10th Edition, McGraw Hill, 2002

List of Reference Books	
1.	D.G. Wilson. The Design of High-Efficiency Turbomachinery and Gas Turbines, MIT Press, 1984
2.	Earl Logan, Marcel Dekker. Turbomachinery, Basic Theory and Applications, Marcel Dekker, Inc., New York, 1993
3.	O.E. Balje. Turbomachines: A Guide to Design, Selection and Theory, John Wiley & Sons, 1981

4.	Gorla, S.R. Rama, Aijaz A. Khan. Turbomachinery: Design and Theory, CRC Press, 2003
5.	Dixon, S. Larry, Cesare Hall. Fluid mechanics and Thermodynamics of Turbomachinery, Butterworth-Heinemann, 2013
URLs	
1.	http://www.cementechnology.ir/Library/Turbomachinery.Design.and.Theory.pdf

Lecture Plan (about 40-50 Lectures):

Lecture No.	Topic	Remarks
1-5	**Introduction:** Equations of motion, Coriolis effect and centrifugal forces, momentum and energy equation, similarity rules and Cordier diagram	
6-8	**Equations:** Euler equation, streamline theory, mass-momentum principle, Circulation	
9-16	**Impellers:** Classification of impellers, axial flow, radial flow and mixed flow machines, prerotation, vortex theory, classification of casing	
17-20	**Diffuser:** Diffuser, principle and characteristics of turboblowers	
21-25	**Cascade Analysis:** Two-dimensional cascade theory, lift and drag, blade efficiency, estimation of loss, cascade nomenclature, compressor and turbine cascade	
26-28	**Cascade Testing:** Cascade testing and curves, losses in cascade, correlation of low speed	
29-33	**Axial Flow Compressor:** Stage characteristics, blading efficiency, design parameters, three dimensional flow considerations	
34-40	**Design of Axial flow Compressor:** Radial equilibrium design approach procedure and calculations, losses, Mach and Reynolds number	
41-44	**Steam Turbine and Compressor:** Transonic and supersonic compressor, industrial steam turbines classification, characteristics and properties	
45-48	**Steam Turbine and Compressor:** Stresses in discs and blades- interstage traversing, total pressure, static pressure, vane angles, turbine performance	

***Min 48 (for four credit course)**

Evaluation Criteria:

Sl. No.	Name of Examination	Marks Allotted	Remarks
1	Mini Test	10	
2	Mid Semester Test	20	
3	Assignment if any	20	
4	Tutorial if any	-	
5	Quiz if any	-	
6	Seminar, Viva voce if ay	-	
7	End Semester Examination	50	
8	Experiments if any (for practical courses)	-	
9	Any other	-	

Name of Program	M. Tech. in Mechanical Engineering with Specialization in Thermal Engineering	Semester: I/II	Year: I
Name of Course	Design and Simulation of IC Engines		
Course Code	TH24556		
Core / Elective / Other	Elective		

Prerequisite if any:	
1.	Thermal Engineering (Basic Internal Combustion Engines)
2.	Computational Fluid Dynamics
Course Outcomes:	
1.	Identify and assess the fundamentals of internal combustion system.
2.	Integrate the fundamentals of thermodynamics into heat engines
3.	Demonstrate skills required for design of internal combustion systems
4.	Prepare simulation of the designed models with respective to boundary conditions
5.	Suggest advanced and innovative models for optimized and efficient combustion
Description of Contents in brief:	
Unit 1.	First and second laws of thermodynamics, estimation of properties of gas mixtures, structure of engine models – Otto, Diesel and Dual Cycle studies
Unit 2.	Chemical reactions, first law application to combustion, heat of combustion, adiabatic flame temperature, chemical equilibrium and calculation of equilibrium composition, heat transfer in engines, heat transfer models for engines
Unit 3.	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
Unit 4.	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.
Unit 5.	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.
List of Text Books:	
1.	V. Ganesan. Computer Simulation of Spark Ignition Engine Processes, Universities Press, 1995
2.	Ashley S. Campbell. Thermodynamic Analysis of Combustion Engines, John Wiley and Sons, 1980
List of Reference Books:	
1.	Ashley S. Campbell. Thermodynamic Analysis of Combustion Engines, John Wiley and Sons, 1980
2.	V. Ganesan. Computer Simulation of Spark Ignition Engine Processes, Universities Press, 1995
3.	V.Ganesan. Computer Simulation of Compression Ignition Engine Processes, Universities Press, 2002
4.	Gordon P. Blair. The Basic Design of Two-Stroke Engines, SAE Publications, 1990
5.	J.I. Ramos. Internal Combustion Engine Modeling, Hemisphere Publishing Corporation, 1989
6.	Horlock and Winterbone. The Thermodynamics and Gas Dynamics of Internal Combustion Engines, Vol. I & II, Clarendon Press, 1986
7.	J.N.Mattavi and C.A. Amann. Combustion Modeling in Reciprocating Engines, Plenum Press, 1980

URLs:	
1.	http://www.dragonfly75.com/motorbike/2StrokeDesign.pdf

Lecture Plan (about 40-50 Lectures):

*Lecture No.	Topic	Remarks
1-5	Introduction: First and second laws of thermodynamics, estimation of properties of gas mixtures	
6-8	Cycle studies: Structure of engine models – Otto, Diesel and Dual Cycle Studies	
9-14	Chemical studies: Chemical Reactions, first law application to combustion, heat of combustion, adiabatic flame temperature, chemical equilibrium and calculation of equilibrium composition	
15-20	Heat transfer: Heat transfer in engines, heat transfer models for engines	
21-25	Combustion in SI engines, flame propagation and velocity, single zone models, multi zone models, mass burning rate	
26-30	Combustion in SI: Turbulence models, one dimensional models, chemical kinetics modelling, multidimensional models	
31-35	Combustion in CI engines, single zone models, premixed, diffusive models, Wiebe' model, Whitehouse way model	
36-40	Combustion in CI: Two zone models, multizone models, Meguerdichian and Watson's model, Hiroyasu's model, Lyn's model. Introduction to multidimensional and spray modelling.	
41-44	Flow through engine manifold: Thermodynamics of the gas exchange process, flows in engine manifolds, one dimensional and multidimensional models, flow around valves	
45-48	Flow through ports, models for scavenging in two stroke engines, isothermal and non-isothermal models	

***Min 48 (for four credit course)**

Evaluation Criteria:

Sl. No.	Name of Examination	Marks Allotted	Remarks
1	Mini Test	10	
2	Mid Semester Test	20	
3	Assignment if any	20	
4	Tutorial if any	-	
5	Quiz if any	-	
6	Seminar, Viva voce if ay	-	
7	End Semester Examination	50	
8	Experiments if any (for practical courses)	-	
9	Any other	-	

Name of Program	M. Tech. in Mechanical Engineering with Specialization in Thermal Engineering	Semester: I/II	Year: I
Name of Course	Advanced Fluid Mechanics		
Course Code	TH24557		
Core / Elective / Other	Elective		

Prerequisite if any:	
1.	Fluid Mechanics
Course Outcomes:	
1.	Students will able to understand the conservation principle of mass, momentum and energy for fluid flow.
2.	Students will be able to obtain the exact analytical solution using N-S equation.
3.	Students will be able to apply the principles of fluid mechanics to solve engineering problems and to design systems.
4.	Student will apply the numerical techniques for boundary-layer equations.
Description of Contents in brief:	
Unit 1.	**Introduction:** Definition of continuum, Lagrangian and Eulerian Approach, types of flow, streamline, path line, streak line, material derivative and acceleration, angular deformation of fluid Element, vorticity and stream function, velocity potential
Unit 2.	**Fundamental equation of viscous flow:** Derivation of continuity, Navier-Stokes and energy equations, initial and boundary conditions, exact solutions of Navier-Stokes Equations, Couette flow, Hagen-Poiseuille flow, Stokes problems, creeping flows, theory of lubrications
Unit 3.	**Boundary Layer Theory:** Introduction, boundary layer equations, flow over a flat plate, boundary layer with pressure gradient, momentum-integral approach, boundary layer separation, approximate methods for boundary-layer equations
Unit 4.	**Turbulent Flow:** Introduction to turbulent flows, features of turbulence, mean and fluctuating components, derivations of Reynolds averaged Navier-Stokes equations, turbulent boundary layer equations, eddy viscosity and mixing length hypothesis.
Unit 5.	**Compressible flow:** Introduction, one dimensional compressible flow, compressible flow in nozzle, origin of shock in supersonic flow, normal shock relations, oblique shock
List of Text Books:	
1.	*Pijush K. Kundu, Ira M. Cohen, David R. Dowling.* Fluid Mechanics,*Academic Press, 2015*
2.	*Frank M. White.* Fluid Mechanics,*McGraw-Hill Education, 2015*
3.	R.W. Fox, A.T. McDonald. Introduction to Fluid Mechanics, John Wiley & Sons, 2011
4.	S.W. Yuan. Foundations of Fluid Mechanics, Prentice Hall of India, 1970
List of Reference Books:	
1.	Frank M. White. Viscous Fluid Flow,*McGraw Hill Education, 2005*
2.	*H. Schlichting.*Boundary Layer Theory, *McGraw Hill Education, 1979*
3.	H. Tennekes, John L. Lumley. A First Course in Turbulence, M.I.T. Press, 1972
4.	K. Muralidhar, G. Biswas. Advanced Engineering Fluid Mechanics, Alpha Science International Limited, 2005
URLs:	
1.	https://nptel.ac.in/courses/112/105/112105218/
2.	https://nptel.ac.in/courses/112/105/112105287/

3.	http://web.iitd.ac.in/~pmvs/course_mcl702.php	
Lecture Plan (about 40-50 Lectures):		
***Lecture No.**	**Topic**	**Remarks**
1	Review of fundamental of fluid mechanics	
2	Demonstration on various application of fluid mechanics	
3	Types of flows, Lagrangian and Eulerian approach	
4	Material derivative and acceleration	
5	Streamline, path line and streak line	
6	Strain rate, translation, rotation and distortion of fluid element	
7	Vorticity and stream function, velocity potential	
8	Derivation of conservation of mass equation- differential method and control volume method	
9	Derivation of conservation of mass equation- control volume method	
10	Derivation of Navier-Stokes equations	
11	Special form of Navier-Stokes equations	
12	Derivation of energy equation	
13	Initial and boundary conditions	
14	Fully developed flow in a straight channel	
15	Fully developed flow in power-law fluid	
16	Couette flow and Hagen-Poiseuille flow	
17	Lubrication theory	
18	Unsteady flow in a long tube	
19	Stokes 1^{st} problem	
20	Stokes 2^{nd} problem	
21	Creeping flow	
22	Problems	
23	Introduction to boundary layer theory	
24	Derivation of 2-D boundary layer equations	
25	Similarity solution for flow over flat plate	
26	Momentum-Integral equation for boundary	
27	Boundary layer separation	
28	Blassius solution of boundary layer equation	
29	Kármán-Pohlhausen method for flow over plate	
30	Kármán-Pohlhausen method for non-zero pressure gradient	
31	Entry flow in a duct	
32	Numerical method for boundary-layer equations	
33	Problems solving session	
34	Introduction to turbulent flow and engineering applications	
35	Characteristics of turbulent flow	
36	Time mean motions and fluctuations	
37	Derivations of governing equations for turbulent flow	
38	Prandtl mixing length hypothesis	
39	k-ε model of turbulence	
40	Flat plate turbulent boundary layer	
41	Problems	
42	Introduction to compressible flow with example	
43	Speed of sound and isentropic gas relations	
44	Compressible flow in nozzle: Area-velocity relations	
45	Convergent divergent nozzle and velocity measurement using pitot tube	
46	Origin of shock in supersonic flow	

47	Normal shock and oblique shock	
48	Problems	

***Min 48 (for four credit course)**

Evaluation Criteria:

Sl. No.	Name of Examination	Marks Allotted	Remarks
1	Mini Test	10	
2	Mid Semester Test	20	
3	Assignment if any	10	
4	Tutorial if any	-	
5	Quiz if any	05	
6	Seminar, Viva voce if any	05	
7	End Semester Examination	50	
8	Experiments if any (for practical courses)	-	
9	Any other	-	

Name of Program	M. Tech. in Mechanical Engineering with Specialization in Thermal Engineering	Semester: I/II	Year: I

Name of Course	Microfluidics
Course Code	TH24558
Core / Elective / Other	Elective

Prerequisite if any:	
1.	Fluid Mechanics

Course Outcomes:	
1.	The student will understand the physics involved in gas and liquid flow in microchannels.
2.	The student will able to analyze the problems of gas and liquid flows in microchannels.
3.	The student will able to design the microchannel system.

Description of Contents in brief:	
Unit 1.	**Introduction:** Origin, definition, benefits, challenges, applications, physics of miniaturization, scaling laws, conservation of mass, momentum, energy and species conservation equation, boundary conditions
Unit 2.	**Pressure-Driven Microflows**: Fully developed flow, Hagen-Poiseuille flow, low Reynolds hydrodynamics, Stokes problem, unsteady flows, Stokes drag on sphere
Unit 3.	**Capillary flows:** Surface tension and interfacial energy, contact angle, capillary length and capillary rise, interfacial boundary conditions, Marangoni effect
Unit 4.	**Electrokinetics:** Electrokinetic effects, electroosmosis, dielectrophoresis, magnetophoresis
Unit 5.	**Microfabrication Technique:** Materials, clean room, silicon crystallography, photolithography - mask, spin coating, exposure and development, etching, bulk and surface micromachining, polymer microfabrication, PMMA/COC/PDMS substrates, micro-molding, hot embossing, fluidic interconnections
Unit 6.	**Biomicrofluidics:** An introduction to bio-microfluidics, and some applications computational modelling of micro-flows: MD and DSMC methods

List of Text Books:	
1.	P. Tabeling. *Introduction to Microfluidics*, Oxford University Press Inc., 2005
2.	N.T. Nguyen, S.T. Werely. *Fundamentals and Applications of Microfluidics*, Artech House Inc., 2002
3.	S. Colin. *Microfluidics*, John Wiley & Sons, 2009

List of Reference Books:	
1.	M.J. Madou. *Fundamentals of Microfabrication*, CRC press, 2002
2.	H. Bruus. *Theoretical Microfluidics*, Oxford University Press Inc., 2008

URLs:	
1.	https://nptel.ac.in/courses/112/105/112105187/
2.	https://nptel.ac.in/courses/112/106/112106169/
3.	https://canvas.harvard.edu/courses/8157/assignments/syllabus

Lecture Plan (about 40-50 Lectures):

*Lecture No.	Topic	Remarks
1.	Introduction to microfluidics	
2.	Applications	
3.	Scaling Laws	

4.	Conservation of mass	
5.	Navier-Stoke equations	
6.	Derivation of Navier-Stokes equation	
7.	Energy equation	
8.	Species conservation equation	
9.	Flow driven by pressure gradient	
10.	Fully developed flow between two parallel plates	
11.	Hagen-Poiseuille flow	
12.	Low Reynolds hydrodynamics	
13.	Unsteady flows	
14.	Stokes 1st Problem	
15.	Stokes 2nd Problem	
16.	Stokes drag on sphere	
17.	Surface driven flows	
18.	Young Laplace equation	
19.	Contact angle: Interpretation of Young law	
20.	Capillary rise and pump	
21.	Interfacial boundary conditions	
22.	Marangoni effect	
23.	Problem solving session	
24.	Fundamental of electrohydrodynamic	
25.	The Debye layer	
26.	Electric double layer	
27.	Ideal electroosmotic flow	
28.	Electroosmotic flow with back pressure	
29.	The cascade electroosmotic pump	
30.	Electrophoresis of particle	
31.	Electrophoretic velocity dependence on particle size	
32.	Dielectrophoresis	
33.	Induced polarization and dielectric forces	
34.	Point dipole in a dielectric fluid	
35.	The dielectrophoretic forces on a dielectric sphere	
36.	Dielectric particle tracking	
37.	Magnetostatics	
38.	Basic equation for magnetophoresis	
39.	Material used in the microfabrication	
40.	Photolithography- mask and spin coating, exposure	
41.	Etching and resists stripping	
42.	Bulk and surface micromachining	
43.	Polymer microfabrication	
44.	PMMA/COC/PDMS substrates, micro-molding	
45.	Hot embossing, fluidic interconnections	
46.	Microfluidics components	
47.	Introduction to Biomicrofluidics	
48.	Drug Delivery, Diagnostics, and Bio Sensing	
49.	Scope of computational modelling in microflows	

***Min 48 (for four credit course)**

Evaluation Criteria:

Sl. No.	Name of Examination	Marks Allotted	Remarks
1	Mini Test	10	
2	Mid Semester Test	20	
3	Assignment if any	05	
4	Tutorial if any	-	
5	Quiz if any	05	
6	Seminar, Viva voce if any	10	
7	End Semester Examination	50	
8	Experiments if any (for practical courses)	-	
9	Any other	-	

Name of Program	M. Tech. in Mechanical Engineering with Specialization in Thermal Engineering	Semester: I/II	Year: I

Name of Course	Convective Heat & Mass Transfer
Course Code	TH24559
Core / Elective / Other	Elective

Prerequisite if any:	
1.	Fluid Mechanics
2.	Heat Transfer

Course Outcomes:	
1.	Able to apply knowledge of mathematics, science and engineering fundamentals for solving mechanical engineering problems
2.	Able to formulate mechanical engineering problems and to find solution using principles engineering sciences, mathematics and literature
3.	Ability to synthesis the information, analysis and interpretation of data to find valid conclusion of the problem

Description of Contents in brief:	
Unit 1.	**Governing Equations:** Continuity, momentum and energy equations and their derivations in different coordinate systems, boundary layer approximations to momentum and energy
Unit 2.	**Laminar External Flow and Heat Transfer:** (a) Similarity solutions for flat plate (Blasius solution), flows with pressure gradient (Falkner-Skan and Eckert solutions), and flow with transpiration (b) Integral method solutions for flow over aniso-thermal flat plate, flat plate with constant heat flux and with varying surface temperature (Duhamel's method), flows with pressure gradient (von Karman-Pohlhausen method)
Unit 3.	**Laminar Internal Flow and Heat Transfer:** (a) 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 (b) Integral method for internal flows with different wall boundary conditions
Unit 4.	**Natural Convection Heat Transfer:** Governing equations fornatural convection, Boussinesq approximation, dimensional analysis, similarity solutions for laminar flow past a vertical plate with constant wall temperature and heat flux conditions, integral method for natural convection flow past vertical plate, effects of inclination, natural convection in enclosures, mixed convection heat transfer past vertical plate and in enclosures
Unit 5.	**Turbulent Convection:** Governing equations for averaged turbulent flow field (RANS), analogies between heat and mass transfer (Reynolds, Prandtl-Taylor and Von Karman Analogies), turbulence models (zero, one and two equation models), turbulent flow and heat transfer across flat plate and circular tube, turbulent natural convection heat transfer, empirical correlations for different configurations
Unit 6.	**Convective Heat Transfer through Porous Media:** Area weighted velocity, Darcy flow model, energy equation, boundary layer solutions for 2-D forced convection, fully developed duct flow, natural convection in porous media, filled enclosures, stability of horizontal porous Layers

List of Text Books:	
1.	W. Kays, M. Crawford, B. Weigand. Convective Heat and Mass Transfer, 4th Edition, McGraw Hill International, 2005

2.	S. Kakac and Y.Yener. Convective Heat Transfer, 2nd Edition, CRC Press, 1995
3.	A. Bejan. Convection Heat Transfer, 3rd Edition, JohnWiley, 2004
List of Reference Books:	
1.	H. Schlichting, K. Gersten. Boundary Layer Theory, 8th Edition, Springer-Verlag, 2000
2.	F.P. Incropera, D. Dewitt. Fundamentals of Heat and Mass Transfer, 7th Edition, John Wiley, 2011
URLs:	
1.	http://www.nptel.ac.in
2.	https://swayam.gov.inResearch

Lecture Plan (about 40-50 Lectures):

*Lecture No.	Topic	Remarks
1.	Introduction to convective heat transfer	
2.	Governing equations	
3.	Continuity, momentum and energy equations	
4.	Derivations of continuity, momentum and energy equations cartesian coordinate systems	
5.	Derivations of continuity, momentum and energy equations cylindrical coordinate systems	
6.	Derivations of continuity, momentum and energy equations spherical coordinate systems	
7.	Boundary layer approximations to momentum and energy	
8.	Tutorial problems	
9.	Laminar external flow and heat transfer	
10.	Similarity solutions for flat plate (Blasius solution),	
11.	Introduction to flows with pressure gradient	
12.	Flows with pressure gradient (Falkner-Skan solutions)	
13.	Flows with pressure gradient (Eckert solutions)	
14.	Flow with transpiration	
15.	Integral method solutions for flow over aniso-thermal flat plate	
16.	Flat plate with constant heat flux and with varying surface temperature (Duhamel's method)	
17.	Flows with pressure gradient (Von Karman-Pohlhausen method)	
18.	Tutorial Problems	
19.	Laminar internal flow and heat transfer	
20.	Exact solutions to N-S equations for flow through channels	
21.	Exact solutions to N-S equations for flow through circular pipe	
22.	Fully developed forced convection in pipes with different wall boundary Conditions	
23.	Forced convection in the thermal entrance region of ducts and channels (Graetz solution)	
24.	Heat transfer in the combined entrance region	
25.	Integral method for internal flows with different wall boundary conditions	
26.	Tutorial Problems	
27.	Natural Convection heat transfer	
28.	Governing equations fornatural convection	
29.	Boussinesq approximation	
30.	Dimensional Analysis	
31.	Similarity solutions for laminar flow past a vertical plate with constant wall temperature conditions	

32.	Similarity solutions for laminar flow past a vertical plate with constant heat flux conditions	
33.	Integral method for natural convection flow past vertical plate	
34.	Effects of inclination	
35.	Natural convection in enclosures	
36.	Mixed convection heat transfer past vertical plate and in enclosures	
37.	Tutorial Problems	
38.	Turbulent convection: Governing equations for averaged turbulent flow field (RANS)	
39.	Analogies between heat and mass transfer (Reynolds, Prandtl-Taylor and Von Karman analogies)	
40.	Turbulence models (zero, one and two equation models)	
41.	Turbulent flow and heat transfer across flat plate and circular tube	
42.	Turbulent natural convection heat transfer	
43.	Empirical correlations for different configurations	
44.	Tutorial Problems	
45.	Convective heat transfer through porous media: Introduction	
46.	Area weighted velocity – Darcy flow model	
47.	Energy equation – boundary layer solutions for 2-D forced convection	
48.	Fully developed duct flow – Natural convection in porous media – filled Enclosures	
49.	Stability of horizontal porous layers.	
50.	Tutorial Problems	

***Min 48 (for four credit course)**

Evaluation Criteria:

Sl. No.	Name of Examination	Marks Allotted	Remarks
1	Mini Test	10	
2	Mid Semester Test	20	
3	Assignment if any	20	
4	Tutorial if any	-	
5	Quiz if any	-	
6	Seminar, Viva voce if ay	-	
7	End Semester Examination	50	
8	Experiments if any (for practical courses)	-	
9	Any other	-	

Name of Program	M. Tech. in Mechanical Engineering with Specialization in Thermal Engineering	Semester: I/II	Year: I

Name of Course	Instrumentation for Thermal Engineering
Course Code	TH24560
Core / Elective / Other	Elective

Prerequisite if any: Nil

Course Outcomes:

1.	Identify and select proper measuring instrument for specific application
2.	Illustration working principle of measuring instruments, Explain calibration methodology and error analysis related to measuring instruments
3.	Mathematically model and analyze system/process for standard input responses

Description of Contents in brief:

Unit 1.	Fundamentals of Mechanical Measurement**,** Introduction, Significance of mechanical measurement, Methods of measurements, Generalized measuring system, measurement standards, calibration, uncertainty.
Unit 2.	Measurements characteristics, Instruments classification, characteristics of instrument- static and dynamic, Error analysis, Accuracy and precision, Statistical analysis.
Unit 3.	Temperature measurement : Introduction, Classification of Temperature Measuring Devices, Liquid in glass, Thermometer, Pressure Gauge thermometer, Bimetal temperature sensing element, Thermocouples, Temperature measurement errors.
Unit 4.	Pressure measurement : Introduction, Types of pressure measurement devices, Manometers, Dynamic response of manometer, Bourdon tube, Additional pressure transducers, Calibration methods.
Unit 5.	Measurement of velocity & flow, Data acquisition system, Hot wire, Anemometer.

List of Text Books:

1.	Ernest O. Doebelin. Measurement Systems: Application and Design, McGraw Hill, 2003
2.	A.K. Sawhney, PuneetSawhney. A Course in Mechanical Measurements and Instrumentation & Control, DhanpatRai& Co., 2013
3.	Thomas G. Beckwith, Roy D. Marangoini, John H. Lienhard. Mechanical Measurements, Pearson, 1993

List of Reference Books:

1.	Chennakesava R. Alawala. Principles of Industrial Instrumentation and Control Systems, Cengage Learning Asia, 2009
2.	Jack Holman. Experimental Methods for Engineers, McGraw-Hill Education, 2011
3.	William Bolton. Instrumentation and Control Systems, Newnes, 2004

URLs:

1.	https://nptel.ac.in/courses/112/107/112107242/
2.	https://nptel.ac.in/courses/112/106/112106139/

Lecture Plan (about 40-50 Lectures):

Lecture No.	Topic	Remarks

1	Fundamentals of Mechanical Measurement**,**	
2	Introduction, Significance of mechanical measurement,	
3	Methods of measurements,	
4	Generalized measuring system,	
5	measurement standards,	
6	calibration,	
7	uncertainty.	
8	Measurements characteristics	
9	Instruments classification,	
10	characteristics of instrument- static	
11	characteristics of instrument- dynamic,	
12	Error analysis,	
13	Accuracy	
14	precision,	
15	Statistical analysis.	
16	Temperature: Introduction	
17	Temperature measurement	
18	Classification of Temperature Measuring Devices	
19	Thermometer	
20	Liquid in glass Thermometer	
21	Pressure Gauge thermometer,	
22	Bimetal temperature sensing element,	
23	Thermocouples,	
24	Temperature measurement errors.	
25	Pressure measurement	
26	Introduction	
27	Types of pressure measurement devices	
28	Manometers,	
29	Dynamic response of manometer,	
30	Bourdon tube,	
31	Additional pressure transducers,	
32	Calibration methods.	
33	Measurement of velocity.	
34	Measurement of flow,	
35	Data acquisition system,	
36	Hot wire, Anemometer.	

***Min 36 (for three credit course)**

Evaluation Criteria:

Sl. No.	Name of Examination	Marks Allotted	Remarks
1	Mini Test	10	
2	Mid Semester Test	20	
3	Assignment if any	10	

4	Tutorial if any	-	
5	Quiz if any	10	
6	Seminar, Viva voce if ay	-	
7	End Semester Examination	50	
8	Experiments if any (for practical courses)	-	
9	Any other	-	

Name of Program	**M. Tech. in Mechanical Engineering with Specialization in Thermal Engineering**	**Semester: I/II**	**Year: I**

Name of Course	Advanced Computational Fluid Dynamics
Course Code	TH24561
Core / Elective / Other	Elective

Prerequisite if any:	
1.	Fluid Flow & Gas Dynamics
2.	Engineering Mathematics
3.	Advance Heat Transfer

Course Outcomes:	
1.	Understand the different iterative methods used in CFD
2.	Analyses the turbulent phenomenon using different models.
3.	Apply CFD approaches to the analysis of complex fluid flows.

Description of Contents in brief:	
Unit 1.	Governing equations in fluid dynamics; Compact and explicit convection schemes; Linear iterative solver – introduction to Conjugate Gradient method, Geometric multigrid technique
Unit 2.	Structured Grid generation - algebraic methods, elliptic techniques; Finite difference technique - Convection-diffusion equation, Projection method, coordinate transformation.
Unit 3.	Finite volume method - integral approximations, flows in simple and complex geometries, introduction to unstructured grid computations
Unit 4.	Parallel computations - Need for vectorization, domain decomposition technique, MPI Libraries
Unit 5.	Introduction to Turbulent flow computations – ideas behind Direct Numerical Simulation (DNS), Large Eddy Simulation (LES) and turbulence modeling.

List of Text Books:	
1.	J. C. Tannehill, D. A. Anderson and R. H. Pletcher, *Computational Fluid Mechanics and Heat Transfer*, Taylor & Francis, 1997.
2.	J. H. Ferziger and M. Peric, *Computational Methods for Fluid Dynamics*, Springer 2002.
3.	J. D. Anderson Jr, *Computational Fluid Dynamics*, McGraw-Hill International Edition, 1995.

List of Reference Books:	
1.	K.Muralidhar and T. Sundararajan, *Computational Fluid Flow and Heat Transfer*, Narosa Publishing House, 1995.
2.	Tapan K. Sengupta, *Fundamentals of Computational Fluid Dynamics*, Universities Press, 2004.
3.	S. V. Patankar, *Numerical Heat Transfer and Fluid Flow*, Hemisphere, 2000.

URLs:	
1.	https://nptel.ac.in/courses/112105045

Lecture Plan (about 40-50 Lectures):

***Lecture No.**	**Topic**	**Remarks**
1.	Introduction and application of CFD	
2.	Mass conservation equations	
3.& 4.	Momentum equation	

5. & 6.	Energy equation	
7.	Initial and boundary condition	
8.	Solution of Simultaneous Equations: point iterative/block iterative Methods	
9.	Gauss-Seidel iteration (concept of central coefficient and residue, SOR), CGS, Bi-CGSTAB and GMRES (m) matrix solvers, different acceleration techniques.	
10.		
11.	Finite difference technique-convection-diffusion equation	
12.	Projection method and coordinate transformation	
13.	Fundamental of finite volume method	
14.	Flows in simple and complex geometries, introduction to unstructured grid computations	
15 - 17.	Body fitted grids in complex geometries, orthogonal grids, mapping functions, staggered/collocated and structured/unstructured, various method of grid generations	
18. & 19.	Sources of uncertainties, studies on grid independence, time-step independence, domain independence, initial condition dependence.	
20. & 21.	Discussion on SIMPLE/SIMPLER	
22.	Discretization of governing equations and boundary conditions in FVM Framework	
23.	Introduction to parallel computation and need of parallel computation	
24.	Need for vectorization	
25.	Domain decomposition technique	
26.	MPI libraries	
27.	Solution of Euler equation	
28. & 29.	MacCormack, Jameson algorithm in finite volume formulation and transformed coordinate system.	
30.	Introduction to turbulence and scales of turbulence,	
31.	Reynolds Averaged Navier Stokes (RANS) equation,	
32. & 33.	Eddy viscosity model, k-ε and k-ω model	
34.	Introduction to large eddy simulation (LES)	
35.	Direct numerical simulation (DNS)	

Evaluation Criteria:

Sl. No.	Name of Examination	Marks Allotted	Remarks
1	Mini Test	10	
2	Mid Semester Test	20	
3	Assignment if any	20	
4	Tutorial if any	--	
5	Quiz if any	--	
6	Seminar, Viva voce if any	--	
7	End Semester Examination	50	
8	Experiments if any (for practical courses)	--	
9	Any other	--	

Name of Program	**M. Tech. in Mechanical Engineering with Specialization in Thermal Engineering**	**Semester: I/II**	**Year: I**

Name of Course	Design of Thermal Systems
Course Code	TH24562
Core / Elective / Other	Elective

Prerequisite if any:	
1.	Heat and Mass Transfer, Fluid Mechanics, Turbo Machines
2.	Thermodynamics, Refrigeration and Air conditioning, Mathematics

Course Outcomes:	
1.	Understand the basics steps in designing for thermal systems
2.	To make model of thermal systems and study various types of model and interaction between Them
3.	To generate numerical modelling for thermal systems and methods of simulation
4.	Optimization techniques used in design
5.	Economic analysis in the context of thermal system design

Description of Contents in brief:	
Unit 1.	Introduction to engineering design, thermal systems, basic considerations in design, conceptual design, steps in the design process, computer-aided design of thermal systems, material selection, properties and characteristics for thermal systems
Unit 2.	Modelling of thermal systems, types of models, interaction between models, mathematical modelling, physical modelling and dimensional analysis, curve fitting
Unit 3.	Numerical modelling and simulation, solution procedure, numerical model for a system, system simulation, methods for numerical simulation. Successive substitution method-examples. Newton Raphson method-One unknown/ multiple unknowns. Gauss Seidel Method-Examples. Rudiments of finite difference method for partial differential equations with an example
Unit 4.	Optimization in design, basic concepts, mathematical formulation, optimization methods, calculus methods Lagrange multiplier method-proof, examples. Search methods-concept of interval of uncertainty, reduction ratio, reduction ratios of simple search techniques like exhaustive search, dichotomous search, fibonacci search and golden section search-numerical examples, optimization of thermal systems, optimization of unconstrained problems, conversion of constrained to unconstrained, optimization of constrained problems
Unit 5.	Economic consideration, Introduction, calculation of interest, worth of money as a function of time, series of payments, raising capital, economic factor in design, cost comparision, rate of return, application to thermal systems

List of Text Books:	
1.	Yogesh Jaluria. Design and Optimization of Thermal Systems, CRC Press, 2nd Edition, 2008
2.	W.F. Stoecker. Design of Thermal Systems, 3rd Edition, McGraw Hill, 1989
3.	Robert F. Boehm. Design Analysis of Thermal Systems, Willey, 1987
4.	Kalyanmoy Deb. Optimization for Engineering Design, PHI, 2012

List of Reference Books:	
1.	Adrian Bejan, George Tsatsaronis, Michel Moral. Thermal Design and Optimization, 1st Edition, John Wiley and Sons, 1996
2.	I.J. Nagrath, M. Gopal. Systems Modeling and Analysis, Tata McGraw Hill, 1986

3.	D.J. Wide. Globally Optimal Design, Wiley Interscience, 1978
URLs:	
1.	www.nptel.ac.in
2.	https://swayam.gov.in/nc_details/NPTEL

Lecture Plan (about 40-50 Lectures):

*Lecture No.	Topic	Remarks
1.	Introduction to engineering design	
2.	Introduction to engineering design	
3.	Basic considerations in design	
4.	Conceptual design	
5.	Steps in the design process	
6.	Thermal systems	
7.	Computer-aided design of thermal systems	
8.	Material selection	
9.	Properties and characteristics for thermal systems	
10.	Modelling of thermal systems	
11.	Types of models	
12.	Types of models	
13.	Interaction between models	
14.	Mathematical modeling	
15.	Mathematical modeling	
16.	Mathematical modeling	
17.	Physical modeling	
18.	Physical modeling	
19.	Dimensional analysis	
20.	Curve fitting	
21.	Numerical modelling and simulation	
22.	Numerical modelling and simulation	
23.	Solution procedure	
24.	Numerical model for a system	
25.	System simulation	
26.	Methods for numerical simulation	
27.	Successive substitution method - Newton Raphson method - one unknown / multiple unknowns.	
28.	Gauss Seidel method - examples	
29.	Rudiments of finite difference method for partial differential equations, with an example	
30.	Rudiments of finite difference method for partial differential equations, with an example	
31.	Optimization in design	
32.	Basic concepts	
33.	Mathematical formulation	
34.	Optimization methods	
35.	Optimization methods	
36.	Calculus methods: Lagrange multiplier method – proof, examples	
37.	Search methods: Concept of interval of uncertainty, reduction ratio, reduction ratios of simple search techniques	
38.	Exhaustive search, dichotomous search-numerical examples	
39.	Fibonacci search and golden section search – numerical examples.	

40.	Optimization of thermal systems	
41.	Optimization of unconstrained problems	
42.	Conversion of constrained to unconstrained	
43.	Economic consideration introduction	
44.	Calculation of interest	
45.	Worth of money as a function of time	
46.	Series of payments	
47.	Raising capital	
48.	Economic factor in design	
49.	Cost comparison, rate of return	
50.	Application to thermal systems	

***Min 48 (for four credit course)**

Evaluation Criteria:

Sl. No.	Name of Examination	Marks Allotted	Remarks
1	Mini Test	10	
2	Mid Semester Test	20	
3	Assignment if any	20	
4	Tutorial if any	-	
5	Quiz if any	-	
6	Seminar, Viva voce if any	-	
7	End Semester Examination	50	
8	Experiments if any (for practical courses)	-	
9	Any other	-	

Name of Program	M. Tech. in Mechanical Engineering with Specialization in Thermal Engineering	Semester: I/II	Year: I

Name of Course	Thermal Power Plant Engineering
Course Code	TH24563
Core / Elective / Other	Elective

Prerequisite if any:	
1.	Engineering Thermodynamics

Course Outcomes:	
1.	Able to apply knowledge of Refrigeration and Air conditioning engineering fundamentals for solving problems
2.	Able to formulate Refrigeration and Air conditioning problems for different applications and to find solution using principles engineering sciences, mathematics and literature
3.	Ability to design and develop Refrigeration and Air conditioning component /system and processes that meets specific needs

Description of Contents in brief:	
Unit 1.	Review of power cycle, introduction to various energy conversion systems, conventional and non-conventional energy conversion system. Site selection criteria of thermal power plant, selection of quality of steam, layout of thermal power plant, fuel handling system, fuel preparation system, fuel combustion equipments
Unit 2.	Generation of Steam: Introduction of high pressure boilers, super critical and ultra-super critical boilers, calculation of capacity and major dimensions of boiler, fuel firing system, principle of combustion of fuel, theoretical and actual air fuel ratio, super-heaters feed water heaters, re-heaters, air pre-heater boiler draught system, dust collection systems, ash handling systems
Unit 3.	Thermal design of steam condensers–water-cooled and air-cooled, heat transfer in condenser, condensing heat transfer coefficient for outside and inside surfaces, cooling tower system, cooling tower performance criteria
Unit 4.	Power Plant Management: Operation and maintenance of turbines**,** starting, loading and stopping of turbine, normal operation checks, maintenance logging, parallel operation
Unit 5.	Power plant instrumentation, general & special instrumentation, centralized & automatic control equipment, types of controls. power plant testing, preliminary performance checks, acceptance tests for various components
Unit 6.	Station Economics: Definitions and application of load curves, load factor, plant capacity factor, plant utilization factor, diversity factor and demand factor. Introduction to energy audit. Elements of fixed and operating costs, power and various tariff

List of Text Books:	
1.	P.K. Nag. Power Plant Engineering, Tata McGraw-Hill Education, 2002
2.	R.K. Rajput. A Textbook of Power Plant Engineering, Laxmi Publications, 2005
3.	Domkundwar & Arora, A Course in Power Plant Engineering, Dhanpat Rai and Sons,2005

List of Reference Books:	
1.	Joel Weisman, Eckart Roy. Modern Power Plant Engineering, PHI, 1985
2.	Black & Veatch,Power Plant Engineering, Springer, 1996

URLs:	
1.	https://www.power-eng.com/

Lecture Plan (about 40-50 Lectures):

*Lecture	Topic	Remarks

No.		
1-4	Review of power cycle, introduction to various energy conversion system, conventional and non-conventional energy conversion system	
5-10	Site selection criteria of thermal power plant, selection of quality of steam, layout of thermal power plant, fuel handling system, fuel preparation system, fuel combustion equipments	
11-18	Introduction of high pressure boilers, super critical and ultra-super critical boilers, calculation of capacity and major dimensions of boiler	
19-26	Fuel firing system, principle of combustion of fuel, theoretical and actual air fuel ratio, super-heaters feed water heaters, re-heaters, air pre-heater boiler draught system, dust collection systems, ash handling systems	
27-32	Thermal design of steam condensers–water-cooled and air-cooled, heat transfer in condenser, condensing heat transfer coefficient for outside and inside surfaces, cooling tower system, cooling tower performance criteria	
33-38	Power Plant Management: Operation and maintenance of turbines**,** starting, loading and stopping of turbine, normal operation checks, maintenance logging, parallel operation	
39-42	Power plant instrumentation, general & special instrumentation, centralized & automatic control equipment, types of controls. Power plant testing, preliminary performance checks, acceptance tests for various components	
43-46	Definitions and application of load curves, load factor, plant capacity factor, plant utilization factor, diversity factor and demand factor	
47-50	Introduction to energy audit. Elements of fixed and operating costs, power and various tariff	

***Min 48 (for four credit course)**

Evaluation Criteria:

Sl. No.	Name of Examination	Marks Allotted	Remarks
1	Mini Test	10	
2	Mid Semester Test	20	
3	Assignment if any	10	
4	Tutorial if any	-	
5	Quiz if any	10	
6	Seminar, Viva voce if ay	-	
7	End Semester Examination	50	
8	Experiments if any (for practical courses)	-	
9	Any other	-	

Name of Program	M. Tech. in Mechanical Engineering with Specialization in Thermal Engineering	Semester: I/II	Year: I

Name of Course	Power Generation Systems
Course Code	TH24564
Core / Elective / Other	Elective

Prerequisite if any:	
1.	Theory and Design of Steam Turbines, Steam & Gas Power Cycles
2.	Thermal Power Plant, Vibration, Fuels and Combustion in IC engines

Course Outcomes:	
1.	Ability to understand and design various components of Steam Turbine
2.	Knowledge about functioning of Steam Turbine Systems
3.	Advantages and limitations of combined cycle power generation
4.	Knowledge about functioning of Engine systems and Combustion
5.	Need for clean energy and new emission norms for fuels

Description of Contents in brief:	
Unit 1.	**Stator Design:** Stator Design, Design of Casing & Diaphragms
Unit 2.	**Rotor Design:** Rotor Stresses & Design, Design of turbine rotors. Rotors of constant strength and of constant thickness rotors with hyperbolic profile. Temperature stresses in rotors, Turbine Rotor Vibration, Critical speeds, Balancing of rotors
Unit 3.	**Steam Turbine Systems:** Design procedure for steam turbine stages, Axial thrust in steam turbine, Effect of turbine load on the steam pressure profile, Turbine seals Blade erosion, Blade Corrosion, Blade Vibration, System of turbine governing, Starting and stopping a steam turbine ,Overspend tripping, Turbine protective devices, Design of the lubricating system.
Unit 4.	Binary Vapour Cycle, Cogeneration and Types of Cogeneration system
Unit 5.	**Engines Systems & Combustion:** Fuel Systems, S.I. Engine, CI Engines and Gas Turbines. S.I. and C.I. Engine Combustion, and Gas Turbines & Combustion Chamber Design.
Unit 6.	**Alternative Technology:** Alternative Power Sources, Eco friendly fuels, Fuel cells, Emission Norms

List of Text Books:	
1.	W.J. Kearton. Steam Turbine Theory and Practice, CBS, 2004
2.	R. Yadav. Steam and Gas Turbines, Central Publishing House, Allahabad, 1997
3.	V. Ganesan. Internal Combustion Engines, Tata McGraw-Hill Education, 2008
4.	P.K. Nag. Power Plant Engineering, McGraw Hill Education, 2017
5.	M.L. Mathur and R.P. Sharma. A Course in I. C. Engines, Dhanpat Rai Publications, 4th Edition, 1981
6.	J.B. Heywood. I. C Engine Fundamentals, Tata McGraw Hill, 1st Edition, 1998

List of Reference Books:	
1.	P. Shlyakhin. Steam Turbines -Theory &Design, Peace Publications, 2005
2.	J.E. Lee. Steam & Gas Turbine, McGraw Hill, 1962.
3.	Willard W. Pulkrabek. Engineering Fundamentals of the Internal Combustion Engine, Pearson Prentice Hall, 2004

4.	L. Richard. Alternate Fuels Guide Book, Society of Automotive Engineers, 1997
URLs:	
1.	http://nptel.ac.in
2.	https://swayam.gov.in/nc_details/NPTEL

Lecture Plan (about 40-50 Lectures):

*Lecture No.	Topic	Remarks
1.	Design of Casing	
2.	Design of Casing	
3.	Design of Diaphragms	
4.	Design of Diaphragms	
5.	Rotor Stresses	
6.	Causes of different types stress generation in rotors	
7.	Design of turbine rotors	
8.	Design of turbine rotors	
9.	Rotors of constant strength and of constant thickness	
10.	Rotors with hyperbolic profile	
11.	Temperature stresses in rotors	
12.	Turbine Rotor Vibration	
13.	Critical speeds of turbine rotors	
14.	Balancing of rotors	
15.	Problems on rotor vibration and critical speed of rotors	
16.	Problems on rotor vibration and critical speed of rotors	
17.	Design procedure for steam turbine stages	
18.	Axial thrust in steam turbine	
19.	Effect of turbine load on the steam pressure profile	
20.	Turbine seals	
21.	General instructions for starting and stopping a steam turbine	
22.	Blade Corrosion	
23.	Blade Erosion	
24.	Blade Vibration	
25.	System of turbine governing	
26.	System of turbine governing	
27.	Over speed tripping	
28.	Turbine protective devices	
29.	Steam Turbine Lubrication System	
30.	Steam Turbine Lubrication System	
31.	Binary Vapour Power Cycle (BVPC)	
32.	Cogeneration	
33.	Different types of Cogeneration System	
34.	Problems on BVPC and Cogeneration	
35.	Fuel Systems in S.I. Engine	
36.	Fuel Systems in CI Engines	
37.	Fuel Systems in Gas Turbines	
38.	Combustion in S.I. Engine	
39.	Combustion in C.I. Engine	
40.	Combustion in Gas Turbines	
41.	Design of combustion chamber in SI engines	
42.	Design of combustion chamber in CI engines	
43.	Introduction to Alternative Power Sources and Fuels	

44.	Need for Alternative Fuels	
45.	Emission norms (International and National)	
46.	Different types of alternative eco friendly fuels	
47.	CNG, LNG, Hydrogen as eco friendly fuels	
48.	Introduction to Fuel Cells	
49.	Working of fuel cells	
50.	Advantage and Limitations of alternative fuels	

***Min 48 (for four credit course)**

Evaluation Criteria:

Sl. No.	Name of Examination	Marks Allotted	Remarks
1	Mini Test	10	
2	Mid Semester Test	20	
3	Assignment if any	20	
4	Tutorial if any	-	
5	Quiz if any	-	
6	Seminar, Viva voce if any	-	
7	End Semester Examination	50	
8	Experiments if any (for practical courses)	-	
9	Any other	-	

Name of Program	M. Tech. in Mechanical Engineering with Specialization in Thermal Engineering	Semester: I/II	Year: I

Name of Course	Finite Element Methods
Course Code	SM24564
Core / Elective / Other	Elective

Prerequisite if any:	
1.	

Course Outcomes:
At the end of the course, the student shall be able to:

1.	Understand the fundamental theory of the finite element method.
2.	Generate the governing FE equations for systems governed by partial differential equations.
3.	Understand the use of the basic finite elements for structural applications using truss, beam, frame, and plane elements.
4.	Demonstrate the ability to evaluate, and interpret FEA analysis results for design, and evaluation purposes.
5.	Ability to create models for trusses, frames, plate structures, machine parts, and components using ANSYS general-purpose software.

Description of Contents in brief:

Unit 1.	Introduction: Historical background, the basic concept of the finite element method, comparison with the finite difference method.
Unit 2.	Variational methods: calculus of variation, the Rayleigh-Ritz, and Galerkin methods; Finite element analysis of 1-D problems: formulation by different approaches (direct, potential energy, and Galerkin); Derivation of elemental equations, and their assembly, solution, and its post-processing. Applications in heat transfer, fluid mechanics, and solid mechanics. Bending of beams, analysis of truss, and frame.
Unit 3.	Finite element analysis of 2-D problems: finite element modeling of single variable problems, triangular, and rectangular elements; Applications in heat transfer, fluid mechanics, and solid mechanics
Unit 4.	Numerical considerations: numerical integration, error analysis, mesh refinement. Plane stress, and plane strain problems; Bending of plates; Eigenvalue, and time-dependent problems.
Unit 5.	Discussion about preprocessors, postprocessors, and finite element packages *namely* ANSYS, ABAQUS, LS Dyna, Simufact to name a few.

List of Text Books:

1.	U.S. Dixit, Finite element methods for engineer, Cengage Learning, 2009.
2.	K.J. Bathe, Finite element procedures, Second Edition, Prentice-Hall, 1996.
3.	J. N. Reddy, An introduction to the finite element method, 3rd edition, McGraw-Hill, 2006.
4.	R.D. Cook, D. S. Malkus, and M. E. Plesha, Concepts, and Applications of Finite Element Analysis, 4th edition, John Wiley, 2007

List of Reference Books:

1.	O. C. Zienkiewicz, and R. L. Taylor, The Finite Element Method, 7th edition, Butterworth-Heinemann, 2013.
2.	T. J. R. Hughes, The Finite Element Method, Prentice-Hall, 1986.

URLs:	
1.	https://nptel.ac.in/courses/112/104/112104116/
2.	https://nptel.ac.in/courses/112/104/112104115/
3.	https://nptel.ac.in/courses/112/106/112106135/
4.	https://nptel.ac.in/courses/112/106/112106130/
5.	https://nptel.ac.in/courses/105/108/105108141/

Lecture Plan (about 40-50 Lectures):

***Lecture No.**	**Topic**	**Remarks**
1.	Finite element method: a quick introduction	
2.	Direct FEM formulation of axial rod problem	
3.	Direct FEM formulation of beam problem	
4.		
5.	Some classical function approximation methods for solving differential equations: Ritz method, Galerkin method, The Least square method, Collective methods.	
6.		
7.		
8.		
9.	Ritz FEM formulation	
10.		
11.	Galerkin FEM formulation	
12.		
13.	Developing elemental equations by Ritz method	
14.	Developing element equations by Galerkin method	
15.	**Some one-dimensional C^0 continuity FEM formulation**: steady-state heat conduction; longitudinal deformation of a rod; fluid flow problem	
16.		
17.	**Finite element formulation for bending of beams**: Galerkin FEM formulation; weak form; choose suitable approximating shape functions; Hermitian shape function; elemental equation, application of boundary conditions, and solution	
18.		
19.	Finite element formulation for trusses, and frames	
20.		
21.	**Introduction to 2-D, and 3-D FEM**	
22.	Triangular elements, Tetrahedral element, Rectangular elements, Bricks element	
23.	Governing heat conduction equation for 2D heat conduction problems	
24.	Weak form, and FEM formulation	
25.	Assembly procedure of 2D problems in FEM	
26.	Poisson equation for 3D FEM	
27.	Torsion of circular, and non-circular cross-section	
28.		
29.	Numerical integration: One-dimensional integration formula; Two-dimensional integration formula	
30.	Integration over the square region; Integration over triangular region	
31.	Natural coordinates, and iso-parametric, sub-parametric, and super parametric elements	
32.	Four noded quadrilateral elements, and serendipity Elements	
33.	Eight noded curvilinear elements	

34.	FEM Formulation for Plane Stress, and Plane Strain Problems	
35.		
36.		
37.	**Free Vibration Problems:** Vibration of A Rod, and vibration of a beam	
38.		
39.	Finite Element Formulation of Time-Dependent Problems	
40.	FEM formulation of plate problem	
41.		
42.	FEM formulation of 2D flow problem	
43.		
44.	Error analysis in finite element methods: errors measure	
45.	Types of errors, Super convergent patch recovery (SPR) Technique	
46.	Higher-order of approximations of primary variables	
47.	Error estimates by recovery	
48.	**Miscellaneous topics**: Difference between FEM, and FDM, Essential, and Natural boundary conditions, Solving the problem of fracture mechanics using FEM, Ill condition system, patch test.	
49.		
50.		

Evaluation Criteria:

Sl.No.	Name of Examination	Marks Allotted	Remarks
1	Mini Test	10	
2	Mid Semester Test	20	
3	Assignment if any	10	
4	Tutorial if any		
5	Quiz if any	10	
6	Seminar, Viva voce if ay	--	
7	End Semester Examination	50	
8	Experiments if any (for practical courses)	--	
8	Any other	--	

Name of Program	M. Tech. in Mechanical Engineering with Specialization in Thermal Engineering	Semester: I/II	Year: I

Name of Course	Research Methodology
Course Code	ME24524
Core / Elective / Other	Elective

Prerequisite if any:	
1.	Graduation in a sciences
2.	Graduation in a Technologies
Course Outcomes:	
1.	Student will be able to apply knowledge Research Methodology different field and research
2.	Student will be able to design always the research problem with different quantities and qualitative method of data collection tool and techniques
3.	Student will be able to apply knowledge and Research Methodology to write research paper.
4	Student will be able to identified the tools , software and techniques for data analysis and data validation.
Description of Contents in Brief:	
Unit 1.	Research Meaning, Objectives, Motivation, Types of Research, Research Approach, Research and Scientific Methods, Identification of Problem, Significance of Defining Research Problem, Research Design, Research Ethics
Unit 2.	Data Collection Methods, Primary Data, Secondary Data, Questionnaire Preparation, Case Study Method, Measurement Scales, Levels of measurement – Nominal, Ordinal, Interval, Ratio Measures of Central Tendency (Mean, medium, Mode), Measures of Dispersion (range, mean deviation, standard deviation), Graphical Representation of Data, Tabular Presentation of Data, Oral Presentation, Posters Presentation
Unit 3.	Sampling Design, Sample Size, Non Response. Characteristics of a good sample. Probability Sample – Simple Random Sample, Systematic Sample, Stratified Random Sample & Multi-stage sampling. Determining size of the sample, Research Question, Normal Probability Curve, Standard Error, Confidence Intervals
Unit 4.	Significance of correlation, Pearson's Product Moments Correlation. Regression and Multiple Regression equations, Hypothesis Formation, Hypothesis Testing, Testing the Significance of difference between means(z and 't' test), Analysis of Variance (ANOVA) -concept and applications, Chi Square Test steps, Type I and Type II errors,
Unit 5.	Writing Research Report:, Interpretation, Significance of Report Writing, Steps In Writing Report, Types of Report, Technical Report Writing, Review of Related Literature, Structure of The Research Report, Precaution In Writing Report, Layout of Research Paper, Format and Style, Impact Factor of Journals, Suitability of Journal for Publication, Plagiarism, Citation, Reference Writing, IPR, Copyright, Patents,

Unit 6	Introduction of Softwares used for Research like Matlab, SPSS, Reference Management Software like Zotero/Mendeley, Software for paper formatting like LaTeX/MS Office, Software for detection of Plagiarism, Google Scholar, Research Gate,

List of Text Books:

1.	Research Methodology: Methods and Techniques, Kothari, C.R, New Age International Publishers, 2010 , 2010
2.	Fundamentals of Mathematical Statistics, Gupta, S. C. and Kapoor, V. K, Sultan Chand and Sons, New Delhi. , 2010
3.	Theory and Application of Statistics, Bruce E. Wampold and Difford J. Drew, McGraw-Hill International Editions. , 2010

List of Reference Books:

1.	Business Research Methods – Donald Cooper & Pamela Schindler, TMGH, 9th edition
2.	Business Research Methods – Alan Bryman& Emma Bell, Oxford University Press
3.	Business Research Methods, Naval Bajpai, Pearson

URLs:

2.	https://swayam.gov.in/nd1_noc19_ge21/preview
3.	https://www.youtube.com/watch?v=Yzfl3rtF0SM

Lecture Plan (about 40-50 Lectures):

Lecture No.	**Topic**	**Remarks**
1-2	Research Meaning, Objectives	
3-4	Motivation	
5-6	Types of Research, Research Approach,Research and Scientific Methods	
7-8	Identification of Problem, Significance of Defining Research Problem,	
9-10	Research Design, Research Ethics	
11-12	Data Collection Methods, Primary Data, Secondary Data,	
13	Questionnaire Preparation, Case Study Method,	
14-15	Measurement Scales, Levels of measurement – Nominal, Ordinal, Interval,	
16-17	Ratio Measures of Central Tendency (Mean, medium, Mode), Measures of Dispersion (range, mean deviation, standard deviation),	
18	Graphical Representation of Data, Tabular Presentation of Data,	
19-20	Oral Presentation, Posters Presentation	
21	Sampling Design, Sample Size, Non Response. Characteristics of a good sample. Probability Sample – Simple Random Sample, Systematic Sample, Stratified Random	

	Sample & Multi-stage sampling.	
22	Determining size of the sample, Research Question, Normal Probability Curve, Standard Error, Confidence Intervals	
23	Significance of correlation, Pearson's Product Moments Correlation.	
24	Regression and Multiple Regression equations,	
25-26	Hypothesis Formation, Hypothesis Testing, Testing the Significance of difference between means(z and 't' test),	
27-28	Analysis of Variance (ANOVA) -concept and applications, Chi Square Test steps, Type I and Type II errors,	
29-30	Writing Research Report:, Interpretation, Significance of Report Writing, Steps In Writing Report, Types of Report,	
31	Technical Report Writing, Review of Related Literature, Structure of The Research Report, Precaution In Writing Report,	
32-33	Layout of Research Paper, Format and Style, Impact Factor of Journals, Suitability of Journal for Publication, Plagiarism, Citation, Reference Writing, IPR, Copyright, Patents,	
34	Introduction of Softwares used for Research like Matlab, SPSS,	
35	Reference Management Software like Zotero/Mendeley,	
36	Software for paper formatting like LaTeX/MS Office,	
37	Software for detection of Plagiarism, Google Scholar, Research Gate, ,	

***Min 36 (for three credit course)**

Evaluation Criteria:

Sl.No.	Name of Examination	Marks Allotted	Remarks
1	Mini Test	10	
2	Mid Semester Test	20	
3	Assignment if any	10	
4	Tutorial if any		
5	Quiz if any	10	
6	Seminar, Viva voce if ay	--	
7	End Semester Examination	50	
8	Experiments if any (for practical courses)	--	
8	Any other	--	