First Year Curriculum of
Postgraduate Degree in Thermal Engineering

A. Structure of curriculum

1st year syllabus for ME Thermal Engineering

(Semester I)

Semester I													
Sr No	**Category**	**Sub Code**	**Course Title**	**Hours Per Week**			**Total Hours**	**Credits**	**E**	**M**	**I**	**V**	**Total**
				L	**T**	**P**							
1	Program Core I	TE3101	Mathematical Methods for Mechanical Engineering	3	1	0	4	4	70	30	20	30	150
2	Program Core II	TE3102	Advanced Thermodynamics & Heat transfer	3	0	2	5	4	70	30	20	30	150
3	Program Elective I	TE3103/04/05	Program Elective I	3	0	2	5	4	70	30	20	30	150
4	Program Elective II	TE3106/ 07/ 08	Program Elective II	3	1	0	4	4	70	30	20	30	150
5	Research Methodology and IPR	MH3101	Research Methodology and IPR	2	0	0	2	2	0	0	20	30	50
6	Audit Course	MH3102	Disaster Management	2	0	0	2	0	30	20	0	0	50
		Total					**22**	**18**					**700**

Program Elective I	**Sub Code**	**Program Elective II**	**Sub Code**
Advanced Fluid power systems	TE3103	Pump and Pumping System	TE3106
Advanced IC engines	TE3104	Combustion Engineering	TE3107
Finite element method	TE3105	Advanced Power Plant Engineering	TE3108

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Semester II

Sr No	Category	Sub Code	Course Title	Hours Per Week			Total Hours	Credits	E	M	I	V	Total
				L	T	P							
1	Program Core III	TE3109	Advanced Fluid Mechanics & Gas dynamics	3	0	2	5	4	70	30	20	30	150
2	Program Core IV	TE3110	Advanced Refrigeration & Air conditioning systems	3	0	2	5	4	70	30	20	30	150
3	Program Elective III	TE3111/ 12/13	Program Elective III	3	0	2	5	4	70	30	20	30	150
4	Program Elective IV	TE3114/ 15/16	Program Elective IV	3	0	0	3	3	70	30	0	0	100
5	Open Elective-I	TE3117/ 18	Open Elective-I	3	0	0	3	3	70	30	0	0	100
6	Audit Course	MH3104	English for research paper writing	2	0	0	2	0	30	20	0	0	50
		Total					**23**	**18**					**700**

Program Elective III	Sub Code	Program Elective IV	Sub Code
Design of heat exchangers	TE3111	Boiler auxiliaries and performance evaluation	TE3114
Theory of heat pipes	TE3112	EXERGY ANALYSIS OF THERMAL SYSTEMS	TE3115
Computational Fluid Dynamics	TE3113	Thermal Measurements and Process Controls	TE3116

Open Elective I	Sub Code
Solar energy systems	TE3117
Renewable energy technology	TE3118

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B. Course code and definition:

Course code	Definitions
L	Lecture
T	Tutorial
P	Practical
E	Theory External Examination Marks
M	Theory Internal Examination Marks
I	Practical Internal Examination Marks
V	Practical External Examination Marks

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UPL University of Sustainable Technology

Shroff S.R. Rotary Institute of Chemical Technology

Master of Engineering
Subject Code: TE3101
Subject Name: Mathematical methods for Mechanical Engineering

Semester: - I

Type of course: Program Core 1

Prerequisite: Engineering Science Mathematics

Rationale: Course is intend to offer the various applications of mathematics to solve the engineering problems for the mechanical systems.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	1	0	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs.
	SECTION-A	
1	Introduction to Probability Theory: Probability theory & Sampling Distributions, Basic probability theory along with examples, Standard discrete & continuous distributions like Binomial, Poisson, Normal, Exponential etc., Central limit theorem & its significance, some sampling distributions like χ^2,t,F	**7**
2	Testing of Statastical Hypothesis: Testing a Statastical Hypothesis, tests on single samples & two samples concerning means & variances, ANOVA: One-way, Two-way with/without interactions.	**6**
3	Ordinary Differential Equations: Ordinary simple differential equations solvable by direct solution methods, Solvable nonlinear ODE's	**5**
	SECTION-B	

Master of Engineering
Subject Code: TE3101
Subject Name: Mathematical methods for Mechanical Engineering

4	Partial Differential Equations and Concepts in Solution to Boundary Value Problems: First & second order partial differential equations, Canonical forms	**6**
5	Major Equation Types Encountered in Engineering & Physical Sciences: Solution methods for wave equation, D'Alembert solution, potential equation, properties of harmonic functions, maximum principle, solution by variable separation method	**6**
6	Fourier Analysis: Fourier Series; Arbitrary Period, Even and Odd Functions, Half-Range Expansions; Forced Oscillations; Approximation by Trigonometric Polynomials; Sturm–Liouville Problems, Orthogonal Functions; Orthogonal Series, Generalized Fourier Series; Fourier Integral; Fourier Cosine and Sine Transforms; Fourier Transform, Discrete and Fast Fourier Transforms Variational Calculus:	**6**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
5%	**25%**	**30%**	**20%**	**15%**	**5%**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Text Book:

F. Ayres, Jr. and E. Mendelson " Schaum's Outline of Calculus" (6th Edition), McGraw Hill, New York, 2013.

Reference Books:

1. Douglas C, Montgomery "Design & Analysis of Experiments" (7th Edition), Wiley Student Edition,2009.

2. S.P.Gupta, Statistical Methods, S. Chand & Sons, 37th revised edition, 2008.

3. William W Hines, Douglas C, Montgomery, David M Goldsman, Probability & Statistics for Engineering (4th Edition), Wiley student edition, 2006.

4. Advanced Engineering Mathematics (9th Edition, Erwin Kreyszig, Wiley India, 2013.

List of Practical/ tutorials:

1. Study & solve the problem of Ordinary Differential Equation.

2. Develop the mathematical model for the fourier series problems.

3. Understand the concept of Probability statistics.

4. Solve the engineering problems using MATLAB.

5. Solve the wave equation using D'Alemberts Solution.

6. Solve the engineering problems of fourier analysis.

7. Solve the engineering problems by variable separation method.

8. Solve the fourier series problems of Half-range expansions & Forced Oscillations

9. Solve the first & second order partial differential equations.

10. Test a statistical hypothesis.

Course Outcomes:

Sr. No.	CO statement
CO-1	Apply statistical techniques to analyze multivariate functions.
CO-2	Identify & solve engineering problems by applying the knowledge of ordinary & partial differential equations.
CO-3	Students will be able to develop mathematical models of physical phenomena
CO-4	Identify nature of a given wave equation & solve by applying D'Alemberts solution and/or method of solution of method of separation of variables.
CO-5	Students will learn fundamentals of statistics and probability.
CO-6	Able to solve the engineering problems by using fourier method.

Master of Engineering
Subject Code: TE3101
Subject Name: Mathematical methods for Mechanical Engineering

List of Open Source Software/learning website:

- http://nptel.ac.in/

UPL University of Sustainable Technology

Shroff S.R. Rotary Institute of Chemical Technology

Master of Engineering
Subject Code: TE3102
Subject Name: Advanced Thermodynamics & Heat transfer

Semester: - I

Type of course: Core subject

Prerequisite: Basics of Thermodynamics and Heat Transfer

Rationale: The course is designed to provide insights on implementation of basic laws and principles of Thermodynamics and Heat Transfer in real life problems

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs.
	SECTION-A	
1	**Entropy and Exergy:** Clausius theorem, concept of entropy, Inequality of Clausius, entropy principle and its applications, entropy change for closed and open system, Tds relation, entropy generation, entropy balance, exergy and its types, exergy concepts for control volume and closed system, irreversibility, second law efficiency, exergy analysis of processes and cycles, pictorial representation of exergy balance, exergy based property diagram, exergy costing, exergo-economic analysis.	**7**
2	**Properties of Pure substances:** P-V-T surfaces, phase diagram, phase changes, various properties diagram, 1st order phase transition and 2nd order phase transition, Clapeyron's equation, Ehrenfest's equations, Maxwell's equations, equation for internal energy, enthalpy, entropy, specific heat and joule Thompson coefficient.	**5**
3	**Equation of state for real gases:** Compressibility factor and generalized compressibility chart, Law of corresponding state, law of pseudo critical pressure and temperature, reduced coordinate, Wander-Walls equation of state and other equation of state.	**5**

Master of Engineering
Subject Code: TE3102
Subject Name: Advanced Thermodynamics & Heat transfer

SECTION-B		
4	**Conduction:** Conduction Rate Equation, Heat Diffusion Equation, Boundary and Initial Conditions, General conduction Equation, Conduction with Heat Generation, Heat transfer through Extended Surfaces, Two-Dimensional Steady State Conduction: Mathematical, Graphical and Numerical Analysis of Two-Dimensional Heat Conduction Unsteady State Conduction: Lumped Parameter Analysis, Numerical Solutions, Heisler and Semi Analytical Analysis	**7**
5	**Convection**: Dimensional analysis of free and forced convection. Useful non dimensional numbers and empirical relationships for free and forced convection. Equation of laminar boundary layer on flat plate and in a tube. Laminar forced convection on a flat plate and in a tube. Combined free and forced convection. **Phase Transformation:** Boiling: Pool Boiling and its Correlations, Forced Convection Boiling, Condensation: Laminar and Turbulent Film Contestation, Film Condensation in Radial Surfaces and Horizontal Tubes, Heat Pipe	**7**
6	**Radiation:** Radiation Intensity, Blackbody Radiation, Emission from Real Surfaces Radiation: Combine with Conduction and Convection, Radiation Exchange with Participating Media, Radiative exchange and overall heat transfer in furnaces	**5**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
20	**30**	**15**	**15**	**10**	**10**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Text Books:

1. Advanced Thermodynamics for Engineers by Desmond E. Winterbone and Ali Turan, Science Direct Journals and Book (Text Book)
2. A text book of Engineering Thermodynamics by P.K. Nag, McGraw-Hill , New Delhi

Master of Engineering
Subject Code: TE3102
Subject Name: Advanced Thermodynamics & Heat transfer

Reference Books:

1. Thermodynamics – An Engineering Approach by Yunus Cengel & Boles, McGraw-Hill Publication, New Delhi
2. Fundamentals of Heat and Mass Transfer, by Incropera, Dewitt, John Wiley & Sons (Asia) Pvt. Ltd.
3. Heat Transfer by J P Holman, McGraw-Hill Publication, New Delhi

List of Practicals:

1. Study of Energy and Exergy analysis of any thermal utility
2. Study of Thermo-economic analysis of any thermal utility
3. Experiment on Heat transfer through composite wall at different temperature
4. Experiment on Heat transfer by forced convection and natural convection
5. Experiment on Heat transfer by radiation: Stefan-Boltzmann Law
6. Experiment on Thermal conductivity of metal rod
7. Experiment on Drop and Film wise condensation
8. Experiment on Unsteady state conduction heat transfer

Course Outcomes:

Sr. No.	CO statement
CO-1	Apply entropy principle to various thermal engineering applications
CO-2	Apply the concept of second law efficiency and exergy principle to various thermal engineering applications
CO-3	Understand properties of pure substance and thermodynamic properties of real gases.
CO-4	Analyze steady state and transient heat conduction problems of real-life Thermal systems
CO-5	Analyze extended surface heat transfer problems and problems of phase change heat transfer like boiling and condensation
CO-6	Analyze radiation heat transfer problems of various thermal systems

List of Open Source Software/learning website:

- nptel.ac.in

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Shroff S.R. Rotary Institute of Chemical Technology

Master of Engineering
Subject Code: TE3103
Subject Name: Advanced Fluid Power Systems

Semester: - I

Type of course: Program Elective Subject

Prerequisite: Basics of Fluid Power Engineering

Rationale: The course is designed to discuss the advanced and relevant technologies of fluid power and related system components.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs.
	SECTION-A	
1	**Fundamentals of Turbo Machines:** Introduction to turbo machines, classifications, applications, fundamental laws and equations, specific speed, thermodynamic and dimensional analysis applied to turbo machines. comparison and selection criteria of various turbo machines	**6**
2	**Centrifugal & Axial Flow Compressors:** Centrifugal blowers and compressors, Euler's characteristics and velocity triangles of centrifugal compressor, hydraulic efficiency, analysis of flow through impeller, diffusers and casing, pressure recovery, slip factor, disc friction, Stanitz and Stodola formulas, axial flow fans and compressors, geometry of axial flow compressor, velocity diagrams, vortex and airfoil theory, stage pressure ratio, degree of reaction, stage design, surge, chocking and stall, blade twist and design considerations for supersonic flow.	**8**
3	**Analysis of Axial & Radial Flow Gas Turbines:** Work done, velocity triangles and efficiencies, thermodynamic flow analysis, Zweifels relation, cascade analysis, Soderberg– Hawthrone – ainley-correlations, secondary flow, blade angles for variable degree of reaction, stresses in blades, blade assembling, materials and cooling of blades, matching of	**7**

	compressor and turbine; off-design performance.	
SECTION-B		
4	**Analysis of Pumps:** Classification of pumps, Pumping theory of positive displacement pumps, construction and working of Centrifugal pump, Gear pumps, Vane pumps, Piston pumps, fixed and variable displacement pumps, Pump performance characteristics, pump selection factors, problems on pumps. Accumulators: Types, selection/ design procedure, applications of accumulators. Types of Intensifiers, Pressure switches/sensor, Temperature switches/sensor, Level sensor.	**7**
5	**Multistage Machine:** Analysis of multistage axial compressors and turbines, prediction of stage performance and effect of stacking; rotating stall and surge, turbine blade heat load and blade cooling.	**4**
6	**Testing and control of Turbo Machines:** Performance testing, noise control, speed control, throttling control at discharge and inlet and maintenance of fans, blowers, compressors and turbines.	**4**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
20	**30**	**15**	**15**	**10**	**10**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Text Book:

1. A text book of Fluid Mechanics and Hydraulic Machines by R.K. Bansal, Laxmi Prakashan.

Reference Books:

1. Principles of Turbo Machines/DG Shepherd / Macmillan
2. Anthony Esposito, "Fluid Power with applications", Pearson edition,2000
3. Fluid Mechanics and Hydraulic Machines by R.K. Rajput , S.Chand & Co.
4. Turbines, Compressors and Fans by S.M. Yahya., TMH Publishers

Master of Engineering
Subject Code: TE3103
Subject Name: Advanced Fluid Power Systems

List of Practicals:

1. Performance test on Pelton turbine
2. Performance test on Kaplan turbine
3. Performance test on Francis turbine
4. Performance test on Centrifugal pump
5. Performance test on Reciprocating pump
6. Performance test on Reciprocating compressor
7. To study the constructional details of axial flow compressor and draw its characteristics curve
8. Performance test on Centrifugal compressor

Course Outcomes:

Sr. No.	CO statement
CO-1	Understand the principles and energy transfer process in turbo machines.
CO-2	Understand the structural and functional aspects of major components of turbo machines.
CO-3	Analyse the turbo machines to improve and optimize its performance
CO-4	Formulate and analyze models of hydraulic components.
CO-5	Design and predict the performance of fluid power components
CO-6	Understand control and maintenance aspects of turbo machines.

List of Open-Source Software/learning website:

- nptel.ac.in

UPL University of Sustainable Technology

Shroff S.R. Rotary Institute of Chemical Technology

Master of Engineering
Subject Code: TE3104
Subject Name: Programme Elective 1 (Advanced Internal Combustion Engine)

Semester: - 1

Type of course: Applied Thermodynamics (Advanced)

Prerequisite: Basic thermodynamics and Basic Internal Combustion engine.

Rationale: The course is designed to provide the detailed understanding of internal combustion engines, its performance and emission under various conditions.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
03	00	02	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs.
	SECTION-A	
1	**Spark Ignition Engines:** Air-fuel ratio requirements, Design of carburetor –fuel jet size and venture size, Stages of combustion normal and abnormal combustion, Factors affecting knock, Combustion chambers.	**05**
2	**Compressed Ignition Engine:** Stages of combustion-normal and abnormal combustion – Factors affecting knock, Direct and Indirect injection systems, Combustion chambers, Turbo charging.	**06**
3	**Engine Exhaust Emission Control:** Formation of NOX , HC/CO mechanism, Smoke and Particulate emissions, Green Effect , Methods of controlling emissions , Three way catalytic converter and Particulate Trap, Emission (HC,CO, NO and NOX ,) measuring equipments, Smoke and Particulate measurement, Indian Driving Cycles and emission norms.	**07**
	SECTION-B	
4	**Alternate Fuels:** Alcohols, Vegetable oils and bio-diesel, Bio-gas, Natural Gas, Liquefied Petroleum Gas, Hydrogen, Properties, Suitability, Engine Modifications, Performance, Combustion and Emission	**05**

	Characteristics of SI and CI Engines using these alternate fuels.	
5	**Recent Trends:** Homogeneous Charge Compression Ignition Engine, Lean Burn Engine, Stratified Charge Engine, Surface Ignition Engine, Electronic Engine Management, Common Rail Direct Injection Diesel Engine, Gasoline Direct Injection Engine, Plasma Ignition.	**06**
6	**Engine for Special Application:** Mining, Defence, Off-highway - Tractor, Bulldozer etc. Submarines, Race car Engine systems, Flexible fuel systems, Zero Emission Vehicle.	**07**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
20	**25**	**20**	**15**	**15**	**05**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Test Books:

1. V. Ganesan, "Internal Combustion Engines", TMH Publishers
2. V.M. Domkundwar "A course in Internal Combustion Engines", Dhanapat Rai publications.

Reference Books:

1. John B. Heywood, "Internal Combustion Engine Fundamental", 1st Edition, Tata McGraw-Hill Education.
2. Mathur. R.B. and R.P. Sharma, "Internal Combustion Engines"., Dhanpat Rai & Sons
3. Heinz Heisler, "Advanced Engine Technology", Trafalgar Square, 1997.
4. Introduction to internal combustion engines by Richard stone 3rd edition, society of automotive engineers.

Master of Engineering
Subject Code: TE3104
Subject Name: Programme Elective 1 (Advanced Internal Combustion Engine)

List of Practical/ tutorials:

1. To study the constructional details and working principal of IC engines.
2. To study the valve timing diagram for 2 stroke and 4 stroke engine.
3. To study the effect of A/F ratio on the performance of the four stroke single cylinder petrol engine.
4. To prepare variable speed performance test of a multi / single cylinder petrol / diesel engine and prepare the curve: (i) BP, IP, FP v/s Speed (ii) Indicated specific fuel consumption v/s Speed
5. To find the indicated horse power on multi cylinder diesel engine / petrol engine by Morse test.
6. To measure the performance of single cylinder petrol engine wit eddy current dynamometer.
7. To study about first law analysis for steady state reacting system and combustion stoichiometric.
8. To analyze the exhaust gases emission from single / multi cylinder petrol engine.
9. To prepare a report on Indian emission norms.
10. To prepare a report on different alternate fuels available in India.

Course Outcomes:

Sr. No.	CO statement
CO-1	Understand the operating characteristics of IC engines.
CO-2	Perform a thermodynamic analysis of IC engine cycles.
CO-3	Accomplish a combustion analysis of IC engines.
CO-4	Realize the generation of undesirable exhaust emissions and ways to reduce them
CO-5	Assess the scope and application of different alternate fuels for internal combustion application
CO-6	Recognize the recent trends in I C engine and engine technology used in special application.

Master of Engineering
Subject Code: TE3104
Subject Name: Programme Elective 1 (Advanced Internal Combustion Engine)

List of Open Source Software/learning website:

- Students can refer to video lectures available on the websites including NPTEL.
- Students can refer to the CDs which are available with some reference books for the solution of problems using software/spreadsheets.
- https://ocw.mit.edu

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Shroff S.R. Rotary Institute of Chemical Technology

Master of Engineering
Subject Code: TE3105
Subject Name: Finite Element Method

Semester: I

Type of course: Program Elective Course

Prerequisite: Numerical Methods

Rationale: Methods for formulations of mathematical models of analysis of mechanical systems include 1D and 2D structural, thermal and fluid problems.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs.
	SECTION-A	
1	**Fundamental Concept of Finite Element Method:** Introduction, Historical Background, Stress and equilibrium, Boundary conditions, Strain Displacement relations, Stress strain relations, Temperature effects, Potential Energy and equilibrium, Rayleigh-Ritz Method, Galerkin's Method,Saint Venant's Principle, von Mises Stress, Computer Programs.	05
2	**One–Dimensional Problems:** Introduction, Finite Element Modeling, Coordinates and Shape Functions, The Potential Energy Approach, The Galerkin Approach, Assembly of the Global Stiffness Matrix and Load vector, Properties of K, The Finite Element Equations; Treatment of Boundary Conditions, Quadratic Shape Functions, Temperature Effects.	07
3	**1-D Thermal and Fluid Problems:** Steady state heat transfer: Element formulations, treatment to boundary conditions with application to 1-D heat conduction, heat transfer through thin fins; Potential flow problems.	06
	SECTION-B	
4	**Two–Dimensional Problems:** Introduction, Finite Element Modeling, Constant-Strain Triangle, Problem Modeling and Boundary Conditions, Orthotropic Materials. The Four-Node Quadrilateral, Numerical Integration,	07

	Higher Order Elements, Four-Node Quadrilateral for Axisymmetric Problems, Conjugate Gradient Implementation of the Quadrilateral Element.	
5	**2-D Thermal and Fluid Problems:** Steady state heat transfer: Element formulations, treatment to boundary conditions with application to 2-D heat conduction, heat transfer through thin fins; Potential flow problems.	**06**
6	**Three–Dimensional Problems:** Tetrahedran element – Jacobian matrix – Stiffness matrix.	**05**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
15	**25**	**20**	**20**	**20**	**0**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Text Books:

1. Chandrupatla & Belegundu, Introduction to Finite Elements in Engineering, PHI
2. S.S. Bhavikati, Finite Element Analysis, Newage Publications

Reference Books:

1. Krishnamurthy, Finite Element Analysis, TMH
2. J.N.Reddy, Finite element methods,Mc graw hill publition ltd.
3. Kenneth Lt. Huebner," The FEM for Engineers", Wiley India Pvt.Ltd. New Delhi
4. C.S. Desai and J.F.Abel.,Introduction to finite element methods ,CBS

List of Practicals:

1. Introduction to Finite Element Analysis software.
2. Solve 1D – Structural problems using FEA software.
3. Solve 1D – thermal problems using FEA software.
4. Solve 1D – fluid problems using FEA software.
5. Solve 2D – Structural problems using FEA software.
6. Solve 2D – thermal problems using FEA software.
7. Solve 2D – fluid problems using FEA software.
8. Solve 3D – Structural problems using FEA software.
9. Solve 3D – thermal problems using FEA software.
10. Solve 3D – fluid problems using FEA software.

Using analysis software like ANSYS/NASTRAN/LS-DYNA/ABACUS/COMSOL or any suitable software perform the following practical

Master of Engineering
Subject Code: TE3105
Subject Name: Finite Element Method

Course Outcomes:

Sr. No.	CO statement
CO-1	Understand the concept of finite element method for solving Mechanical Engineering problems.
CO-2	Apply the knowledge of FEM for 1D stress analysis.
CO-3	Formulate and solve problems of 1D heat transfer analysis and fluid flow analysis.
CO-4	Apply the knowledge of FEM for 2D stress analysis.
CO-5	Formulate and solve problems of 2D heat transfer analysis and fluid flow analysis.
CO-6	Apply the knowledge of FEM for 3D stress analysis.

List of Open Source Software/learning website:

- https://nptel.ac.in/courses/112/104/112104116/
- https://www.ansys.com/en-in/academic/learning-resources

Major Equipment: Computational facility and FEA solver (ANSYS/NASTRAN/LS-DYNA/ABACUS/COMSOL or any).

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Shroff S.R. Rotary Institute of Chemical Technology

Master of Engineering
Subject Code: TE3106
Subject Name: Pump and Pumping System

Semester: - I

Type of course: Elective

Prerequisite: Nil

Rationale: The course is aimed to provide a detailed understanding of pumps as well as the ability to undertake performance analysis and assessment on a pumping system.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	1	0	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs.
	SECTION-A	
1	Rotodynamic Pumps: introduction, construction and working of centrifugal pumps, work done by centrifugal pump, multistaging of pump, series and parallel connection of pumps.	5
2	Positive displacement pumps: introduction, description and working, flow rate and power, indicator diagram, air vessels, rotary pumps.	5
3	Pump selection and comparison, heads and efficiencies of a pump, cavitation, priming, NPSH, specific speed and significance. Introduction to piping, pipe classifications, pipe sizing and design.	7
	SECTION-B	
4	Pump Performance: introduction, system characteristics, pump curves, factors affecting pump performance, efficient pumping system operation.	7
5	Performance assessment: introduction, purpose of the performance test, performance terms and definitions, field testing, flow measurement, determination of total head, hydraulic power and pump efficiency, examples based on performance testing.	8

6	Energy conservation opportunities in pumping systems: adequate NPSH, best efficiency point, minimize throttling, seals and packing to minimize water loss by dripping, siphon effect.	4

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10	15	20	20	20	15

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Text Books:

1. Fluid Mechanics and Hydraulic Machines by R. K. Bansal, Laxmi Publication
2. Pumps by G.K.Sahu, New age international

Reference Books:

1. Fluid Mechanics and Hydraulic Machines by R. K. Bansal, Laxmi Publication
2. Pump handbook by Karassik
3. Energy Audit Reports of National Productivity Council
4. Pump Hand Book by Igori Karassik, McGraw-Hill International Edition

List of Tutorials:

1. Calculations based on Heads and efficiencies of a pump.
2. Problems based on performance assessment of a pump
3. Case study based on Centrifugal Pump.
4. Case study based on Reciprocating Pump.
5. Case study based on analysis and energy performance of a pumping system.
6. Study of recent advancement in Centrifugal Pumps
7. Study of recent advancement in Screw Pumps
8. Study of recent advancement in Reciprocating Pumps
9. Study of instruments used to measure the performance parameters.
10. Study of recent advancements in energy efficient pumps.

Master of Engineering
Subject Code: TE3106
Subject Name: Pump and Pumping System

Course Outcomes:

Sr. No.	CO statement
CO-1	Collect the theories of centrifugal pump.
CO-2	Understand the concept of positive displacement pumps.
CO-3	Calculate the head and efficiencies of a pump.
CO-4	Recognize the factors affecting the performance of a pump.
CO-5	Evaluate and analyze the performance parameters for the assessment.
CO-6	Identify the energy saving opportunities in pumping system.

List of Open Source Software/learning website:

- https://beeindia.gov.in/content/energy-auditors

UPL University of Sustainable Technology

Shroff S.R. Rotary Institute of Chemical Technology

Master of Engineering
Subject Code: TE3107
Subject Name: Programme Elective II (Combustion Engineering)

Semester: - 1

Type of course: Applied Thermodynamics (Advanced)

Prerequisite: Internal Combustion Engine and Heat Transfer

Rationale: To understand and analyze the combustion with emphasis on engineering applications.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
03	01	0	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs.
	SECTION-A	
1	**Thermodynamics of Combustion:** Fuels and combustion, Theoretical and actual combustion processes, Enthalpy of formation and enthalpy of combustion, First law analysis of Reacting systems, Adiabatic flame temperature, Entropy change of reacting systems, Second law analysis of reacting systems, problems	**05**
2	**Chemical Kinematics:** Rate of reactions and their functional dependence - chain reactions, Pre-Ignition kinetics, Global reactions, Nitrogen Oxide kinetics, Soot kinetics.	**06**
3	**Combustion of Gaseous and Vaporized Fuels:** Review of types of fuels, Types of flames, Energy balance and furnace efficiency, Burner type, Emissions from gas-fired furnaces, Emissions control, Chamber design, Detonation	**07**
	SECTION-B	
4	**Combustion of Liquid Fuels:** Spray combustion in furnace, spray formation and droplet behavior, Gas turbine operating parameters, combustor design, ignition delay, and detonation of liquid fuel sprays	**05**

Master of Engineering
Subject Code: TE3107
Subject Name: Programme Elective II (Combustion Engineering)

5	**Combustion of Solid Fuels:** Drying of solid fuels, devolatilization of solid fuels, stoker-fired boilers, Refuse and biomass fired boilers, Pulverized coal-burning systems, Pulverized coal combustion, Emission from pulverized coal	**06**
6	**Fluidized Bed Combustion:** Fluidization fundamentals, combustion in bubbling bed, atmospheric fluidized bed combustion systems, circulating fluidized beds, pressurized fluidized bed combustion.	**07**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
20	**25**	**20**	**20**	**15**	**00**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Test Books:

1. Sharma S. P. and Chandramohan, "Fuels and Combustion" - Tata McGraw Hill Publishing Company Limited – 1984

Reference Books:

1. Turns S. R., "An Introduction to Combustion" – Tata McGraw Hill - 1996
2. Borman G. L. and Ragland K. W. - 'Combustion Engineering' - McGraw-Hill - 2005
3. Kuo K. K., "Principles of Combustion" - John Wiley & Sons - 1984
4. Heywood J. B., "Internal Combustion Engine Fundamentals" – McGraw Hill - 1993
5. Yunus.A.Cengel, "A textbook of Thermodynamics".

List of Practical/ tutorials:

1. To understand the theoretical and practical combustion process.
2. To study about different methods to find out calorific value of fuel.

3. To apply second law of thermodynamics to different system.
4. To understand concept of laminar and diffused flame speed of fuel and different methods to find out this flame speed.
5. To understand different chemical Kinematics.
6. To study different techniques related to combustion of solid fuels.
7. To do energy balance of combustion process in different furnaces.
8. To do energy balance of combustion process in different application.
9. Selection criteria for gaseous and vaporized fuels.
10. To understand different fluidized bed combustion techniques with selection criteria.

Course Outcomes:

Sr. No.	CO statement
CO-1	Acquire an overview of combustion process and different methodology related to combustion.
CO-2	Assess and analyze combustion kinematics.
CO-3	Interpret the basic principle of combustion of gaseous and vaporized fuels
CO-4	Analyze the combustion phenomena of liquid fuel.
CO-5	Interpret and estimate combustion phenomena of different type of solid fuels at different application.
CO-6	Understand the different types process of fluidized bed combustion and its application.

List of Open Source Software/learning website:

- Students can refer to video lectures available on the websites including NPTEL.
- Students can refer to the CDs which are available with some reference books for the solution of problems using software/spreadsheets.
- https://ocw.mit.edu

UPL University of Sustainable Technology

Shroff S.R. Rotary Institute of Chemical Technology

Master of Engineering
Subject Code: TE3108
Subject Name: Advanced Power Plant Engineering

Semester: - I

Type of course: Program Elective Course

Prerequisite: Engineering Thermodynamics, Heat Transfer and Thermal Engineering

Rationale: To make the students to understand the energy scenario and the environmental issues related to the power plants also to create awareness to the students on the various utilities in the power plants and the avenues for optimizing them.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	1	0	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs.
	SECTION-A	
1	**Introduction To Power Plants:** Layout of Steam, Hydel, Diesel, MHD, Nuclear and Gas turbine Power Plants Combined Power cycles, Comparison and selection, Load duration Curves, Recent developments in power generation.	**03**
2	**Steam Power Plant:** Steam power plant: Main elements and working of steam power plant, Steam boilers and cycles, Super Critical Boilers, Fluidized Bed Boilers, thermodynamic analysis of simple Rankine cycle, performance enhancement methods; regeneration (up to 3-stages), reheat, thermal analysis of steam condenser & cooling tower, recent development and advancement in steam power plant engineering, maintenance as well as safety measure of components of steam power plant.	**10**
3	**Advanced Power Cycles:** Cogeneration systems, topping & bottoming cycles, Performance indices of cogeneration systems, Heat to power ratio, Thermodynamic performance of steam turbine cogeneration systems, Thermionic steam power plant.	**05**

Master of Engineering
Subject Code: TE3108
Subject Name: Advanced Power Plant Engineering

SECTION-B		
4	**Nuclear And Hydroelectric Power Plants :** Nuclear Energy-Fission , Fusion Reaction, General aspects of Nuclear Engineering, Components of nuclear power plants, Nuclear reactors & types – PWR, BWR, CANDU, Gas Cooled, Liquid Metal Cooled and Breeder reactor, Nuclear safety, Environmental issues. Bi-Product of nuclear power generation, Nuclear power plant in India, three stage program, Future of nuclear power. Hydroelectric Power plants, classifications, essential elements, pumped storage systems, Micro and mini hydel power plants	**07**
5	**Diesel And Gas Turbine Power Plant:** Types of diesel plants, components, Selection of Engine type, applications, Gas turbine power plant, Fuels, Gas turbine material, open and closed cycles, Reheating, Regeneration and Intercooling, Combined steam and gas turbine plant.	**06**
6	**Power From Renewable Energy And Economics Of Power Plants:** Construction and working of Wind, Tidal, Solar Photovoltaic (SPV), Solar Thermal, Geo Thermal and Fuel Cell power systems, Cost of electric Energy, Fixed and operating costs, Energy rates, Types tariffs, Economics of load sharing, Comparison of various power plants, Pollution control technologies including Waste Disposal Options for Coal and Nuclear Power Plants.	**05**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
25%	**20%**	**30%**	**20%**	**5%**	**0**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

TextBooks:

1. Power Plant Engineering By Dr. R.K. Shukla, Tech-Neo Publications, 2021.
2. Plant Engineering By H.G. Katariya & J.P. Hadiya, 8th Edition, Books India Publication.

Reference Books:

1. Conventional and Alternative Power Generation: Thermodynamics, Mitigation and Sustainability By Neil Packer, Tarik Al-Shemmeri, Willey Publication.

2. A Course in Power Plant Engineering by Arora S.C and Domkundwar S, Dhanpat Rai, 2001.
3. Power Plant Engineering by Nag P.K, Third edition Tata McGraw- Hill, 2007.
4. Thermal Engineering by R.K.Rajput, Laxmi Publication.
5. Introduction to Nuclear by Lamarsh, J.R., Engg.2nd edition, AddisonWesley, 1983.

List of Tutorials:

1. Layouts of Different types of Power plants.
2. Working of Supercritical boiler and fluidized boilers.
3. Problems on performance of Steam Power plant.
4. Explain Thermodynamic performance of steam turbine cogeneration systems with examples.
5. Different types of Nuclear Reactors with construction and working diagram.
6. Arrangement and Working of Diesel Power plant.
7. Problems on performance of Gas Turbine power plant.
8. Case study on combined steam and gas turbine plant.
9. Construction and working of different Power plant based on Renewable energy.
10. Estimate the costs of electrical energy production.

Course Outcomes:

Students will be able to:

Sr. No.	CO statement
CO-1	**Define** the basic concepts of different power generation methods and its layouts.
CO-2	**Familiarization** with Steam power plant, components and will have specialized knowledge in steam boiler performance evaluation.
CO-3	**Study** various methods of Advanced power cycle for thermodynamic analysis.
CO-4	**Understand** construction, working and significance of gas Nuclear power plant and Hydroelectric power plant.
CO-5	**Analyze** thermodynamic cycles of Diesel power plant and understand construction and significance of Gas turbine power plant.
CO-6	**Explain** the layout, construction and working of the components of Renewable Energy power plants and Estimate the costs of electrical energy production.

Master of Engineering
Subject Code: TE3108
Subject Name: Advanced Power Plant Engineering

List of Open Source Software/learning website:

- http://nptel.ac.in/
- http://npti.in/default.aspx

Industrial Visit: It is strongly suggested and recommended to arrange a visit to Thermal Power Plant/Hydro Power Plant /Nuclear Power Plant /Solar Power Plant.

UPL University of Sustainable Technology

Shroff S.R. Rotary Institute of Chemical Technology

Master of Engineering
Subject Code:
Subject Name: Research Methodology and IPR

Semester: - I

Type of course: Research Methodology and IPR

Prerequisite: Zeal to learn

Rationale: To orient students with the scientific methodology of research and presenting their thesis. To acquaint students with various Intellectual Property Rights.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
2	0	0	2	0	0	30	20	50

Content:

Sr. No.	Content	Total Hrs.
	SECTION-A	
1	**Introduction** Introduction to research (its meaning, objective, motivation & types), Importance of knowing how research is done, criteria of good research, Reviewing the literature, Identify the gaps, formulating a problem statement, its necessity and techniques involved.	2
2	**Research Design, Sampling Design, Measuring Technique** Research Design (its meaning, need, features), Different Research Design and basic principles of experimental designs. Sampling Design (its concept, steps, implication & criteria of selecting a sampling procedure), Characteristic of good sample design, types of sample design, sample selection, Measurement in Research, sources of errors in measurement, test of sound measurement,	5
3	**Design of Experiments** Test of hypotheses, Chi-square test, Analysis of Variance, full-factorial design, and fractional factorial design (resolution III, IV & V) design & Taguchi's Method, Response Surface Methodology	8
	SECTION-B	
4	**Patents, Designs, Trade and Copyright.** Process of Patenting and Development: Technological research innovation, patenting, development. International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.	2

Master of Engineering
Subject Code:
Subject Name: Research Methodology and IPR

5	**Patent Rights:** Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases.	**2**
6	**Drafting of thesis, and Patent** Method, use of various online tools and offline tools.	**2**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10%	**60%**	**10%**	**10%**	**5%**	**5%**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Text Books:

1. Kothari C. R. "Research Methodology – Methods & Techniques" New Age International Ltd, fourth edition, 2019
2. Dr Ramesh Shahabadkar and Dr S Sai Satyanarayana Reddy, "Intellectual Property Rights", Notion Press, 2019

Reference Books:

1. Ranjit Kumar, "Research Methodology: A Step by Step Guide for Begineers", 2nd edition.
2. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students"
3. Ramakrishna B & Anil Kumar H.S, "Fundamentals of Intellectual Property Rights: For Students, Industrialist and Patent Lawyers", 2017
4. S.V. Damodar Reddy "Intellectual Property Rights -- Law and Practice"
5. Montgomery D. C. "Design and Analysis of Experiments", eighth edition, John Wiley & Sons, 2012.

Course Outcomes:

Sr. No.	CO statement
CO-1	Understand and describe, the importance of, and, criteria of good research. Conduct quality literature review, find the research gap and Prepare Problem statement for his/her research
CO-2	Understand and select proper research design, sampling design or measuring technique for conducting research
CO-3	Use proper design of experiment technique
CO-4	Understand IPR protection for further research and better products
CO-5	Understand scope, application and procedure of Patent filing
CO-6	Familiarize with various tools available for drafting of thesis and patent.

Master of Engineering
Subject Code:
Subject Name: Research Methodology and IPR

List of Open Source Software/learning website:

- http://nptel.ac.in/
- http://npti.in/default.aspx

Industrial Visit: NA

UPL University of Sustainable Technology

Shroff S.R. Rotary Institute of Chemical Technology

Master of Engineering
Subject Code: MH3102
Subject Name: Disaster Management
Semester: - I

Type of course: Audit Course

Prerequisite: To provide students an exposure to disasters, their significance, types & Comprehensive understanding on the concurrence of Disasters and its management.

Rationale: To ensure that students begin to understand the relationship between vulnerability, disasters, disaster prevention, risk reduction and the basic understanding of the research methodology for risk reduction measures. Equipped with knowledge, concepts, and principles, skills pertaining to Planning, Organizing, Decision- making and Problem solving methods for Disaster Management.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
2	0	0	0	30	20	0	0	50

Content:

Sr. No.	Content	Total Hrs.
	SECTION-A	
1	Introduction Disaster: Definition, Factors And Significance; Difference Between Hazard And Disaster; Natural And Manmade Disasters: Difference, Nature, Types And Magnitude.	04
2	Repercussions Of Disasters And Hazards: Economic Damage, Loss Of Human And Animal Life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts	04
3	Disaster Prone Areas In India Study Of Seismic Zones; Areas Prone To Floods And Droughts, Landslides And Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post-Disaster Diseases And Epidemics	04
	SECTION-B	

Master of Engineering
Subject Code: MH3102
Subject Name: Disaster Management

4	Disaster Preparedness And Management Preparedness: Monitoring Of Phenomena Triggering A Disaster Or Hazard; Evaluation Of Risk: Application Of Remote Sensing, Data From Meteorological And Other Agencies, Media Reports: Governmental And Community Preparedness, Emergency Stage, Post Disaster stage- Rehabilitation. Remedy to Disasters, Role of panchayats in disaster mitigations	04
5	Risk Assessment Disaster Risk: Concept And Elements, Disaster Risk Reduction, Global And National Disaster Risk Situation. Techniques Of Risk Assessment, Global Co-Operation In Risk Assessment And Warning, People's Participation In Risk Assessment. Strategies for Survival.	04
6	Disaster Mitigation Meaning, Concept And Strategies Of Disaster Mitigation, Emerging Trends In Mitigation. Structural Mitigation And Non-Structural Mitigation, Programs Of Disaster Mitigation In India.	04

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
09	09	08	08	08	08

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Text book

1. Disaster Education and Management, A joyride for students, Teachers and Disaster managers by Rajendra Kumar Bhandari, Springer

Reference Books:

1. Disaster Science and Management by Bhattacharya,T., Mc-Graw Hill.
2. Understanding Earthquake Disasters by Sinvhal, A., Mc-Graw Hill.
3. Environmental Geography by Singh, S., Prayag Pustak Bhawan.
4. Disaster Management by Gupta, H.K., University Press.
5. Disaster Mitigation Experiences And Reflections by Sahni, Pardeep, Prentice Hall Of India, New Delhi.

6. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'New Royal book Company

7. Goel S. L. , Disaster Administration And Management Text And Case Studies" ,Deep &Deep Publication Pvt. Ltd., New Delhi

Course Outcomes:

After Learning this Course, Students will be able to:

Sr. No.	CO statement
CO-1	Develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations
CO-2	Learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response
CO-3	Understand Disaster management and Risk Reduction measures.
CO-4	Apply the concepts in real life scenario.
CO-5	Identify the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in
CO-6	Classify understanding of key concepts in disaster risk reduction and humanitarian response

List of Open Source Software/learning website:

- http://nptel.ac.in/

UPL University of Sustainable Technology

Shroff S.R. Rotary Institute of Chemical Technology

Master of Engineering
Subject Code: TE3109
Subject Name: Advanced Fluid Mechanics and Gas Dynamics

Semester: - II

Type of course: Core

Prerequisite: Undergraduate knowledge in Fluid Mechanics and Gas Dynamics

Rationale: The course is designed with a thorough understanding of fluid mechanics and gas dynamics.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs.
	SECTION-A	
1	Introduction: Review of the fundamentals of fluid mechanics, Kinematics of fluids, Lagrangean and Eulerian systems, Velocity potential, Stream function and Vorticity, Euler's equation and Bernoulli's equation-applications of the Bernoulli's equation.	6
2	Viscous incompressible flows: General viscosity law, Navier – Stokes Equation and exact solutions, Couette flow, Hagen-Poiseuille flow, Flow between two concentrating rotating cylinders, Low Reynolds number flow, Hydrodynamic theory of lubrication.	8
3	Turbulent Flows: Introduction to turbulent Flow, Reynolds experiment, Frictional loss in pipe flow, Shear stress in turbulent flow, Velocity distribution in turbulent flow, Turbulent boundary layer.	6
	SECTION-B	
4	Introduction to Compressible Flow: Review of fundamentals-stagnation Properties – relations, Propagation of motion in compressible fluids-Mach number.	5
5	Isentropic Flow: Isentropic flow relations-flow through nozzles and diffusers- Isentropic flow relations and Tables-Numericals.	6
6	Normal shocks: Fanno line flows, Ryleigh line flows, Flow properties across normal shocks, Oblique shock.	5

Master of Engineering
Subject Code: TE3109
Subject Name: Advanced Fluid Mechanics and Gas Dynamics

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
15	10	25	20	15	15

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Text Books:

1. R.K.Bansal, A Text Book of Fluid Mechanics and Hydraulic Machines, Laxmi Publications Limited, New Delhi.
2. K Murlidhar and G Biswas, Advanced Fluid Mechanics, Narosa Publication

Reference Books:

1. F M White, Fluid Mechanics, McGraw Hill Publishing Co. Ltd.
2. F M White, Viscous Fluid Flow, McGraw Hill Publishing Co. Ltd.
3. Yunus Cengel and John Cimbala, Fluid Mechanics, McGraw Hill Publishing Co. Ltd.
4. H Schlichting, Boundary Layer Theory, McGraw Hill Publishing Co. Ltd.
5. Fox, Pritchard and McDonald, Introduction to Fluid Mechanics, John Wiley & Sons
6. Zucker & Biblarz, Fundamentals of Gas Dynamics, John Wiley & Sons, Inc.
7. James John and Theo Keith, Gas Dynamics, Pearson Prentice Hall
8. S M Yahya, Fundamentals of Compressible Flow, New Age International Publishers
9. Gas dynamics by Babu, Blachandran, Ramachandran, Radhakrishnan, Zoeb Husain

List of Practicals:

1. To study the effect of angle of attack on Lift and Drag force.
2. To study the loss of energy in wake region behind various models (car, jeep, bus etc.) in the wind tunnel.
3. To draw profile of NACA Aero foils.

4. To Investigate on Recent development and advances in rarefied gas dynamics.
5. Determination of friction factor as a function of Reynolds number in pipe flow
6. To visualize and plot the pattern of flow around an object in a fluid stream using Hale-Shaw apparatus.
7. To develop temperature distribution in thermal boundary layer for the flow over a flat plate.
8. Measurements of boundary layer thickness using numerical & analytical solution.
9. To develop a Gas Table (Isentropic flow, Normal shocks, Fanno flow, Rayleigh flow) for different γ values.
10. A case study: Performance of real nozzle.

Course Outcomes:

Sr. No.	CO statement
CO-1	Understand the kinematics and dynamics of fluid mechanics.
CO-2	Apply the principles of low Reynolds number flows to fluid flow systems.
CO-3	Apply the concepts of turbulent flow in turbulence model.
CO-4	Review the concepts of compressible flow to various fluid flow systems.
CO-5	Create the Gas Table for isentropic flow.
CO-6	Analyze the principles of normal shock formation and its effects.

List of Open Source Software/learning website:

https://nptel.ac.in/courses/

UPL University of Sustainable Technology

Shroff S.R. Rotary Institute of Chemical Technology

Master of Engineering
Subject Code: TE3110
Subject Name: Advanced Refrigeration & Air Conditioning Systems

Semester: - II

Type of course: Program Core Course

Prerequisite: Basics of Refrigeration & Air conditioning principle

Rationale: The course is designed to give knowledge of various refrigeration & air conditioning systems, properties of refrigerants and its behavior under various conditions

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs.
SECTION-A		
1	**Refrigerants:** Alternate eco-friendly refrigerants and their properties, secondary refrigerants, mixture of refrigerants, azeotropics **Air Refrigeration:** Aircraft refrigeration systems – simple, Boot strap, regenerative and reduced ambient, analysis of an aircraft refrigeration cycles and their applications	**5**
2	**Vapour Compression & Absorption Refrigeration:** dual pressure vapour compression system and its analysis, compound compression with flash cooler and flash intercooler, multiple expansions, various types of cascade systems and their analysis Analysis of vapour absorption refrigeration systems, heat balance, COP comparison with vapour compression refrigeration systems, two stage vapour absorption refrigeration system, solar driven sorption systems	**8**
3	**Load estimation:** Sources of heat generation, insulating materials, design principles of cold storage, milk tankers and blood plasma storage. Refrigeration Applications: Refrigeration for preservation of food, refrigerating systems for transport by trucks and containers, Refrigerated railway cars, Marine	**5**

	refrigeration.	
SECTION-B		
4	**Applied psychometric:** Different psychrometric charts, combinations of different processes and their representation on psychrometric charts, psychrometric calculations for cooling and dehumidification, high latent heat load, dehumidified air quantities based on total and effective room loads, GSHF and RSHF, effective surface temperature, effect of bypass factor on GSHF, analysis for using all outside air, psychrometric of partial load control	**4**
5	**Design conditions and Heat load calculation:** Selection of inside design conditions for different applications, Thermal comfort, Different equations governing thermal exchanges, environmental indices, AQ and its importance, Basic terminology for heat load calculation, heat transfer through walls and roofs, heat gain through glass, solar heat gain factor, shading of glass, shading devices and its selection, load due to other sources, stack effect, brief idea about other ASHRAE methods of calculating cooling load.	**9**
6	**Air conditioning systems:** Factors affecting the selection of the systems, classification, design procedure, system features, controls of all air, air water, all water, DX, VAV and dual duct systems, basic idea of cold air distributions systems	**5**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10	**20**	**20**	**20**	**20**	**10**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Text Books:

1. Refrigeration and air conditioning, C. P. Arora, McGraw Hill

Reference Books:

1. ASHRAE Hand Book, (1) Fundamentals (2) Refrigeration
2. 40 Lessons on Refrigeration and Air Conditioning IIT KGP
3. Principles of Refrigeration, R J Dossat, Pearson Education Asia
4. Refrigeration and air conditioning, Stocker, McGraw Hill
5. Refrigeration and air conditioning, Jordan and Priester, McGraw Hill

Master of Engineering
Subject Code: TE3110
Subject Name: Advanced Refrigeration & Air Conditioning Systems

List of Practical/ tutorials:

1. To compare and analyze advance refrigeration cycle for different refrigerants.
2. Performance analysis of VCR system using capillary tube as a throttling device.
3. Performance analysis of VCR system using thermostatic expansion valve as a throttling device.
4. Design of a vapour absorption refrigeration (LiBr-H2O or NH3-H2O) system for a particular application.
5. Design of cascade refrigeration system for a particular application.
6. To study various instruments used in air conditioning.
7. Study of advanced air conditioning systems.
8. Study of air conditioning test rig.
9. Performance evaluation of air conditioning system with different psychrometric conditions.
10. To carry out cooling load calculation of a residential/commercial building.

Course Outcomes:

Sr. No.	CO statement
CO-1	Appraise refrigerants, their properties and air refrigeration system.
CO-2	Discuss vapor compression & absorption refrigeration systems and analyze them.
CO-3	Estimate the refrigeration load and appraise applications of refrigeration.
CO-4	To make calculation of various Psychometric processes
CO-5	To estimate the cooling load requirements of residential and commercial building and design the system components accordingly
CO-6	To develop the skills to analyze the domestic and industrial requirement of air conditioning systems

List of Open Source Software/learning website:

- nptel.ac.in

UPL University of Sustainable Technology

Shroff S.R. Rotary Institute of Chemical Technology

Master of Engineering
Subject Code: TE3111
Subject Name: Design of Heat Exchanger

Semester: - II

Type of course: Program Elective Subject

Prerequisite: Fundamentals of Heat Transfer

Rationale: The course is design to provide fundamental knowledge of different type of heat exchangers used for thermal application

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs.
	SECTION-A	
1	**Basic design methodologies:** Classification of heat exchanger, selection of heat exchanger, Thermal-Hydraulic fundamentals, Overall heat transfer coefficient, LMTD method for heat exchanger analysis for parallel, counter, multipass and cross flow heat exchanger, e-NTU method for heat exchanger analysis, heat exchanger design methodology	**6**
2	**Design of double pipe heat exchangers:** Thermal and Hydraulic design of inner tube and annulus, hairpin heat exchanger with bare and finned inner tube, total pressure drop	**5**
3	**Design of Shell & tube heat exchangers:** Basic components, basic design procedure of heat exchanger, TEMA code, J-factors, conventional design methods, Bell-Delaware method.	**8**
	SECTION-B	
4	**Fouling of heat exchangers:** Basic consideration, effect of fouling on heat transfer and pressure drop, cost of fouling, design of heat exchangers subject to fouling, fouling resistance, cleanliness factor, techniques to	**5**

Master of Engineering
Subject Code: TE3111
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	control fouling	
5	**Design of compact heat exchangers:** Heat transfer enhancement, plate fin heat exchanger, tube fin heat exchanger, heat transfer and pressure drop	**6**
6	**Heat transfer enhancement and performance evaluation:** Enhancement of heat transfer, Performance evaluation of Heat Transfer Enhancement technique. Introduction to pinch analysis	**6**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10	**15**	**15**	**20**	**10**	**05**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Text Books:

1. Fundamentals of Heat Exchanger Design by Ramesh K Shah, Wiley Publication
2. Heat Exchanger Selection, Rating and Thermal Design by Sadik, Kakac, CRC Press

Reference Books:

1. Compact Heat Exchangers by Kays, V.A. and London, A.L.,McGraw Hill
2. Heat Exchanger Design Handbook by Kuppan, T, Macel Dekker, CRC Press
3. Process Heat transfer by Donald Q Kern, McGraw Hill

List of Practicals:

1. Design of heat exchange equipment by using LMTD method.
2. Design of heat exchange equipment by using effectiveness– NTU method.
3. Design and analysis of double pipe heat exchanger with parallel and counter flow arrangement.
4. Design and analysis of shell and tube type heat exchanger.
5. Measure the effectiveness of shell and tube heat exchanger.
6. Design and analysis of plate type heat exchanger.

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Subject Name: Design of Heat Exchanger

Course Outcomes:

Sr. No.	CO statement
CO-1	Understand the basic concept and design methodology of heat exchangers
CO-2	Determine general design requirements for different types of heat exchangers
CO-3	Learn to select appropriate Heat Exchanger for the given application
CO-4	Estimate the overall heat transfer coefficient and the effectiveness of a heat exchanger
CO-5	Measure the performance degradation of heat exchangers subject to fouling
CO-6	Become aware of single and multiphase heat transfer and friction coefficient correlations

List of Open Source Software/learning website:

- nptel.ac.in
- www.learnerstv.com
- cosmolearning.org

UPL University of Sustainable Technology

Shroff S.R. Rotary Institute of Chemical Technology

Master of Engineering
Subject Code: ME6233
Subject Name: Theory of Heat Pipes

Semester: - II

Type of course: Program Elective III

Prerequisite: Heat-transfer, Fluid mechanics

Rationale: Course is intended to offer to be get aware about the design methods, thermal performance & their applications in thermal engineering.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs.
	SECTION-A	
1	Heat Pipe: Operating principle, Working fluids and its temperature ranges, Heat transfer limits and Heat pipe characteristics, Various Applications.	**4**
2	Interfacial heat and mass transfer, Physical surface phenomena, Capillary and disjoining forces – Interfacial resistance in vaporization and condensation process, Interfacial mass, Momentum, energy, pressure balance – Interfacial phenomena in grooved structures.	**6**
3	Heat Pipe Analysis: Steady hydrodynamics – Thermal characteristics and heat transfer limitation, Thermal Fluid phenomena in capillary media, Vapor flow Analysis, Thermal characteristics including the wall effects and effect of vapor flow – Capillary boiling – Sonic.	**6**
	SECTION-B	
4	Entrainment, Viscous, condenser, Continuum, and Frozen startup Limitations - Area temperature relations -Heat pipe dimensions and structural considerations - Heat pipe heat exchanger – Design procedures.	**8**
5	Heat pipe Behaviour: Transient response to sudden change in temperature heat input, Frozen startup and shut down of heat pipe – Numerical and Analytical model for Frozen start up.	**6**

Master of Engineering
Subject Code: ME6233
Subject Name: Theory of Heat Pipes

6	Two phase closed Thermosyphon – Reflux condensation heat transfer in Analysis, Evaporation heat transfer Analysis, Transient and oscillatory behavior of Thermosyphon. Minimum liquid fill requirement, Thermosyphon with capillary wicks.	**6**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
5%	**25%**	**30%**	**20%**	**15%**	**5%**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Text Books:

1. Amir Faghr, "Heat Pipe Science and Technology", Taylor & Francis, 1995.
2. M.N. Ivanovskii, "The Physical Principles of Heat Pipes", V.P. Sorokin and I.V. Yagodkin, Clarendon press, Oxford.

Reference Books:

3. S.W. Chi, "Heat Pipe Theory and Practice", the Hemisphere publishing corporation, Inc., Washington, 1976.
4. Dunn, P.D and Reay, D.A, "Heat Pipes" (3rd Edition), Pergamon Press,1982.
5. Amir Faghr, "Heat Pipe Science and Technology", Taylor & Francis, 1995.
6. V.P. Carey, "Liquid – Vapor phase – Change phenomena: An Introduction to the Thermophysics of vaporization and condensation Processes in Heat Transfer Equipment", Hemisphere Publishers, New York, 1992.
7. J.N. Israelachvili, "Intermolecular and Surface Forces", Academic press, London,1985.
8. I.B. Ivanov, "Thin Liquid films: Fundamentals and Application", Marcel Dekkar, New York, 1988.
9. M.N. Ivanovskii, "The Physical Principles of Heat Pipes", V.P. Sorokin and I.V. Yagodkin, Clarendon press, Oxford.

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List of Practical/ tutorials:

1. Design the heat pipe container.

2. Determine the capillary limitation on heat transport capability.

3. Determine the effective thermal conductivity of wick structure.

4. Determination of Heat Transfer Coefficient in a Forced Convention Flow through a Pipe.

5. Determine the Overall heat transfer coefficient for Parallel flow heat exchanger.

6. Determine the Overall heat transfer coefficient for Counter flow heat exchanger.

7. Experimental analysis over two phase closed Thermosyphon.

8. Determine Reflux condensation heat transfer Analysis

9. Solve the physical surface phenomena over the pipes.

10. Determine the vapor flow analysis.

Course Outcomes:

Sr. No.	CO statement
CO-1	Learn how to design the heat pipe.
CO-2	Learn to select appropriate heat pipe for the application.
CO-3	Do the design calculation for the heat transfer.
CO-4	Create the heat pipe modeling on the software for design.
CO-5	Analyze the thermal performance & consider the improvement in the design criteria.
CO-6	Do the research / project work related to the heat pipe.

List of Open Source Software/learning website:

- nptel.ac.in
- www.learnerstv.com
- Cosmolearning.org

Master of Engineering
Subject Code: ME6233
Subject Name: Theory of Heat Pipes

UPL University of Sustainable Technology

Shroff S.R. Rotary Institute of Chemical Technology

Master of Engineering
Subject Code: TE3113
Subject Name: Computational Fluid Dynamics

Semester: - II
Type of course: Program Elective Subject
Prerequisite: Basics of Fluid Mechanics

Rationale: This course aims to introduce numerical modelling and develop finite difference and finite volume discretized forms of the CFD equations and to formulate explicit & implicit algorithms for solving the Euler Equations & Navier Stokes Equations.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs.
	SECTION-A	
1	**Introduction:** Illustration of the CFD approach, CFD as an engineering analysis tool, Review of governing equations, Modeling in engineering, Partial differential equations- Parabolic, Hyperbolic and Elliptic equation, CFD application in Chemical Engineering, CFD software packages and tools.	**4**
2	**Finite difference discretization:** Elementary finite difference coefficients, basic aspects of finite difference equations, consistency, explicit and implicit methods, errors and stability analysis. Stability of elliptic and hyperbolic equations. Fundamentals of fluid flow modeling- conservative property, upwind scheme, transporting property, higher order up winding	**5**
3	**Grid Transformation:** Introduction, general transformation equations, matrices and Jacobean, transformed version of governing equation particularly suited for CFD, compressed grids, elliptic grid generation, adaptive grids.	**5**
	SECTION-B	

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4	**Simple CFD Technique**: Lax Wandroff technique, Mac-Cormack's technique, relaxation technique and its use with low speed, alternating direction implicit technique (ADI), pressure correction technique: need for staggered grid and its formula, boundary condition for pressure correction method	**8**
5	**Heat Conduction and Convection Conduction:** 1D conduction equation, grid layout discretization, stability and convergence, dealing with non-linearity, methods of solution, 2D conduction. Convection: 1D convection, exact solution and its discretization, upwind difference scheme, comparison of central difference scheme, upwind difference scheme and exact solution, numerical false diffusion, hybrid and power-law schemes, total variation diminishing scheme, 2D Convection: cartesian and complex domain, Unsteady conduction and convection, Stability of the unsteady flow	**8**
6	**Finite Volume Method:** Introduction to finite volume method (FVM), FVM for diffusion and convection–diffusion problems, discretization of equation for two dimensions, false diffusion, computation of the flow field using stream function and vorticity formulation, solution procedure for unsteady flow calculations: SIMPLE, SIMPLEC, PISO, and MAC algorithms, Solution algorithms for pressure–velocity coupling in steady flows	**6**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10	**25**	**15**	**25**	**10**	**05**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Text Books:

1. An Introduction to Computational Fluid Dynamics: The Finite Volume Method by H. Versteeg, Pearson
2. Introduction to Computational Fluid Dynamics: Development, Application and Analysis by Atul Sharma, Willey

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Subject Name: Computational Fluid Dynamics

Reference Books:

1. Fundamentals of Computational Fluid Dynamics, Tapan K. Sengupta, Universities Press.
2. Computational Fluid Dynamics the Basics with Applications, John D Anderson, Jr., McGraw Hill Book Company.
3. Principles of Computational Fluid dynamics, Pieter Wesseling, Springer International Edition
4. Computational Fluid Mechanics and Heat Transfer Anderson, D. A., Tannehill, J. C., Pletcher, R. H., Hemisphere

List of Practical:

1. Perform Analytical and Numerical analysis on Pin-Fin to calculate temperature distribution.
2. Perform Analytical and Numerical analysis on 1-D steady state heat conduction to calculate temperature distribution along wall thickness.
3. Perform Analytical and Numerical analysis on 2-D steady state heat conduction to calculate temperature distribution along wall thickness.
4. Perform Analytical and Numerical analysis on 1-D unsteady state heat conduction along the wall thickness.
5. Perform Analytical and Numerical analysis on 2-D unsteady state heat conduction along the wall thickness.
6. Perform Analytical and Numerical analysis on unsteady state heat transfer by convection.

Course Outcomes:

Sr. No.	CO statement
CO-1	Understand and be able to numerically solve the governing equations for fluid flow
CO-2	Comprehend the methodology and algorithms of CFD analysis.
CO-3	Gain the elementary knowledge of finite elements method for flow and heat transfer problems.
CO-4	Understand and apply finite difference, finite volume and finite element methods to fluid flow problems
CO-5	Analyse the numerical simulation to solve major engineering design problems involving fluid flow and heat transfer
CO-6	Analyze radiation heat transfer problems of various thermal systems

Master of Engineering
Subject Code: TE3113
Subject Name: Computational Fluid Dynamics

List of Open Source Software/learning website:

- Open FOAM and SCILAB
- www. Cfd-online.com
- https://fluids.ac.uk/talks
- http://www.efluids.com

UPL University of Sustainable Technology

Shroff S.R. Rotary Institute of Chemical Technology

Master of Engineering
Subject Code: TE3114
Subject Name: Boiler Auxiliaries and Performance Evaluation

Semester: - II

Type of course: Elective

Prerequisite: Basic knowledge of a boiler

Rationale: The course is designed to enable the performance analysis and assessment of a boiler**.**

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	0	3	70	30	0	0	100

Content:

Sr. No.	Content	Total Hrs.
	SECTION-A	
1	Overview of boilers auxiliaries: Different auxiliaries used in an industry, safety valves, PA , FD and ID Fan, Burner and wind box arrangements, fans and their classifications.	3
2	Boiler auxiliaries system: Air and draft system, fuel firing system, pulveriser system, fuel system and boiler auxiliaries' specifications.	6
3	Boiler performance parameters: boiler efficiency: direct and indirect method, boiler evaporation ratio, boiler blowdown, boiler terminologies.	7
	SECTION-B	
4	Factors affecting boiler performance: heat loss due to dry flue gas, heat loss due to evaporation of water formed, heat loss due to moisture present in fuel and air, heat loss due to incomplete combustion, heat loss due to radiation and convection, heat loss due to unburned carbon in fly ash and bottom ash, boiler water treatment.	5
5	Energy performance assessment: introduction, purpose of the performance test, performance terms and definitions, measurements	8

Master of Engineering
Subject Code: TE3114
Subject Name: Boiler Auxiliaries and Performance Evaluation

	required for performance assessment testing, test conditions and precautions for indirect method testing, boiler efficiency and blowdown calculation.	
6	Energy conservation techniques: Stack temperature, feed water heating using economizer, Combustion Air Preheat, Incomplete Combustion, Excess Air Control, Radiation and Convection Heat Loss, Automatic Blowdown Control, Reduction of Scaling and Soot Losses, Reduction of Boiler Steam Pressure, Variable Speed Control for Fans, Blowers and Pumps, Proper Boiler Scheduling, Boiler Replacement, Case Study for energy saving opportunities.	6

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10	15	20	20	20	15

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Text Books:

1. Boiler Operation Engineering by P. Chattopadhyay, Tata McGraw Hill Publishing Co. Ltd, New Delhi

Reference Books:

1. Boiler Operation Engineering by P. Chattopadhyay, Tata McGraw Hill Publishing Co. Ltd, New Delhi
2. Steam Boiler Operation by James J.Jackson,Prentice-Hall Inc,New Jersey, 1980.
3. Boilers by Carl D.Shields, McGraw Hill Book Company,U.S, 1961.
4. Industrial Heat Generation and Distribution -NIFES Training Manual Issued For CEC – India Energy Bus Project
5. Practical Boiler Water Treatment by Leo.I.Pincus,McGraw Hill Inc,New York, 1962.
6. Technical Papers, Boiler Congress-2000 Seminar, 11 & 12 January 2000
7. Bureau of Energy Efficiency 532. Boilers

8. Industrial Boilers by David Gunn and Robert Horton, Longman Scientific & Technical, New York
9. Steam Generation, Distribution and Utilisation by TERI, GTZ and EMC
10. Efficient Operation of Boilers by National Productivity Council
11. Energy Hand book, Second edition, Von Nostrand Reinhold Company - Robert L.Loftness

Course Outcomes:

Sr. No.	CO statement
CO-1	Review the boiler auxiliaries and the arrangement.
CO-2	Describe the important auxiliaries system used in a boiler.
CO-3	Understand the concept of boiler performance parameters.
CO-4	Recognize and enlist the factors affecting the performance of a boiler.
CO-5	Evaluate and analyze the performance parameters for the assessment.
CO-6	Identify the energy saving opportunities in a boiler.

List of Open Source Software/learning website:

https://beeindia.gov.in/content/energy-auditors

UPL University of Sustainable Technology

Shroff S.R. Rotary Institute of Chemical Technology

Master of Engineering
Subject Code: TE3115
Subject Name: Programme Elective IV (Exergy Analysis of Thermal Systems)
Semester: - II

Type of course: Applied Thermodynamics (Advanced)

Prerequisite: Fundamental knowledge of thermodynamics and energy analysis of thermal components and power cycle

Rationale: The course is design to impart detailed study of exergy analysis of various thermal systems and exergy-economics.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
03	00	0	3	70	30	00	00	100

Content:

Sr. No.	Content	Total Hrs.
	SECTION-A	
1	**Basic exergy concepts:** Basic concept of energy analysis of thermal system, Classification of forms of exergy, concepts of exergy, exergy concepts for a control region, physical exergy, chemical exergy, exergy concepts for closed system analysis.	**05**
2	**Exergy Analysis of Simple Processes:** Expansions process, Compression processes, Heat transfer process, Mixing & separation Process, Chemical process including combustion.	**06**
3	**Elements of plant analysis:** Control mass analysis, Control region analysis, Criteria of performance, Pictorial representation of exergy balance, Exergy based property diagram.	**07**
	SECTION-B	
4	**Exergy Analysis of Power Plant Cycles:** Maximum power subject to size constraint with fixed heat input and its application to Brayton cycle Steam turbine power plants: External and internal irreversibility, superheater, reheater, vacuum condenser, regenerative feed water heating,	**05**

Master of Engineering
Subject Code: TE3115
Subject Name: Programme Elective IV (Exergy Analysis of Thermal Systems)

	combined feed water heating and reheating Gas turbine power plant: External and internal irreversibility, regeration, reheater, and intercooler, combined steam and gas turbine power plant	
5	**Exergy Analysis of Refrigeration & Air conditioning Systems:** Joule-Thomson Expansion, Work- Producing Expansion, Optical intermediate cooling, Exergy analysis of air-conditioning application, Mixture of air and water vapour, Total flow exergy of humid air and liquid water, Evaporative cooling process and other aspects	**06**
6	**Exergy-Economic Analysis:** Fundamental of exergy-economic, Exergy costing of thermal components of steam and gas turbine, Boiler, Cogeneration system, Exergy analysis of renewable energy systems	**07**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
20	**25**	**20**	**20**	**15**	**00**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Text Books:

1. T J Kotas, "The Exergy Method of Thermal Plant Analysis" Krieger Publishing Company

Reference Books:

1. Adrian Bejan, "Advanced Engineering Thermodynamics" John Wiley & Sons.
2. T J Kotas, "The Exergy Method of Thermal Plant Analysis" Krieger Publishing Company
3. D E Winterbore, Ali Turan, Kidlington, "Advance Thermodynamics for Engineers" Oxford
4. Michel J Moran, Howard N Shapiro, Daisie D Boettne, Argaret Bailey, "Fundamentals of Engineering Thermodynamics" Wiley Publication
5. Adrian Bejan, George Tsatsaronis, Michael Moran, "Thermal Design and Optimization" John Wiley & Sons, Inc.

6. Kenneth Wark, "Advanced Thermodynamics for Engineers" McGraw Hill Publishing Co. Ltd.

Course Outcomes:

Sr. No.	CO statement
CO-1	Acquire an overview of exergy and different methodology for analysis of different system.
CO-2	Identify and apply concepts, theorems of thermodynamics to the various thermal and fluid engineering system.
CO-3	Apply the concepts of exergy analyses in power plants.
CO-4	Apply the concepts of exergy analyses in refrigeration and Air conditioning application.
CO-5	Interpret and estimate exergy losses by, exergy calculations, exergetic efficiency, exergy charts.
CO-6	Calculate exergy-economics costing of thermal components.

List of Open Source Software/learning website:

- Students can refer to video lectures available on the websites including NPTEL.
- Students can refer to the CDs which are available with some reference books for the solution of problems using software/spreadsheets.
- https://ocw.mit.edu

UPL University of Sustainable Technology

Shroff S.R. Rotary Institute of Chemical Technology

Master of Engineering
Subject Code: TE3116
Subject Name: Thermal Measurements and Process Controls

Semester: II

Type of course: Program Elective Course

Prerequisite: Nil

Rationale: The course is designed to provide the fundamental knowledge of experimentation techniques, related instruments used for thermal engineering applications.

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Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	0	3	70	30	00	00	100

Content:

Sr. No.	Content	Total Hrs.
	SECTION-A	
1	**Experimentation Planning:** Planning of experiments, various stages in experimental investigations; preliminary, intermediate and final, steady state and transient techniques, selection of measuring devices based on static, dynamic characteristics and allowable uncertainties, basics of Taguchi method for design of experiments	**05**
2	**Instrumentation & Measurements:** Fundamental elements of a measuring instrument, static and dynamic characteristics, principles of temperature measurement, calibration of thermocouple, RTD, Orifice plate and Pressure gauge, design of temperature measuring instruments, thermo positive elements, thermocouples in series & parallel, pyrometry, steady state and transient methods of measuring heat flux, measurement of thermal radiation and associated parameters, measurement of turbulence, measurement of thermal conductivity of solids, liquids and gases, measurement of thermo-physical properties, measurement of solar radiation.	**08**
3	**Advancement in measurements:** Data logging and acquisition, use of sensors for error reduction, elements of microcomputer interfacing, intelligent instruments and their use, Basics of P, PI, PID controllers, pneumatic and hydraulic controllers, electronic controllers	**07**

Master of Engineering
Subject Code: TE3116
Subject Name: Thermal Measurements and Process Controls

SECTION-B		
4	**Advanced measurement techniques and analysis:** Shadowgraph, Schlieren, Interferometer, Laser Doppler Anemometer, Hot wire Anemometer, Telemetry in measurement, Gas Analyzers, Smoke meters, gas chromatography, spectrometry.	**07**
5	**Uncertainty in measurements:** Errors in instruments, Analysis of experimental data and determination of overall uncertainties in experimental investigation, uncertainties in measurement of measurable parameters like pressure, temperature, flow etc. under various conditions.	**06**
6	**Metallurgical Studies:** Optical and electron microscopy, X-Ray diffraction, Bragg's Law and its application for studying crystal structure and residual stresses. Electron spectroscopy, electron microprobe. Surface Measurements: Micro hardness, roughness, accuracy of dimensions and forms. 3 -D co-ordinate measuring machines.	**05**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10	**20**	**20**	**20**	**20**	**10**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Text Books:

1. Mechanical Measurements - Buck & Beckwith - Pearson
2. Measurement systems, Application and Design - E O Doebelin - McGraw-Hill
3. Experimental Methods for Engineers - J P Holman - McGraw-Hill

Reference Books:

4. Measurements and Instrumentation in Heat Engineering - Prebrashensky V, Volume I &II, MIR Publishers
5. Instrumentation Devices and Systems - Raman C S, Sharma G R, Mani V S N - McGraw-Hill
6. Principles of Measurements and Instrumentation- Morris AS - Prentice Hall of India
7. Measurement Techniques in Heat Transfer - E R G Eckert and Goldsteen – Technovision
8. Mechanical and Industrial Measurements - R K Jain - Khanna Publishers
9. Experimentation and Uncertainty Analysis for Engineers - Huge W Coleman, W Glenn Steele – John Wiley & Sons.

Master of Engineering
Subject Code: TE3116
Subject Name: Thermal Measurements and Process Controls

List of Practicals:

1. To calibrate and measure temperature using thermocouple, RTD
2. To carry out calibration of pressure measuring devices: U-tube manometer, pressure gauge.
3. To measure the thermal conductivity of any fluid.
4. To carry out calibration of flow measuring devices: orifice meter and rotameter.
5. To measure the direct and diffuse solar radiation using pyranometer and pyrheliometer.
6. To carry out exhaust gas analysis with gas chromatographer.
7. To study and familiar with data logging and acquisition system.
8. To study various electronics controllers used in thermal measurements.
9. To study and compare various advanced measurement techniques.
10. To perform experiment with any thermal system and to carry out uncertainty analysis for the same.

Course Outcomes:

Sr. No.	CO statement
CO-1	To perform experiment with any thermal system and to carry out uncertainty analysis for the same.
CO-2	Discuss the various instruments used for measuring different properties significant for evaluation of performance of thermal systems and to carry out uncertainty analysis.
CO-3	Appraise the computing facilities for measurement and acquisition of different properties.
CO-4	Appraise advanced measurement techniques and systems.
CO-5	Analyse the microstructure using various techniques.
CO-6	Utilize the various techniques for the measurement of temperature

List of Open Source Software/learning website:

- www.asme.org/thermal_science,
- https://nptel.ac.in

Major Equipment: calibration set-ups for various thermo-physical properties, pyranometer, pyrheliometer, gas chromatographer, gas analyzer, data acquisition system, interferometer, laser Doppler anemometer, hot wire Anemometer

UPL University of Sustainable Technology

Shroff S.R. Rotary Institute of Chemical Technology

Master of Engineering
Subject Code: TE3117
Subject Name: Solar Energy Systems

Semester: - II

Type of course: Open Elective Course

Prerequisite: Nil

Rationale: The course is designed to give knowledge of solar energy technologies.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	0	3	70	30	0	0	100

Content:

Sr. No.	Content	Total Hrs.
	SECTION-A	
1	**Solar Radiation:** Source of radiation, solar radiation geometry, solar radiation measuring instruments, solar constant, solar radiation on tilted surface, solar charts	5
2	**Solar Concentrating Collectors:** Optical and thermal analysis of compound parabolic collectors, optical and thermal analysis of parabolic through collectors, second law analysis, minimum entropy generation rate, optimum collector temperature, non-isothermal collector, solar non-concentrating collectors, design considerations	6
3	**Performance of Solar Collectors:** Collector thermal efficiency, collector energy losses, collector incident angle modifier, concentrating collector acceptance angle, collector time constant, dynamic system test method, collector test results and preliminary collector selection, quality test methods, analysis of concentric tube collector	7
	SECTION-B	
4	**Solar Thermal Applications:** Selection criteria of storage materials for heating and cooling applications, selection of heat transfer fluid for heating and cooling applications, active and passive solar water heating system, solar space heating, solar cooling with absorption and adsorption refrigeration, solar desalination systems, solar powered absorption air	7

	conditioning system, solar irrigation system, solar chimney, drier, dehumidifier, solar still	
5	**Solar Thermal Power System:** Parabolic through collector system, power tower system, dish systems, thermal analysis of solar thermal power plants, solar ponds, f-chart and utilizability methods.	**5**
6	**Solar Economic Analysis:** Life cycle analysis, time value of money, description of the life cycle analysis method, the P1, P2 method, uncertainties in economic analysis, construction concepts, energy storage -sensible, latent heat and thermo-chemical storage - pebble bed etc. Materials for phase change - glauber's salt - organic compounds, solar ponds	**6**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10	**20**	**20**	**20**	**20**	**10**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Text Books:

1. Solar Energy: Fundamentals and Applications, H P Garg & Jai Prakash, McGraw Hill
2. Solar Energy – Principles of Thermal Collection and Storage, S P Sukhatme, McGraw Hill

Reference Books:

1. Solar Engineering of Thermal Processes, Duffie J A, Beckman W A, Wiley
2. Solar Energy Engineering – Process and Systems, Soteris A Kalogirou, Academic Press
3. Principles of Solar Engineering, D Y Goswami, F Kreith and J F Kreider, Taylor and Francis
4. Engineering Thermodynamics of Thermal Radiation for Solar Power Utilization, Petela R, McGraw-Hill
5. Fundamentals for solar energy conversion, Edward E Anderson, Addison Wesley Publ. Co.
6. Thermal Energy Storage , Dincer I, Rosen M, Wiley

Master of Engineering
Subject Code: TE3117
Subject Name: Solar Energy Systems

Course Outcomes:

Sr. No.	CO statement
CO-1	To know the concept of solar radiation and principle of measuring instruments.
CO-2	To Analysis the different solar collector
CO-3	To understand the performance of concentrating and non-concentrating collectors
CO-4	To know the various applications of solar thermal energy
CO-5	To study the Solar thermal power system
CO-6	To understand the life cycle analysis method and uncertainties in solar economic analysis.

List of Open Source Software/learning website:

- http://nptel.ac.in/

UPL University of Sustainable Technology

Shroff S.R. Rotary Institute of Chemical Technology

Master of Engineering
Subject Code: TE3118
Subject Name: Renewable Energy Technology

Semester: - II

Type of course: Open Elective

Prerequisite: Heat transfer, Fluid Mechanics

Rationale: The course is designed to give knowledge of various renewable energy sources, systems and their applications.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	0	3	70	30	0	0	100

Content:

Sr. No.	Content	Total Hrs.
	SECTION-A	
1	**Need and Status of Renewable Energy Sources**: Needs of renewable energy, advantages and limitations of renewable energy, present energy scenario of conventional and renewable energy sources	2
2	**Solar Energy and Solar Systems:** Energy available from the sun, spectral distribution, solar radiation outside the earth's atmosphere and at the earth's surface, solar radiation geometry, Instruments for solar radiation measurements, empirical equations for prediction of availability of solar radiation, radiation on tilted surface solar energy conversion into heat, types of solar collectors, evacuated and non-evacuated solar air heater, concentrated collectors, thermal analysis of liquid flat plate collector, air heater and cylindrical parabolic collector, solar energy thermal storage, heating and cooling of buildings, solar pumping, solar cooker, solar still, solar drier, solar refrigeration and air conditioning, solar pond, heliostat, solar furnace photovoltaic system for power generation, solar cell modules and arrays, solar cell types, material, applications, advantages and disadvantages	12

Master of Engineering
Subject Code: TE3118
Subject Name: Renewable Energy Technology

3	**Biogas and Biomass Energy :** Types of biogas plants, biogas generation, factors affecting biogas generation, advantages and disadvantages, biomass energy, energy plantation, gasification, types and applications of gasifiers	**4**
	SECTION-B	
4	**Wind Energy and its performance:** Energy available from wind, basics of lift and drag, basics of wind energy conversion system, effect of density, angle of attack and wind speed, windmill rotors, horizontal and vertical axes rotors, drag, lift, torque and power coefficients, tip speed ratio, solidity of turbine, wind turbine performance curves, wind energy potential and site selection, basics of wind farm	**6**
5	**Ocean Energy**: OTEC principle, open, closed and hybrid cycle OTEC system, Energy from tides, estimation of tidal power, tidal power plants, single and double basin plants, site requirements, advantages and limitations, wave energy, wave energy conversion devices, advantages and disadvantages, ocean thermal energy **Geothermal energy:** Introduction, vapor and liquid dominated systems, binary cycle, hot dry rock resources, magma resources, advantages and disadvantages, applications MHD Power generation: concept and working principle	**6**
6	**Economic Analysis of renewable energy systems:** Initial and annual cost, basic definitions, present worth calculations, repayment of loan in equal annual installments, annual savings, cumulative saving and life cycle cost, economic analysis of add on solar system, payback period, clean development mechanism	**6**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10	**15**	**25**	**10**	**5**	**5**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Master of Engineering
Subject Code: TE3118
Subject Name: Renewable Energy Technology

Text Books:

1. Non-conventional energy resources, Shobh Nath Singh, Pearson India

Reference Books:

1. Solar Energy: Principles of Thermal Collection and Storage, S. P. Sukhatme and J. K. Nayak, McGraw-Hill Education
2. Solar Engineering of Thermal Processes, John A. Duffie, William A. Beckman, John Wiley, New York
3. Solar Energy Engineering, Soteris Kalogirou, Elsevier/Academic Press.
4. Principles of Solar Energy, Frank Krieth & John F Kreider, John Wiley, New York

Course Outcomes:

Sr. No.	CO statement
CO-1	To understand the need and importance of renewable energy systems
CO-2	To know the solar radiation energy and based energy systems
CO-3	To study the Biogas and Biomass based energy
CO-4	To Understand the wind energy and its performance
CO-5	To know the potential of Ocean and Geothermal energy
CO-6	To Carry our preliminary economic analysis of renewable energy systems

List of Open Source Software/learning website:

http://nptel.ac.in/courses/112104117/18
http://nptel.ac.in/courses/112104117/4
http://nptel.ac.in/courses/112104117/17

UPL University of Sustainable Technology

Shroff S.R. Rotary Institute of Chemical Technology

Master of Engineering
Subject Code: MH3104
Subject Name: English for Research Paper Writing

Semester: - II

Type of course: Audit course
Prerequisite: Zeal to learn the subject
Rationale:

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
2	0	0	0	50	0	00	00	50

Content:

Sr. No.	Content	Total Hrs.
	SECTION-A	
1	**Planning , work order & structures of sentences:** Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness	**04**
2	**Criticism ,Hedging & Plagiarism:** Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism	**04**
3	**Structure of Review article:** Sections of a Paper, Abstracts. Introduction, Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check	**04**
	SECTION-B	
4	**Key writing skills for Title and literature :** key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature	**04**
5	**Key writing skills for Methods, Results & Conclusion :** skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions	**04**

Master of Engineering
Subject Code: MH3104
Subject Name: English for Research Paper Writing

6	**Useful Phrase & Final checkpoints :** useful phrases, how to ensure paper is as good as it could possibly be the first- time submission	**04**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10	**25**	**20**	**10**	**20**	**15**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Text Book:

1. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011.

Reference Books:

1. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman'sbook
2. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
3. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
4. Swales J.M., Feak C.B., 2004. Academic Writing for Graduate Students. Ann Arbor: University, of Michigan Press.
5. Hyland K., 2009. Teaching and Researching Writing. Pearson Education Limited

Course Outcomes:

Sr. No.	**CO statement**
CO-1	**Developing** writing skills by analyzing model texts (written by 'expert' writers) and texts written by students (with particular focus on issues involving coherence and cohesion)
CO-2	**Expanding** academic vocabulary and Consolidating more advanced aspects of English grammar relevant to writing research papers

Master of Engineering

Subject Code: MH3104

Subject Name: English for Research Paper Writing

CO-3	**Comparing** various practices and conventions used in writing research papers across a range of disciplines.
CO-4	**Consolidation** of language functions found in research papers
CO-5	**Learn** the skills needed when writing a Title, Abstract, Literature review, Methods, Results and conclusions
CO-6	**Ensure** the good quality of paper at very first-time submission

List of Open Source Software/learning website:

- http://nptel.iitm.ac.in/courses.php