VEER MADHO SINGH BHANDARI UTTARAKHAND TECHNICAL UNIVERSITY
(Formerly Uttarakhand Technical University, Dehradun Established by Uttarakhand State Govt. wide Act no. 415 of 2005)
Suddhowala, PO-Chandanwadi, Premnagar, Dehradun, Uttarakhand (Website- www.uktech.ac.in)

SYLLABUS

For

Master of Engineering Programmes

(M.TECH.- Thermal Engineering)

(For admission in 2022-23 and onwards)

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Courses Structure and Scheme of Examination for
M. Tech.- 2 Year Programme
Thermal Engineering

Semester I

Sr. No.	Course Type/Code	Course Name	Teaching Scheme			Credits	Internal Marks			External Marks	Total Marks
			L	T	P		CT	TA	Total		
1	AHT-301	Advanced Mathematics	3	1	0	4	30	20	50	100	150
2	TET-301	Advanced Thermodynamics	3	1	0	4	30	20	50	100	150
3	TET-302	CFD and Heat Transfer	3	1	0	4	30	20	50	100	150
4	TET-3XX	Professional Elective-I	3	0	0	3	30	20	50	100	150
5	TET-3XX	Professional Elective-II	3	0	0	3	30	20	50	100	150
6	TEP-301	Computational Lab	0	0	3	1		25	25	25	50
7	TEP-302	Advanced Heat Transfer Lab	0	0	3	1		25	25	25	50
8	AHT-302	Research Methodology and IPR	2	0	0	2		50	50	50	100
9	AHT-303	Technical Writing and Presentation Skill	2	0	0	NC		50	50	0	NC
		Total	**22**	**3**	**8**	**22**	**150**	**250**	**400**	**600**	**950**
10	TET-3XX	Open Elective (Optional)	3	0	0	3	30	20	50	100	150

Semester II (M. Tech.- 2 Year Programme)

Sr. No.	Course Type/Code	Course Name	Teaching Scheme			Credits	Internal Marks			External Marks	Total Marks
			L	T	P		CT	TA	Total		
1	TET-303	Convective Heat Transfer	3	1	0	4	30	20	50	100	150
2	TET-304	Design of Thermal System	3	1	0	4	30	20	50	100	150
3	TET-3XX	Professional Elective-III	3	1	0	4	30	20	50	100	150
4	TET-3XX	Professional Elective-IV	3	0	0	3	30	20	50	100	150
5	TET-3XX	Open Elective	3	0	0	3	30	20	50	100	150
6	TEP-303	Computational Fluid Dynamics Lab	0	0	3	1		25	25	25	50
7	TEP-304	Thermal Engineering Lab	0	0	3	1		25	25	25	50
		Total	**17**	**3**	**6**	**20**			**400**	**550**	**850**

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9	TET-3XX	Open Elective (Optional)	3	0	0	3	30	20	50	100	150

Semester III (M. Tech.- 2 Year Programme)											
Sr. No.	**Course Type/Code**	**Course Name**	**Teaching Scheme**			**Credits**	**Internal Marks**			**External Marks**	**Total Marks**
			L	T	P		**CT**	**TA**	**Total**		
1	TET-3XX	Open Elective	3	0	0	3	30	20	50	100	150
2	TEP-305	Seminar	0	0	4	2		100	100		100
3	TEP-306	Project	0	0	10	5		100	100	150	250
4	TEP-307	Dissertation	0	0	12	6		300	300		300
		Total	**3**	**0**	**22**	**16**		**520**	**550**	**250**	**800**

Semester IV (M. Tech.- 2 Year Programme)											
Sr. No.	**Course Type/Code**	**Course Name**	**Teaching Scheme**			**Credits**	**Internal Marks**			**External Marks**	**Total Marks**
			L	T	P		**CT**	**TA**	**Total**		
1	TEP-308	Dissertation	0	0	28	14		250	250	450	700
		Total	**0**	**0**	**28**	**14**		**250**	**250**	**450**	**700**

Abbreviations: L-No. of Lecture hours per week, T-No. of Tutorial hours per week, P-No. of Practical hours per week, CT-Class Test Marks, TA-Marks of teacher's assessment including student's class performance and attendance,

1 Hr Lecture	1 Hr Tutorial	2 or 3 Hr Practical
1 Credit	1 Credit	1 Credit

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Course Structure and Scheme of Examination for B.Tech.-M. Tech. Dual 1 Year M.Tech. Programme Thermal Engineering

Semester III											
Sr. No.	Course Type/Code	Course Name	Teaching Scheme			Credits	Internal Marks			External Marks	Total Marks
			L	T	P		CT	TA	Total		
1	AHT-301	Advanced Mathematics	3	1	0	4	30	20	50	100	150
2	MET-301	Advanced Thermodynamics	3	1	0	4	30	20	50	100	150
3	TET-3XX	Open Elective	3	0	0	3	30	20	50	100	150
4	AHT-302	Research Methodology and IPR	2	0	0	2	30	20	50	50	100
5	TEP-305	Seminar	0	0	4	2		100	100		100
6	TEP-306	Project	0	0	10	5		100	100	150	250
7	TEP-307	Dissertation	0	0	12	6		300	300		300
		Total	**11**	**2**	**26**	**26**	**120**	**580**	**700**	**500**	**1200**

Semester IV (B.Tech.-M. Tech. Dual 1 Year M.Tech. Programme)											
Sr. No.	Course Type/Code	Course Name	Teaching Scheme			Credits	Internal Marks			External Marks	Total Marks
			L	T	P		CT	TA	Total		
1	TET-303	Convective Heat Transfer	3	1	0	4	30	20	50	100	150
2	TET-3XX	Professional Elective I/II/IV	3	0	0	3	30	20	50	100	150
3	TET-3XX	Open Elective	3	0	0	3	30	20	50	100	150
4	TEP-303	Computational Fluid Dynamics Lab	0	0	3	1		25	25	25	50
5	TEP-304	Thermal Engineering Lab	0	0	3	1		25	25	25	50
6	TEP-308	Dissertation	0	0	28	14		250	250	450	700
		Total	**9**	**1**	**34**	**26**	**90**	**360**	**450**	**800**	**1250**

Abbreviations: L-No. of Lecture hours per week, T-No. of Tutorial hours per week, P-No. of Practical hours per week, CT-Class Test Marks, TA-Marks of teacher's assessment including student's class performance and attendance,

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1 Hr Lecture	1 Hr Tutorial	2 or 3 Hr Practical
1 Credit	1 Credit	1 Credit

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Syllabus
Advanced Mathematics (AHT-301)

L:T:P:: 3:1:0 **Credits-4**

Course objectives:

From this course, students will be able to:

1. learn distinct methods of solving simultaneous equations.
2. well-versed with partial differential equations and their solutions and applications.
3. acquire the knowledge of transformation to ease the complex problems.
4. acquaintance with basics of random variables and their distribution for dealing with events by chance.
5. study different mathematical domains to deal with real-time engineering problems.

Learning outcomes:

1. Comprehend with engineering problems in different mathematical realm.
2. Learn analytical and numerical methods to deal with mathematical problems.
3. Understand how to model the engineering problems and their solutions.
4. Implement the solutions to real-time complex engineering problems.
5. Apprehend with mathematical methodology.

Course content:

Unit I: Solution of linear simultaneous equations: **(8 hours)**

Consistency, Iterative method, Convergence, Cholesky's (Crout's) method, Gauss-Jordan method, Gauss-Seidel iteration and relaxation methods, Solution of Eigenvalue problems, Smallest, largest, and intermediate Eigen values

Computer based algorithm and programme for these methods (non-evaluative)

Unit II: Partial differential equation and its applications: **(10 hours)**

Introduction and classification of partial differential equation, Four standard forms of non-linear partial differential equations and their solutions, linear equations with constant coefficients. Applications of partial differential equations one and two-dimensional wave equation, one and two-dimensional heat equation, Two-dimensional Laplace's equation.

Unit III: Transform calculus-I: **(8 hours)**

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Laplace transform, Properties of Laplace transform, Inverse Laplace transform, Applications of Laplace transform, Fourier integral theorem, Fourier transforms, Application of Fourier transform

Unit IV: Transform calculus-II: (8 hours)

Z-transform, Properties of Z-transform, Shifting theorems, Initial and final value theorem, Convolution theorems, Inverse Z-transform, Application of Z-transform

Unit V: Basic probability theory: (8 hours)

Concept and laws of probability, Discrete and continuous random variable and their distributions; Some special distributions such as Binomial, Poisson, Negative Binomial, Geometric, Continuous uniform, Normal, Exponential, Weibull, Moments, Moment generating functions, Expectation and variance

Practical demo with statistical software like R, SPSS, SAS, etc. (non-evaluative)

Text Books / References:

1. B.S. Grewal, Engineering Mathematics, Khanna Publications, 44th edition.
2. F.B. Hilderbrand, Method of Applied Mathematics, PHI Publications, 2nd edition.
3. M.D. Raisinghania, Ordinary and Partial Differential Equations, S. Chand Publication, 20th edition.
4. S.C. Gupta and V.K. Kapoor, Fundamentals of Mathmematical Statistics, S. Chand Publication, 4th edition.
5. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons, 10th edition.
6. S. Ross, A First Course in Probability, Pearson Education, 8th edition.

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Syllabus
Advanced Thermodynamics (TET-301)

L:T:P:: 3:1:0 **Credits-4**

Course Objectives:

- To impart knowledge about the concept of basic thermodynamic systems.
- To impart knowledge of real gas behavior and introduction to exergy and statistical thermodynamics.
- To impart knowledge on different thermodynamic property relations and their applications.

Course Outcomes:

CO1: Students will be able to understand the history, concepts, formulations and applications of thermodynamics.
CO2: Students will be able to analyze and solve various practical problems on the applications of thermodynamics.
CO3: Students will be able to apply various solution techniques for solving new applied and theoretical problems.

Course Contents:

UNIT-I **(8 hours)**
First Law of Thermodynamics : First law for closed systems, First law for open systems, Structured presentation of the first law-Poincaré's scheme, Carathéodory's scheme, Keenan and Shapiro's second scheme, Applications to vapor cycle.

UNIT-II **(8 hours)**
Second Law of Thermodynamics : Second law for closed systems, Second law for open systems, Local thermodynamic equilibrium model, Entropy maximum and energy minimum principles , Carathéodory's two axioms, A Heat Transfer man's two axioms, Regenerative power generation in steam power plants.

UNIT-III **(8 hours)**
Entropy Generation : Lost available work, Non-flow processes, Steady flow processes, Mechanisms of entropy generation-Heat transfer across a finite temperature difference, Flow with friction, Mixing, Entropy generation minimization; The method, Entropy generation number, Entropy generation in steam based power generation systems.

UNIT-IV **(8 hours)**
Non-flow systems: Flow systems, Generalized exergy analysis, Exergy analysis of steam based power generation systems.

Irreversible Thermodynamics: Conjugate fluxes and forces, Linearized relation, Reciprocity relations.

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UNIT-V **(8 hours)**

Thermodynamic Relations: The fundamental relation; Energy representation, Entropy representation, Legendre transform, Relation between thermodynamic properties, Maxwell's relations, Bridgman's table, Jacobians in thermodynamics.

Stability of Thermodynamic Systems: Stability conditions for thermodynamic potentials, Qualitative effect of fluctuations, Le Chatelier-Braun principle.

Text Books:

1. Bejan, Advanced Engineering Thermodynamics, Wiley, 2016.
2. E. P. Gyftopoulous, G. P. Beretta, Thermodynamics: Foundations and Applications, Dover, 2013.
3. Thermodynamics: An Interactive Approach , Subrata Bhattacharjee,1e,Pearson.
4. A. Thess, The Entropy Principle: Thermodynamics for the Unsatisfied, Springer, 2011.

Reference Books:

1. R. S. Berry, V. Kazakov, S. Sieniutycz, Z. Szwast, A. M. Tsirlin, Thermodynamic Optimization of Finite-Time Processes, Wiley, 2000.
2. Applied Thermodynamics for Engineering Technologists, 5e , Eastop, Pearson Education
3. P. T. Landsberg, Thermodynamics and Statistical Mechanics, Dover, 2014.
4. M. Planck, Treatise on Thermodynamics, Dover, 2013.

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CFD and Heat Transfer (TET-302)

L:T:P::3:1:0 **Credits-4**

Course Objectives:

- To impart knowledge about the concept of basic heat transfer systems.
- to teach fundamentals of computational method for solving linear and non-linear partial differential equations (PDE).
- To impart knowledge on different thermodynamic property relations and their applications.

Course Outcomes:

Upon successful completion of the course, the students will be able to

CO1: understand flow physics and mathematical model of governing Navier-Stokes equations and define proper boundary conditions for solution.

CO2: use CFD software to solve relevant engineering flow problems.

CO3: analyze the CFD results. Compare with available data, and discuss the findings.

Course Contents:

Unit-I **(8 hours)**

Finite Difference Method: Forward, backward, and central difference scheme- explicit and implicit methods. Errors, consistency, stability analysis, upwind schemes.

Unit-II **(8 hours)**

Incompressible Flow: Finite differences, MAC and SIMPLE algorithms, stream function, velocity potential function and vorticity formulation.

Inviscid Flow: Basic governing equation and different solution algorithms for compressible flow with calculations of lift and drag.

Unit-III **(8 hours)**

Conduction Heat Transfer: Steady and unsteady state, boundary condition, Rang-Kutta method, finite difference method, iterative and direct methods.

Unit-IV **(8 hours)**

Convective Heat Transfer: Governing equations, solutions for natural and forced convection, modeling of convection problems.

Unit-V **(8 hours)**

Radiative Heat Transfer: Basic concepts, radiosity method, Monte – Carlo method, phase change problems.

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Books and References:

1. Yogesh Jaluria and Kenneth E. Torrance, Computational Heat Transfer, Hemisphere Publishing Corporation, 1986.
2. K. Muralidhar& T. Sundararajan, Computational Fluid Flow and Heat Transfer, Narosa Publication, 1995.
3. S.V. Patankar, Numerical Heat Transfer and Fluid Flow, Hemishere Publication Company New York 1980.
4. An Introduction to Computational Fluid Dynamics: The Finite Volume Method by H.K. Versteeg and W. Malalasekara, Pearson Education.
5. Computational Fluid Flow and Heat Transfer by K. Muralidhar and T. Sundararajan, Narosa Publishing.
6. Numerical Heat Transfer and Fluid Flow by S.V. Patankar, McGraw-Hill.
7. Computational Techniques for Fluid Dynamics Volume I & II by C.A.J. Fletcher, Springer.

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Research Methodology and IPR (AHT-302)

L:T:P:: 2:0:0 **Credits-2**

Course Objectives: Students will be able to:

1. To understand the fundaments of research in today's world controlled by technology, ideas, concept, and creativity.
2. To understand different methods of research designing and data collections.
3. To understand the methods of report writing and its different methods of interpretations.
4. To understand research ethics and methods of research publications
5. Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and inturn brings about, economic growth and social benefits.

Course Outcomes:

1. To understand research problem formulation.
2. To study research design and method of data collections.
3. To study methods of report writing.
4. To follow research ethics.
5. To enhance student's competence to discover new inventions.

Syllabus Contents:

UNIT I: FUNDAMENTAL OF RESEARCH

Meaning of research; objectives of research; basic steps of research; criteria of good research; Research methods vs. Methodology. Types of research –criteria of good research; Meaning of research problem; selection of research problem; Approaches of investigation of solutions for research problem, Errors in selecting a research problem, Scope and objectives of research problem, Review of related literature-Meaning, necessity and sources.

Unit 2: RESEARCH DESIGN AND DATA COLLECTION

Research design: Types of research design- exploratory, descriptive, diagnostic and experimental;Variables- Meaning and types; Hypothesis- Meaning, function and types of hypothesis; Null/Alternative hypothesis; Sampling- Meaning and types of sampling; Probability and Non-Probability; Tools and techniques of data collection- questionnaire, schedule, interview, observation, case study, survey etc.

Unit 3:REPORT WRITING AND ITS INTERPRETATION

Meaning of Interpretation, Technique of Interpretation, Precaution in Interpretation, Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Types of Reports, Oral Presentation, Mechanics of Writing a Research Report, Precautions for Writing Research Reports, Conclusions.

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Unit 4:RESEARCH ETHICS AND SCHOLARY PUBLISHING

Ethics-ethical issues, ethical committees (human & animal); scholarly publishing- IMRAD concept and design of research paper, citation and acknowledgement, plagiarism and its concept and importance for scholar.

Unit 5: INTELLECTUAL PROPERTY RIGHT (IPR)

IPR- intellectual property rights and patent law, commercialization, New developments in IPR; copy right, royalty, trade related aspects of intellectual property rights (TRIPS); Process of Patenting and Development; Procedure for grants of patents, Patenting under PCT;Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases.

Reference Books:

1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science &engineeringstudents'"
2. WayneGoddardandStuartMelville,"ResearchMethodology:AnIntroduction"
3. RanjitKumar,2ndEdition,"ResearchMethodology:AStepbyStepGuideforbeginners"
4. Halbert,"ResistingIntellectualProperty",Taylor&FrancisLtd,2007.
5. Mayall,"IndustrialDesign",McGrawHill,1992.
6. Niebel,"ProductDesign",McGrawHill,1974.
7. Asimov,"IntroductiontoDesign",PrenticeHall,1962.
8. Robert P. Merges, Peter S. Menell, Mark A. Lemley, " Intellectual Property in New Technological Age",2016.
9. T.Ramappa,"IntellectualPropertyRightsUnderWTO",S.Chand,2008

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Convective Heat Transfer (TET-303)

L:T:P::3:1:0 **Credits-4**

Course Objectives:

- To impart an introductory treatment of the governing laws for Convection heat transfer.
- To formulate & reduce mass, momentum and energy conservation equations according to the physical situation involved.
- To obtain exact and approximate solutions of external and internal boundary layer flow problems.

Course Outcomes:

Upon successful completion of the course, the students will be able to
CO1: analyze boundary layer development problems.
CO2: analyze external and internal forced convection by applying existing empirical correlations.
CO3: examine the convective heat transfer in porous media and in systems involving phase change.
CO4: apply the concepts to analyze industrial problems.

Course Contents:

Unit-I **(8 hours)**
Principles of Convection: Convection boundary layers, Velocity boundary layers, Thermal boundary layers, Significance of boundary layers, Laminar and turbulent flow, Significance of dimensionless parameters, Reynolds-Colburn analogy, Drag & amp, Heat transfer.

Unit-II **(8 hours)**
Convective Heat Transfer in External Flows: Derivation of hydrodynamic and thermal boundary layer equations, Similarity solution techniques, Momentum and energy integral methods and their applications in flow over flat plates with low and high Prandtl Number approximations, Optimal cooling of stack of vertical heat generating plates.

Unit-III **(8 hours)**
Convective Heat Transfer in Internal Flows: Concept of developing and fully developed flows, Thermally developing flows: Graetz problem, Concept of thermally fully developed flow and its consequences under constant wall flux and constant wall temperature conditions, Steady forced convection in Hagen Poiseuille flow, Plane Poiseuille flow and Couette flow and analytical evaluation of Nusselt numbers in limiting cases, Optimal cooling of stack of heat-generating plates, Heat lines in fully developed duct flow, Optimal duct shape for minimum flow resistance, Enclosures heated from below, Heat transfer results, Scale theory of the turbulent regime.

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Unit-IV **(8 hours)**

Free Convection: Free convection boundary layer equations: order of magnitude analysis, Similarity and series solutions, Concept of thermal stability and Rayleigh Bernard convection. Combined natural and forced convection (Mixed Convection), Heat transfer results including the effect of turbulence, Vertical walls, Inclined walls, Horizontal cylinder, Sphere, Distribution of heat sources on a vertical wall.

Unit-V **(8 hours)**

Convection with Change of Phase: Condensation, Boiling, Contact melting and lubrication, Melting by natural convection, Quasi-steady convection regime, Horizontal spreading of the melt layer.

Convection in Porous Media: Mass conservation, Darcy flow model and the Forchheimer modification, enclosed porous media heated from the side, Penetrative convection, Lateral penetration, Vertical penetration.

Text / References Books:

1. Convective Heat Transfer by Louis C. Burmeister, John Wiley and Sons.
2. Convective Heat Transfer by Bejan, Wiley Publication.
3. Convective Heat Transfer by S. Kakac, Y. Yener& A. Pramuanjaroenkij, CRC Press.
4. Fundamentals of Heat and Mass Transfer, Thirumaleshwar,Pearson
5. Heat Transfer by Kays & Crawford, McGraw-Hill Companies.

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Design of Thermal Systems (TET-304)

L:T:P::3:1:0 **Credits-4**

Course Objectives

- To impart the knowledge about the concept of design of thermal systems.
- To provide an introduction to computer-aided design of thermal systems, including cost and performance analysis.
- To learn tools and techniques of analysis of a thermal systems.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand the aspects of designing of thermal systems.

CO2: Solve the problem using numerical simulation by choosing the design variables which affects the problem.

CO3: Explain economic aspects of designing and able to apply different techniques of optimization applicable to thermal system.

Course Contents

Unit-I **(8 hours)**

Introduction to Thermal System Design: Engineering design, Designing a workable system, Conceptual design, Steps in the design process, Computer-aided design of thermal systems, Types of thermal system models, Interaction between models, Mathematical modelling, Physical modelling and dimensional analysis, Curve fitting techniques, Design of a food freezing plant.

Unit-II **(10 hours)**

Numerical Modeling and Simulation: Solution procedure, Numerical model for a system, System simulation, classes of simulation, Methods for numerical simulation, Successive Substitution, Modeling thermal equipment, Selecting vs simulating a heat exchanger, Workable and optimum systems, Optimization procedures, Lagrange multipliers, Geometric programming, Setting up mathematical statement of optimization problem, Case study on water chilling system.

Unit-III **(8 hours)**

Dynamic Behaviour of Thermal Systems: Dynamic analysis, One dynamic element in a steady state simulation, Laplace transform, Inversion of Laplace transform, Solution of ordinary differential equation, Study of modern developments in thermal systems along with their design, Operation and economic aspects.

Unit-IV **(10 hours)**

Design of Turbomachines: Principles of Design of turbo machines, Design of axial flow turbine stage, Design of axial flow compressor stage, Design of centrifugal compressor.

Design of Heat Exchanger: Study of design aspects, fluid flow and heat transfer characteristics, Material requirement of heat exchange equipment, Liquid - to - liquid and Liquid - to - gas heat exchange systems, Familiarity with use of design related industrial standards and codes, Design of Heat exchanger.

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Unit-V

Design of Auxiliary systems: Lubrication, fuel, seal and gas conditioning **(4 hours)**

Text/ References Books:

1. Design and Optimization of Thermal systems by Yogesh Jaluria, CRC Press.
2. Design of thermal systems by W.F. Stocker, McGraw-Hill Education.B K. Hodge, Robert P. Taylor, Pearson
3. Essentials of Thermal System Design and Optimization, C. Balaji, Ane Books, New Delhi in India and CRC Press in the rest of the world, 2011.
4. Design and optimization of thermal systems, Y. Jaluria, McGraw Hill, 1998.
5. Heat Exchangers: Selection, Rating, and Thermal Design, Third Edition Press

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Technical Writing and Presentation Skills (AHT-303)

L:T:P::2:0:0 **Non-credits**

Course Objectives:

- To develop effective writing and presentation skills in students.
- To develop textual, linguistic and presentation competencies instudents appropriate for their professional careers.

Course Outcomes:

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

CO1: Write clearly and fluently to produce effective technical documents.

CO2: Demonstrate an appropriate communication style to different types of audiences both orally and written as per demand of their professional careers.

CO3: Communicate in an ethically responsible manner.

Course Contents:

WRITING SKILLS

Unit-I **(4 hours)**

Technical Writing-Basic Principles: Words-Phrases-Sentences, Construction of Cohesive Paragraphs, Elements of Style.

Unit-II **(4 hours)**

Principles of Summarizing: Abstract, Summary, Synopsis

Unit-III **(6 hours)**

Technical Reports: Salient Features, Types of Reports, Structure of Reports, Data Collection, Use of Graphic Aids, Drafting and Writing

PRESENTATION SKILLS

Unit-IV **(6 hours)**

Speaking Skills: Accuracy vs. Fluency, The Audience, Pronunciation Guidelines, Voice Control.

Unit-V **(8 hours)**

Professional Presentations: Planning, Preparing, Presentation Strategies, Overcoming, Communication Barriers, Using Technology, Effective Presentations.

References:

1. Kumar, Sanjay & Pushp Lata, "Communication Skills", Oxford UniversityPress,2011.
2. Quirk & Randolph, "A University Grammar of English", Pearson,2006.
3. Rutherford, Andrea J., "Basic Communication Skills for Technology", Pearson 2007.
4. Rizvi, M Ashraf, "Effective Technical Communication", McGraw Hill,2009.
5. Leigh, Andrew & Maynard, Michael, "The Perfect Presentation", Random House.
6. Barker, Larry L., "Communication", Prentice-Hall.
7. Lesikar&Flatley, "Basic Business Communication-Skills for Empowering the Internet Generation", Tata McGraw-Hill.

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Computational Lab (TEP-301)

L:T:P::0:0:3 **Credits-1**

Course Type: Core / Elective

Course Objectives This course enables the students to:

- provide exposure to modern computational techniques in fluid dynamics and heat transfer.
- apply computational methods for solving complex engineering problems.
- set the stage for future recruitment by potential employers in the field of simulation.

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

CO1 recognize the importance of CFD in Heat and Fluid flow.

CO2 analyze forced convection heat transfer coefficient over regular bodies like cylinder.

CO3 solve computational problems related to fluid flows and heat transfer.

CO4 recognize how to handle different boundary conditions.

CO5 analyze how to apply different prebuilt Models in CFD.

List of Experiments:

1. To simulate a Simple Conduction Problem.
2. To simulate a Mixed Boundary Problem (Conduction/ Convection/ Insulated).
3. To simulate a Transient Thermal Conduction Problem.
4. To do a Coupled Structural/Thermal Analysis.
5. To simulate a Conjugate Heat Transfer Problem.
6. To prepare a Computational Thermal Model of fluid flow in an elbow.
7. To simulate fluid flow across a staggered uniformly-spaced tube arrangement.
8. Understanding the simulation using Surface-to-Surface (S2S) Radiation Model.
9. Simulation using the Discrete Ordinates Radiation Model.
10. To simulate flow around an airfoil.

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Advanced Heat Transfer Lab (TEP-302)

L:T:P::0:0:3 **Credits-1**

Course Type: Core / Elective

Course Objectives:

- The primary objective of this course is to provide the fundamental knowledge necessary to understand the behavior of thermal systems.
- This course provides a detailed experimental analysis, including the application and heat transfer through solids, fluids.
- Convection, conduction, and radiation heat transfer in one and two dimensional steady and unsteady systems are examined.

Course Outcomes:

- Perform experiments to determine the thermal conductivity of a metal rod
- Conduct experiments to determine convective heat transfer coefficient for natural and forced convection and correlate with theoretical values.
- Estimate the effective thermal resistance in composite slabs and efficiency in pin-fin
- Determine surface emissivity of a test plate
- Estimate performance of a refrigerator and effectiveness of fin

List of Experiments:

1. Heat transfer from a pin fin under forced convection heat transfer mode
2. Heat transfer from an extended surface under natural convection and radiation
3. Emissivity measurement
4. Natural heat transfer coefficient 'h' from the surface of the tube in both vertical and horizontal position
5. Pool boiling phenomenon up to critical heat flux point
6. Unsteady state heat conduction
7. Convective heat transfer coefficient in forced convection
8. Axial heat flux in a heat pipe using water as the working fluid with that of a solid copper with different temperatures
9. Combined convective and radiation heat transfer coefficient at each zone and compare them to decide the critical thickness of insulation
10. LMTD & Effectiveness of the heat exchanger under parallel and counter Flow arrangement.
11. Make J-type thermocouples using a spot-welding machine and develop a typical calibration curve for a J-type thermocouple
12. Determination of temperature distribution along a rectangular and circular fin subjected to heat loss through convection using Numerical approach (ANSYS/CFD package)

Text Books:

1. Yunus A. Cengel, "Heat Transfer a Practical Approach", Tata McGraw-Hill Education, 4th Edition,2012.
2. R. C. Sachdeva, "Fundamentals of Engineering, Heat and Mass Transfer", New Age publication, 3 rd Edition, 2012. Online Resources: https://en.wikipedia.org/wiki/Heat_Transfer https://en.wikipedia.org/wiki/Heat and Mass Transfer

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Computational Fluid Dynamics (CFD) Lab (TEP-303)

L:T:P::0:0:3 **Credits-1**

Course Type: Core / Elective

Prerequisites: Basic programming skills (FORTRAN, C, MATLAB, Python etc.), Basic Fluid Mechanics/Heat Transfer/Transport Phenomena, Applied Mathematics Course Contents

Review of numerical techniques and discretization methods: Numerical solution of one-dimensional steady state heat conduction, unsteady heat conduction.

Modeling of convection diffusion problems: One dimensional convection-diffusion using central difference scheme. Upwind scheme, numerical diffusion (artificial viscosity); Modelling fluid flow; Flow visualization.

Introduction to open source/commercial CFD tool: Pre-processor, solver, post processor; Grid Independence; Errors in CFD Simulation; Research Ethics in CFD Simulation.

List of Experiments

1. Discretization and numerical solution of 1D steady state heat transfer through a simple fin.
2. Numerical solution of transient heat conduction in a square metallic block subjected to Dirichlet, Neumann and mixed boundary conditions at different faces.
3. Numerical solution of potential flow problem.
4. Solution convergence monitoring, flow visualization and post processing techniques and tools.
5. Introduction to open source CFD software and setup test case-1 for laminar flow in Lid driven cavity. 6. Mesh generation for test case-1 using inbuilt tool and open-source mesh generation software.
6. Grid independence test, results reporting and visualization for test case-1.
7. Investigating the false diffusion in various discretization schemes.
8. CFD study of laminar flow past a backward facing step (test case-2).
9. CFD study of natural convection in a square cavity (test case-3).
10. CFD study of conjugate heat transfer in a heat exchanger (test case-4).
11. CFD study of flow behind a rotating cylinder (test case-5; setting up case with Arbitrary Moving Interface AMI).

Text and Reference books:

1. W Malalasekera. An introduction to computational fluid dynamics: the finite volume method. Pearson Prentice Hall, 2007.
2. An Introduction to Computational Fluid Dynamics The Finite Volume Method, 2e , Versteeg,Pearson education
3. Suhas Patankar. Numerical heat transfer and fluid flow. CRC press, 1980
4. Bengt Andersson, Ronnie Andersson, Love Hakansson, Mikael Mortensen, Rahman Sudiyo, and Berend Van Wachem. Computational fluid dynamics for engineers. Cambridge University Press, 2011.
5. Online resources

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Thermal Engineering Lab (TEP-304)

L:T:P::0:0:3 **Credits-1**

Course Type: Core / Elective

Prerequisites: Engineering Thermodynamic, Fluid Mechanics, I.C Engines, Refrigeration and Air conditioning

Course Contents:

1. To evaluate the performance of the box type solar cooker at: a) No load b) Full load
2. To measure the effectiveness of the heat recovery wheel under different indoor and outdoor condition.
3. Testing of the inverter based split air conditioner.
4. To study the solar air heater and calculate its performance parameter.
5. To perform tests on solar flat plate thermal collector and evaluation of performance parameter in the thermosyphon mode of operation.
6. To do a comparative study of engine performance working on a biodiesel blended (5%) diesel to that of a pure diesel.
7. To study the thermal energy storage systems and calculate its performance parameters.
8. To study the performance of solar flat plate collector

Text and Reference books:

1. V Ganesan, Internal Combustion Engines, Mc Graw hill education.
2. C.P. Arora, refrigeration and air conditioning, Mc Graw hill education
3. SP Sukhatme & JK Nayak, Solar Energy , Mc Graw hill education.
4. Garg, H.P., Mullick S.C., Bhargava, Vijay k, Solar Thermal Energy storage, Springer Publication
5. Online resources

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Professionals Electives			
Professional elective-I		**Professional elective-II**	
Course Title	**Course Code**	**Course Title**	**Course Code**
Advanced Fluid Mechanics	TET-305	Design and Analysis of Solar Energy Systems	TET-309
Gas Turbine and Jet Propulsion	TET-306	Engine Tribology	TET-310
Alternative Fuels in I.C. Engine	TET-307	Exergy Analysis of Thermal Systems	TET-311
Gas Dynamics	TET-308	Power Plant Engineering	TET-312
Professional elective-III		**Professional elective-IV**	
Wind Energy Utilization	TET-313	Design of Thermal Turbo machines	TET-317
Computational Methods in Thermal Engineering	TET-314	Modeling and Simulation	TET-318
Optimization Method in Thermal Engineering	TET-315	Bio-fluid Mechanics	TET-319
Refrigeration and air conditioning system design	TET-316	Internal Combustion Engines and Pollution	TET-320

Open Electives		
Sr. No.	**Course Code**	**Course Title**
1.	TET-321	Environmental and Social Impact Assessment
2.	TET-322	Cryogenic system
3.	TET-323	Alternative Fuel Technology
4.	TET-324	Pollution Control Technologies
5.	TET-325	Electrical and Hybrid Vehicles
6.	TET-326	Energy Conversion Technologies

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Advanced Fluid Mechanics (TET-305)

L:T:P::3:0:0 **Credits-3**

Course Objective:

- To formulate and analyze problems related to calculation of forces in fluid structureinteraction.
- To classify flows and to understand and apply the conservation principles for fluid flows.
- To understand the principles of dimensional analysis.

Course Outcome:

CO1: Students will be able to understand the history, concepts, formulations and applications of fluid mechanics.

CO2: Students will be able to analyze and solve various practical problems on the applications of fluid mechanics.

CO3: Students will be able to apply various solution techniques for solving new applied and theoretical problems.

Course Contents

Unit-I **(8 hours)**

Velocity, Acceleration and Material Derivative, Local continuity equation, Vorticity and circulation, vorticity equation, rotational and irrotational flow, Stream function for 2-D and 3-D flows, Newton's momentum equation, Constitutive Relations, Newtonian and non-Newtonian fluids, Moving co-ordinate system.

Unit-II **(8 hours)**

Dimension analysis and similarities, Buckingham pi theorem, types of similarities

Unit-III **(8 hours)**

Navier-Stokes equation, Exact solutions of Navier-Stokes equations

Unit-IV **(8 hours)**

Boundary layer theory, Integral form of Boundary layer equations, Flow stability, Turbulent flows: Correlations and spectra, Averaged equations of motion, eddy viscosity and mixing length.

Unit-V **(8 hours)**

Compressible flow: Speed of sound, basic equations for 1-D flow, stagnation and sonic properties, normal and oblique shock wave, Mach cone.

Text Books:

1. W. P. Graebel, Advanced Fluid Mechanics, Academic, 2007.
2. P. K. Kundu, I. M. Cohen, Fluid Mechanics, Academic, 2001.

Reference Books:

1. R. A. Granger, Fluid Mechanics, Dover, 2012.
2. F. M. White, Viscous Fluid Flow, McGraw-Hill, 2017.

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Gas turbine and Jet Propulsion (TET-306)

L:T:P:: 3:0:0 **Credits-3**

Course Objectives:

- To understand the compressible fluid flow in turbines and compressors.
- To understand the thermodynamic cycles of jet engines.
- To understand the combustion physics in combustion chambers.

Course Outcome:

Upon successful completion of the course, the students will be able to

CO 1: analyze the ideal and practical gas turbine cycles of air-breathing propulsion devices and industrial gas turbines.

CO2: design the blading and evaluate the performance of centrifugal and axial flow compressors.

CO3: analyze the combustion process in the gas turbine combustion system.

CO4: design axial and radial in-flow gas turbines.

CO5: analyze the off-design performance and matching of the components of a gas turbine.

Course Contents

Unit-I **(8 hours)**

Introduction: Review of the fundamentals, Classification of turbomachines, Applications of gas turbines. Gas Turbine Cycles for Shaft Power: Ideal shaft power cycles and their analysis, Practical shaft power cycles and their analysis, combined cycles and cogeneration schemes.

Gas Turbine Cycles for Propulsion: Propulsive devices - Criteria of performance, Gas turbine cycles for turbojet, turbofan, turboprop and turbo-shaft engines, Thrust augmentation techniques.

Unit-II **(8 hours)**

Fundamentals of Rotating Machines: Euler's energy equation, Components of energy transfer, Impulse and reaction machines, Degree of reaction, Flow over an airfoil, Lift and drag.

Centrifugal Compressors: Construction and principle of operation, Factors affecting stage pressure ratio, Compressibility effects, Surging and choking, Performance characteristics.

Unit-II **(8 hours)**

Flow through Cascades: Cascade of blades, Axial compressor cascades, Lift and drag forces, Cascade efficiency, Cascade tunnel.

Axial Flow Compressors: Construction and principle of operation, Factors affecting stage pressure ratio, Degree of reaction, Three dimensional flow, Design process, Blade design, Stage performance, Compressibility effects, Off-design performance, Axi-radial flow configurations.

Unit-IV **(8 hours)**

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Gas Turbine Combustion System: Operational requirements, Factors affecting combustion chamber design, Combustion process, Flame stabilization, Combustion chamber performance, Practical problems - Gas turbine emissions.

Axial and Radial Flow Turbines: Construction and operation, Vortex theory, Estimation of stage performance, Overall turbine performance, Turbine blade cooling, Radial flow turbines.

Unit-V **(8 hours)**

Off-Design Performance: Off-design performance of single shaft gas turbine, free turbine engine and jet engine, Methods of displacing the equilibrium running line.

Other Topics: Design of Nozzles, afterburners, anti-icing mechanisms.

Text Books:

1. Gas Turbine Theory, Sarvanamuttoo, H.I.H., Rogers, G. F. C. and Cohen, H., PearsonPrentice Hall, 2017, 7th Edition.
2. Gas Turbines, Ganesan, V., Tata McGraw Hill, 2017, 3rd Edition.
3. Fluid Mechanics and Thermodynamics of Turbomachinery, Dixon, S.L, Elsevier, 2014, 7thEdition.
4. Fundamentals of Jet Propulsion with Applications, Flack, R.D., Cambridge University Press, 2011.

Reference Books:

1. Gas Turbine Theory, 7e,Cohen,Pearson Education
2. Turbines, Compressors and Fans, Yahya, S. M, Tata McGraw Hill, 2017, 4th Edition.
3. Gas Turbine Combustion – Alternative Fuels and Emissions, Lefebvre, A.H. and Ballal D. R., CRC Press, 2010.

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Alternatives fuels in I.C. Engine (TET-307)

L:T:P:: 3:0:0 **Credits-3**

Course Objectives:

- To impart knowledge about the importance of alternate fuels.
- To introduce the fundamental concepts relevant to Hydrogen & Fuel cells.

Course Outcome:

At the end of the course, students will be able to

CO1: Modify automotive engine to operate by using various alternative fuels.

CO2: Analyze engine performance and emission characteristics by using alternative fuels.

CO3: Suggest advance engine technology for alternative fuels.

Course Contents

Unit-I **(8 hours)**

Introduction: Need of alternative gaseous fuels, future automotive gaseous fuels, hydrogen, CNG, LNG, and Producer gas, biogas, LPG. Stochiometric air-fuel ratio, Physical properties of different gaseous fuels, mode of engine operations, spark ignition and dual fuel mode, multi fuel mode, combustion and performance of engines, specific problems, safety and environmental aspects,economic aspects, production.

Unit-II **(8 hours)**

Use of alcohol: In four stroke spark ignition engines and diesel engines, use of alcohol in two stroke engines, use of bio diesels, combustion and performance of engines, stochiometric air fuel ratio, specific problems, safety and environmental aspects, economic aspects, production.

Unit-III **(8 hours)**

Impacts: Impact of alternative fuels on engine test and test procedures, guidelines for emission measurements, emission norms for engines using alternative fuels.

Unit-IV **(8 hours)**

Legal Aspects: Legal aspects of blending alternative fuels into conventional liquid fuels, properties of blends, comparison of neat versus blended fuels, fuel testing.

Unit-V **(8 hours)**

Computer simulation: Computer simulation of engines using alternative fuels.

References:

1. Future automotive fuels, Edited by Joseph M. Colucci and Nicoles C. Gallopoulos, Plenum press, New York
2. Dual fuel engines, edited by R.L. Evans, Plenum Press, 1987.

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3. SAE hand book, volume III, Engines, fuels, lubricants, emissions and noise.
4. Automotive fuels and fuel systems, volume II, T.K. Garrett, Pantech Press, London.
5. Gaseous fuels for transportation I, proceedings of the conference held at Vancouver, British Columbia, Canada, 1987.
6. Pandel U, Poonia M.P.; Energy Technologies for Sustainable Development, Prime Publishing House Gajiabad, 2003.

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Gas Dynamics (TET-308)

L:T:P:: 3:0:0 **Credits-3**

Course Objective:

- To understand various theoretical concepts related to compressible flow, normal and oblique shock waves, variable area flow, flow with heat addition.
- To understand the working of various systems related to gas dynamics: shock waves, adiabatic flow in a duct.
- To understand and apply mathematical treatment to various problems related to generalized quasi-onedimensional flow.

Course Outcome:

Upon successful completion of the course, the students will be able to
CO1: Solve flow equations for quasi one-dimensional flow through variable area ducts.
CO2: Analyze flow through constant area ducts with friction and heat transfer.
CO3: Analyze flows with normal and oblique shocks.

Course Contents:

Unit-I **(8 hours)**
Fundamentals of Compressible Flow: Continuity, Momentum and energy equation, Control volume, Sonic velocity, Mach number and its significance, Mach waves, Mach cone and Mach angle, Von Karman rules of supersonic flow, Static and stagnation states, Relationship between stagnation temperature, Pressure, Density and enthalpy in terms of Mach number, Stagnation velocity of sound, Reference speeds, Various regions of flow, Effect of Mach number on compressibility.

Unit-II **(8 hours)**
Isentropic Flow with Variable Area: One dimensional isentropic flow in ducts of varying cross-sectionnozzles and diffusers, Mass flow rate in nozzles, Critical properties and choking, Area ratio as function of Mach number, Impulse function, Effect of back pressure variation of convergent and convergent divergent nozzles, Non-dimensional mass flow rate in terms of pressure ratio, Area ratio and Mach number, Flow through diffusers, operation and analysis of C-D- nozzles, Use of gas tables. Flow in Constant Area Duct with Friction (Fanno flow): Fanno curve and Fanno flow equations, Solution of Fanno flow equations, Variation of flow properties, Variation of Mach no. with duct length, Frictional choking, Isothermal flow in constant area duct with friction, Tables and charts for Fanno flow.

Unit-III **(8 hours)**
Flow in Constant Area Duct with Heat Transfer (Rayleigh flow): Rayleigh curve and Rayleigh flow equations, Variations of flow properties, Maximum heat transfer, Thermal Choking, Tables and charts for Rayleigh flow.

Unit-IV **(8 hours)**
Normal and Oblique Shock Waves: Development of shock wave, Governing equations, Prandtl-Mayer relation, Rankine-Hugoniot relation, Strength of shock wave, Mach number in the downstream of normal

shock, Variation of flow parameters across the normal shock, Normal shock in Fanno and Rayleigh flows, Compression shock wave and expansion fan, Analysis of oblique shock wave.

Unit-V **(8 hours)**

Introduction to Experimental Facilities: Types of wind tunnels-Sub sonic wind tunnel, Supersonic wind tunnel, Free-piston shock tunnel, Detonation-driven shock tunnels, and Expansion tubes.

Books and References

1. Dynamics of Compressible Flow by S.M. Yahya, New Age Publishers.
2. Fundamentals of Compressible Fluid Dynamics by P. Balachandran, PHI Learning.
3. Fundamental of Gas Dynamics by V. Babu, CRC Press.
4. Gas Dynamics by E. Rathakrishanan, PHI Learning.

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Design and Analysis of Solar Energy Systems (TET-309)

L:T:P::3:0:0 **Credits-3**

Course Objectives:

- Understand the design concepts of solar systems.
- Design and development of solar thermal systems.
- Design of photovoltaic system and its components.

Course Outcomes:

Upon successful completion of the course, the students will be able to

CO1: Design & analyze the various types of solar systems & their components.

CO2: Design & develop creative/novel thermal energy storage systems.

Course Contents

Unit-I **(8 hours)**

Design Concepts of Solar Systems: System conceptual design, Design of components, Design of physical principles to the solar system based on application. Process includes idea generation, Concepts election and estimation, Design of major components and overall system design, Solar radiation data.

Unit-II **(8 hours)**

Solar Thermal Energy Storage: Design aspects of solar thermal energy storage systems, Selection criteria of storage materials for heating and cooling applications, Selection of heat transfer fluid for heating and cooling applications, Design of latent heat thermal energy storage (LHTES) for solar process heating and power generation applications.

Unit-III **(8 hours)**

Solar Photovoltaic System: Design of photovoltaic off-grid and grid-connected power systems, Design of system components -PV modules, Batteries, Charge controllers, Inverters, Auxiliaries, Performance analysis of a photovoltaic system, Using software codes for design of solar thermal and photovoltaic systems.

Unit-IV **(8 hours)**

Solar Heating and Cooling Systems: Design of solar thermal systems for water, Space heating, Cooling and power generation, F-Chart calculation method for sizing solar water and space heating systems, Design of non-focusing and focusing collectors.

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Unit-V **(8 hours)**

Performance Analysis: Performance analysis of various solar thermal systems, PV system and evaluation of solar thermal energy storage system, Selection of components and materials, Estimation of economics, Using software tools for design of solar thermal and photovoltaic systems, Case studies.

Books and References

1. Solar Energy: Principles of Thermal Collection and Storage by S.P. Sukhatme, J. K. Nayak, Tata McGraw-Hill.
2. Solar Engineering of Thermal Processes by John A. Duffie William A. Beckman, John Wiley & Sons, Inc.
3. Solar Energy Engineering: Processes and Systems, Kalogirou. S.A, Academic Press.
4. Solar Energy Fundamentals and Modeling Techniques, Sen .Z, Turkey.

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Engine Tribology (TET-310)

L:T:P:: 3:0:0 **Credits-3**

Course Objectives

- To impart knowledge about the surfaces and their related terminologies.
- To introduce the fundamental concepts of friction and wear of engine parts
- To know the types of lubrication
- To enable the students to understand the factors that causes the wear and friction.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand about different concepts related to friction, Wear and Lubrication.

CO2: Know about the various types of wear and their identification and estimation.

CO3: Understand the need and requirement of Lubrication and mechanisms.

Course Contents

Unit-I **(8 hours)**

Introduction: Fundamentals of tribology, General tribological considerations in the engine components such as bearings, gears, cams, followers, reciprocating parts and dynamometer.

Surface Properties: Surface topographyand its measurement, Quantifying surface roughness, Statistical methods of surface texture assessment, Surface modifications and surface coatings, Measurement of surface roughness.

Unit-II **(8 hours)**

Friction: Theories of friction, Sliding friction, Rolling friction characteristics of common metals and nonmetals friction under different environments, Engine friction-Losses and engine design parameters, Friction in extreme conditions.

Unit-III **(8 hours)**

Wear: Types of wear and their mechanism, Mechanism of sliding wear of metal, Fretting wear of metals, Factors affecting wear, Selection of materials for different wear situations, Measurement of wear, Engines wear mechanisms, Wear resistant materials and coatings and failure mode analysis.

Unit-IV **(8 hours)**

Lubrication: Basic concepts of lubrication, Lubrication regimes in IC Engine, Generalized Reynolds equation, Types of fluid film bearings, Hydrodynamic journals bearings, Short and finite bearings, Thrust bearings, Sintered bearing, Non-circular bearings, Multi-recess journal and thrust bearings, Air and gas

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lubricated bearings, Engine lubrication and bearings, Lubrication of cam-follower, Valve train mechanism, Type of lubrication for various parts of engine.

Unit-V **(8 hours)**

Lubricants: Type of lubricants, Classification of lubricants, Gear oil and engine oil properties and testing, Service schedule, Lubrication system, Lubricant monitoring and testing, Ferrography and other rapid testing methods for lubricants contamination.

Books and References

1. Applied Tribology - Bearing Design and Lubrication by Michael M Khonsari, Wiley.
2. Engineering Tribology by John William, Cambridge University Press.
3. Introduction to Tribology by Bharat Bhushan, Wiley India.
4. Engine Tribology by C M Taylor, Elsevier.

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Exergy Analysis of Thermal Systems (TET-311)

L:T:P:: 3:0:0 **Credits-3**

Course Objectives

- To familiarize the students about the exergy and its applications in real life situations.
- To carry out an exergy-economic analysis on the existed thermal system.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify and apply concepts, theorems of thermodynamics to the various thermal and fluid engineering system.

CO2: Apply the concepts of exergy analyses in specific applications e.g. power stations, refrigeration installations, Cryogenic systems.

CO3: Interpret and estimate exergy losses by, exergy calculations, exergetic efficiency, exergy charts.

Course Contents

Unit-I **(8 hours)**

Exergy Analysis of Simple Processes: Mixing and separation process of fluids of different temperature, Heat transfer across a temperature difference, Expansion and compression process, Combustion process.

Unit-II **(8 hours)**

Exergy Destruction: Unavailable work referred to heat engine cycle, Refrigeration cycle, Heat pump cycle, Non-flow and steady flow process, Mechanism of exergy destruction, Modified Gouy-Stodola theorem, Concept of effective temperature.

Unit-III **(8 hours)**

Exergy Analysis of Power Plant Cycles: Steam turbine power plants, External and internal irreversibility, Super heater, Reheater, Vacuum condenser, Regenerative feed water heating, Combined feed water heating and reheating gas turbine power plant, Regeneration and intercooler, Combined steam and gas turbine power plant.

Unit-IV **(8 hours)**

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.

Unit-V **(8 hours)**

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.

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Books and References

1. Advanced Engineering Thermodynamics by Adrian Bejan, John Wiley & Sons.
2. The Exergy Method of Thermal Plant Analysis by T J Kotas, Krieger Publishing Company.
3. Advance Thermodynamics for Engineers by D E Winterbore, Ali Turan, Kidlington, Oxford.
4. Fundamentals of Engineering Thermodynamics by Michel J Moran, Howard N Shapiro, Daisie D Boettne, argaretBailey, Wiley.

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Power Plant Engineering (TET-312)

L:T:P::3:0:0 **Credits-3**

Course Objectives

- To introduce students to different aspects of power plant engineering.
- To familiarize the students to the working of power plants based on different fuels.
- To expose the students to the principles of safety and environmental issues.

Course Outcomes:

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

CO1: Apply the principles of thermodynamics to analyse the performance of steam, gas, combined and nuclear power plants

CO2: Design and develop power plant components for optimum performance

CO3 Select appropriate site and technology for power plants

CO4: Evaluate economic and environmental implications on power plants.

Course Contents

Unit-I **(8 hours)**

Introduction: Energy resources and their availability, types of power plants, selection of the plants, review of basic thermodynamic cycles used in power plants.

Steam Power Plants: Flow sheet and working of modern-thermal power plants, site selection, and plant efficiency

Unit-II **(8 hours)**

Steam generators and their accessories: High pressure Boilers, design of accessories, Steam generator control, Draught system.

Fuel and combustion: coal storage and preparation, coal handling systems, coal combustion, mass and energy balance of steam generator, feeding and burning of pulverized fuel, Fluidized bed combustion system, ash handling systems, dust collection -mechanical dust collector and electrostatic precipitator.

Unit-III **(8 hours)**

Condensers: Direct Contact Condenser, Surface Condensers, Effect of various parameters on condenser performance, Design of condensers, Cooling towers and cooling ponds

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Combined Cycles: Gas turbine power plants, Arrangements of combined plants (steam & gas turbine power plants), parameters affecting thermodynamic efficiency of combined cycles, Integrated gasification combined cycle, PFBC based combined cycle, re-powering of thermal power plant.

Unit-IV **(8 hours)**

Nuclear Power Plants: Principles of nuclear energy, basic nuclear reactions, Nuclear cross-section, different components of nuclear power station, PWR, BWR, CANDU, liquid metal cooled, gas cooled, fast breeder, nuclear waste disposal.

Non-conventional energy generation: Geothermal power plant, Tidal and wave power plant, solar power plant, wind power generation, direct to electricity method - Magneto-hydrodynamic (MHO) power generation.

Unit-V **(8 hours)**

Hydro-Electric Power Plants: Rainfall and run-off measurements and plotting of various curves for estimating stream flow and size of reservoir, comparison with other types of power plants.

Power Plant Economics: load curve, different terms and definitions, base load and peak load plants, energy storage, cost of electrical energy, tariffs, methods of electrical energy, performance & operating characteristics of power plants - incremental rate theory, input-output curves, efficiency, heat rate, economic load sharing, Problems.

Text / Reference Books:

1. Power Plant Engineering, P. K. Nag, McGraw Hill Education; 2017, 4th Edition.
2. Power Plant Engineering, R.K. Hegde, Pearson Education
3. Practical Power Plant Engineering: A Guide for Early Career Engineers, Zark Bedalov, Wiley
4. Power Plant Engineering, D.K. Mandal, S. chakrabarti, A. Kumar, P.K. Das, Wiley
5. Advanced Power Plant Materials, Design and Technology, Dermot Roddy, Elsevier

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Wind Energy Utilization (TET-313)

L:T:P::3:1:0 **Credits-4**

Course Outcomes:

To provide the students with

CO1: basic knowledge about factors affecting wind power at different atmospheric and terrain conditions.

CO2: understanding of working principles of different wind driven machines.

CO3: knowledge of analyzing different wind driven machines.

CO4: knowledge of techno-economic analysis of wind driven machines.

CO5: understanding the energy market regulations and pricing mechanisms

Course Contents:

Unit-I **(8 hours)**

Wind Energy Fundamentals: Wind Energy Basics, Wind energy potential- offshore and onshore wind energy, Terrain, Roughness, Atmospheric Boundary Layer, Turbulence, Wind Speeds and scales, Wind Speed variations, Instruments for wind measurements, Wind data analysis, Wind energy conversion system.

Unit-II **(8 hours)**

Modern Wind Turbines: Basic classification, Advantages and disadvantages, Conceptual designs, Components and control, Blade designs, Blade motions, Blade material, Wind Turbine noise, Environmental impact, Site selection, Wind farm.

Unit-III **(8 hours)**

Aerodynamics of Wind Turbines: Actuator disc concepts, Blade element momentum theory, Stream tube models, Vortex theory, CFD analysis, Aerodynamic loading and aero-elasticity of wind turbines.

Unit-IV **(8 hours)**

Wind Turbine Performance: Betz's Limit, Performance curves, Constant rotational speed operation, variable-speed operation, Wind turbine Performance Measurements, Aerodynamic

Unit-V **(8 hours)**

Performance Assessment:

Cost Economics: Wind energy market, Fixed and variable costs, Value of wind energy, Life cycle costing and cash flow of wind power projects. Regulations pertaining to Wind Farm integration into existing supply structure, Regulations for energy pricing and its trading.

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Books and Reference:

1. Handbook of Wind Energy Aerodynamics, Bernhard Stoevesandt, Gerard Schepers, Peter Fuglsang, Sun Yuping, Springer
2. Wind Energy System and Applications, D.P. Kothari, Narosa Publishing
3. Fundamentals of Wind Energy Utilization, A.G. Powar, A.G.Mohod, Jain Brothers New Delhi
4. Wind Energy: An Introduction by Mohamed A El Sharkawi, CRC Press
5. Wind Energy Explained: Theory, Design and Application, James F. Manwell, Jon G. Mcgowan, Anthony L. Rogers, Wiley

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Computational Methods in Thermal Engineering (TET-314)

L:T:P::3:1:0 Credits-4

Course Objectives:

- To impart knowledge of various computational methods dealing problems related to thermal engineering.
- To knowhow finite difference, finite element & boundary elements based computational methods.

Course Outcomes:

Upon successful completion of the course, the students will be able to

CO1: use various programming languages to model & obtain solutions of relevant engineering problems.

CO2: analyze the outcomes and compare with available literature results in order to conclude the findings.

Course Content:

Unit I (6 hours)

Introduction to Computational Methods: Finite difference method (FDM), Finite element method (FEM), Boundary element method (BEM).

Unit II (8 hours)

Finite Difference Method (FDM): Introduction, History, Application, Discretization methods: Methods for solving discretized equations, Consistency, Stability and convergence, Representation of a derivative, Backward difference, Central difference, Forward, Backward and central difference, Stencil, Stencil in Y direction, 2^{nd} order and mixed derivative, Boundary consideration, Polynomial approach, Order of approximation.

Unit III (8 hours)

Application of FDM to thermal engineering problem: 1D steady state conduction, Treatment of boundary condition, Algebraic equation and matrix form, Unsteady heat conduction with FDM, Application to transient heat transfer by FDM. Use of FDM for finding solution of 2D and 3D heat transfer problems-Steady state heat conduction, Flux boundary condition, Convective boundary condition and insulated boundary, Related problems.

Unit IV (10 hours)

Finite Element Method (FEM): Introduction, History, Applications, Merits and demerits of FEM, Variational and weighted residual approaches of FEM, Finite elements and interpolation functions (1D, 2D, and 3D), Finite element formulation (Variational and Galerkin's) of 1D, 2D and 3D heat transfer problems, FE formulation of 1D heat transfer with mass transport using Galerkin's method.

Unit V (8 hours)

Boundary Element Method (BEM): Introduction, History, Applications, Merits and demerits of BEM, Approach of BEM, Numerical implementation-determination of Ci, Tackling kernel singularity; 3D BEM formulation for transient heat transfer problem.

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Books and References:

1. Computational Fluid Mechanics and Heat transfer by D.A. Anderson, J.C. Tannehill, and R.H. Pletcher, Hemisphere Publishing Corporation.
2. An Introduction to Computational Fluid Dynamics The Finite Volume Method, 2e , Versteeg, Pearson Education
3. The Finite Element in Engineering by S.S. Rao, Butterworth Heinemann, Boston.
4. Finite and Boundary Element Methods in Engineering by O.P. Gupta, Oxford & IBH Publishing.
5. Computation Fluid Dynamics by Anderson Jr., McGraw Hill

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Optimization Methods in Thermal Engineering (TET-315)

L:T:P::3:1:0 **Credits-4**

Course Objectives

- To introduce students about the methods of optimization.
- To impart knowledge of numerous methods used to solve the problems of thermal engineering.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: understand & execute the basic theoretical principles of optimization.

CO2: formulate various optimization models in order to yield solutions.

CO3: solve wide range of engineering problems related to thermal engineering.

Course Contents:

Unit-I **(8 hours)**

Introduction: Basic terminologies, Design variables, Objective function, Constraints and problem formulation etc. Linear programming, Simplex method, Duality in linear programming.

Unit-II **(8 hours)**

Single Variable Unconstrained Optimization: Global optimum point, Local optimum point, Stationary point, Optimality criteria, Graphical method for optimum point, Direct methods for bracketing the optimum point: Exhaustive search method and bounding phase method, Refining the bracketed optimum point through region elimination methods: Interval halving method, Fibonacci search method and Golden section search method, Gradient based methods: Bisection method, Newton-Raphson method and Secant method.

Unit-III **(8 hours)**

Multi-Variable Optimization Algorithm: Optimality criteria, Unidirectional search, Direct search methods, Box method, Hooke-Jeeves pattern search method, Powell's conjugate direction method, Gradient based methods: Cauchy's steepest descent method, Newton's method, Marquardt's method, Conjugate gradient method and variable metric method.

Unit-IV **(6 hours)**

Constrained Optimization Algorithms: Kuhn-Tucker conditions, Sensitivity analysis, Transformation methods, Penalty function method, Methods of multipliers (MOM).

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Unit-V **(8 hours)**

Specialized Algorithms: Integer Programming: Penalty function method, Branch and bound method, Geometric programming, Non-traditional optimization algorithms: Genetic algorithms, Simulated annealing, Tabu search, Ant colony optimization, Particle swarm optimization, Application of optimization methods in thermal engineering.

Books and References

1. Optimization for Engineering Design: Algorithms and Examples by Kalyanmoy Deb, Prentice Hall of India Pvt. Ltd.
2. Multi-Objective Optimization using Evolutionary Algorithms by Kalyanmoy Deb, Wiley India Pvt. Ltd.
3. Engineering Optimization: Methods and Applications by A. Ravindran, K. M. Ragsdell, G. V. Reklaitis, Second Edition, John Wiley & Sons, Inc.
4. Engineering optimization: theory and practice by Singiresu S Rao, Fourth Edition, New Age International Pvt. Limited Publishers.

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Refrigeration and Air-Conditioning System Design (TET-316)

L:T:P::3:1:0 **Credits-4**

COURSE OBJECTIVES

- To educate the students the basics of refrigeration, unit of refrigeration, different thermodynamic cycles followed and conventional and unconventional refrigeration systems.
- To make the students to understand classification of primary refrigerants, secondary refrigerants, their designations and their different properties. To make the students to learn different refrigerants available for refrigeration and air conditioning applications.
- To make the students to learn different refrigeration equipment such as evaporator, compressor, condenser and expansion devices. To make the students to solve problems related to different conventional and unconventional refrigeration systems.
- To make the students to learn air water mixtures, empirical relations used to calculate desirable properties air water vapour mixture, different psychrometric properties and their use in air conditioning applications.

COURSE OUTCOMES

At the end of the course,

CO1: the student should be able to differentiate between different types of refrigeration systems with respect to application as well as conventional and unconventional refrigeration systems.

CO2: thermodynamically analyze refrigeration and air conditioning systems and evaluate performance parameters.

CO3: apply the principles of Psychometrics to design the air conditioning loads for the industrial applications.

Course Contents:

Unit-I **(8 hours)**

Introduction, COP, Carnot refrigeration cycle, Air refrigeration cycle , Bell Coleman air refrigeration cycle, Refrigerants-Primary and secondary refrigerants, nomenclature, ecofriendly refrigerants, vapour compression system- Single stage system , analysis of theoretical vapour compression cycle, effect of pressure change on COP , Use of T-S & p-h charts , effect of subcooling of condensate on COP& capacity , effect of superheating of vapour compression, two fluid and three fluid refrigeration systems.

Unit-II **(8 hours)**

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Compressors, Single stage compression and multistage compression systems, Evaporators, multi-evaporator system, Condensers, Expansion devices, cooling towers. Effects of condenser and evaporator pressure on COP-multi pressure system-low temperature refrigeration-Cascade systems- problems.

Unit-III **(8 hours)**

Steam jet refrigeration- Ejector refrigeration systems- Thermoelectric refrigeration-Air refrigeration – Magnetic – Vortex and Pulse tube refrigeration systems, Aircraft refrigeration.

Unit-IV **(8 hours)**

Properties of air-vapour mixture, Law of water vapour-air mixture, Enthalpy of moisture, Adiabatic saturation, Psychrometric chart, Simple heating and cooling, Humidification, Dehumidification, Mixture of air streams.

Unit-V **(8 hours)**

Requirements of comfort air conditioning: Oxygen supply, Heat removal, moisture removal, air motion, purity of air, Thermodynamics of human body, comfort and comfort chart, effective temperature, factors governing optimum effective temperature , Air Conditioning System: Process in air conditioning : Summer air conditioning, Winter air conditioning and year round air conditioning, Cooling load calculations.

Books and Reference:

1. C P Arora, Refrigeration & air conditioning, Tata McGraw Hill , 3rd Edition
2. Roy J. Dossat, Principles of Refrigeration, Pearson Education
3. Arora and Domkundwar, Course in Refrigeration and Air conditioning, DhanpatRai& Sons.
4. Stoecker, W. F. Jones, J. W. Stoecker, Wilbert F., Refrigeration and Air Conditioning, McGraw-Hill Science

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Design of Thermal Turbo machines (TET-317)

L:T:P::3:0:0 **Credits-3**

Course Objectives:

- To introduce fundamental concepts related to design of compressor and turbines.
- To enable the students to understand the performance of various types of gas turbines.

Course Outcomes:

Upon successful completion of the course, the students will be able to

CO1: Design compressors and turbines.

CO2: Establish performance characteristics curves of thermal turbomachines.

CO3: Assess & analyze the performance outcomes of thermal turbomachines.

Course Content:

Centrifugal Compressors: Principle of operation, Work done and pressure rise, Components of centrifugal compressor, Stage pressure, Stage efficiency, Degree of reaction, Dimensionless parameters, Slip factor, Causes of slip, Velocity triangles, Euler work, Design of impeller, Design of diffuser, Design of vane less diffuser, Design of volute casing.

Axial Flow Compressors: Basic operation, Elementary theory, Factors affecting stage pressure ratio, Blockage in the compressor annulus, Degree of reaction, Three dimensional flow, Design process, Blade design, Calculation of stage performance, Compressibility affects, Off-design performance, Axial compressor characteristic.

Axial and Radial Flow Turbines: Elementary theory of axial flow turbine, Vortex theory, Choice of blade profile, Pitch and chord, Estimation of stage performance, Overall turbine performance, Radial flow turbine.

Performance Prediction of Gas turbines: Component characteristics, Off-design operation of the single shaft turbine, Equilibrium running of gas generator, Off-design operation of free turbine engine, Off-design operation of the jet engine, Methods of displacing the equilibrium running line, Incorporation of variable pressure losses.

Books and References

1. Centrifugal compressors: A basic guide by M.P. Boyce, Penn Well Books.
2. Gas Turbine theory by Cohen, Rogers, Paul Straznicky, HIH Saravanamuttoo, Andrew Nix Pearson Education.
3. Axial Flow Compressors: A strategy for aerodynamic design and Analysis by R. Aungier, ASME Press.
4. Turbine Compressors and Fans by S.M.Yahya, Tata McGraw-Hill.

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Modeling and Simulation (TET-318)

L:T:P::3:0:0 **Credits-3**

Course Outcome

- Students will understand the techniques of modeling in the context of hierarchy of knowledge about a system and develop the capability to apply the same to study systems through available software.
- Students will learn different types of simulation techniques.
- Students will learn to simulate the models for the purpose of optimum control by using software.

Course Content:

UNIT I **(8 Hours)**

Introduction: System, environment, input and output variables, State variables; Static and Dynamic systems; Hierarchy of knowledge about a system and Modeling Strategy.

Physical Modeling: Dimensions analysis, Dimensionless grouping of input and output variables of find empirical relations, similarity criteria and their application to physical models.

UNIT II **(8 Hours)**

Modeling of System with Known Structure: Review of conservation laws and the governing equation for heat, mass and momentum transfer, Deterministic model-(a) distributed parameter models in terms of partial identification and their solutions and (b) lumped parameter models in terms of differential and difference equations, state space model, transfer functions block diagram and sub systems, stability of transfer functions, modeling for control.

UNIT III **(8 Hours)**

Optimizations and Design of Systems: Summary of gradient based techniques: Nontraditional Optimizations techniques (1) genetic Algorithm (GA)- coding, GA operations elitism, Application using MATLAB:(ii) Simulated Annealing.

UNIT IV **(8 Hours)**

Neural Network Modeling of Systems only with Input-output Database: Neurons, architecture of neural networks, knowledge representation, learning algorithm. Multilayer feed forward network and its back propagation learning algorithm, Application to complex engineering systems and strategy for optimum output.

UNIT V **(8 Hours)**

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Modeling Based on Expert Knowledge: Fuzzy sets, Membership functions, Fuzzy Inference systems, Expert Knowledge and Fuzzy Models, Design of Fuzzy Controllers

Simulation of Engineering Systems: Monte-Carlo simulation, Simulation of continuous and discrete processes with suitable examples from engineering problems.

Text and Reference Books:

1. Zeigler B.P. Praehofer. H. and Kim I.G. "Theory of modeling and simulation", 2 nd Edition.Academic press 2000
2. Process Control: Modelling, Design and Simulation, B Wayne Bequette ,1st edition, Pearson Education
3. Ogata K " Modern control Engineering" 3 rd edition. Prentice hall of India 2001
4. Jang J.S.R. sun C.T and Mizutani E,, "Neuro-Fuzzy and soft Computing ", 3 rd edition,Prentice hall of India 2002
5. Shannon, R. E., “System Simulation: the Art and Science”, Prentice Hall Inc. 1990
6. Pratab.R " Getting started with MATLAB" Oxford university Press 2009

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Bio-fluid Mechanics (TET-319)

L:T:P::3:0:0 **Credits-3**

Course Outcome:

CO1: Students will be able to gain knowledge about basic principles of bio-transport processes and the flow characteristics of various biological fluids

CO2: Students will be able to study the pressure and flow patterns in blood vessels and the bio-fluid mechanics in human organs

CO3: Students will be able to acquire an idea about flow and pressure measurement techniques in human body.

Course Contents:

UNIT I **(10 Hours)**

Fundamentals of bio-transport: Stress Tensor; Conservation of mass, momentum and energy; pulsatile flow in rigid and elastic tubes; Resistance, Compliance and Inertance; Concepts of two-Phase Flows; Classification of non-Newtonian Fluids; Non-Newtonian Fluid Flow in Human Body; Microscale Heat Transfer; Bioheat Transfer; Application of Magnetic Field in Hyperthermia

UNIT II **(6 Hours)**

Hematology and Blood Rheology: Components of blood, Blood Viscosity and Its Aspects, Rheological Models of Blood, Blood Diseases

UNIT III **(6 Hours)**

Circulatory Bio-fluid Mechanics: Macrocirculation System; Microcirculation System, Interstitial and Synovial fluid flow

UNIT IV **(8 Hours)**

Biofluid Mechanics of Organ Systems: Cardiovascular System; Respiratory System; Urinary System; The Liver

UNIT V **(8 Hours)**

Flow and pressure measurement techniques in human body: Indirect Pressure Measurements; Direct Pressure Measurement; Flow Measurement

Text Books:

1. Biofluid Mechanics. Principles and Applications byA.Ostadfar
2. Nano and Bio Heat Transfer and Fluid Flow by M. Ghassemi and A. Shahidian
3. BiofluidMechanics,An Introduction to Fluid Mechanics, Macrocirculation, and Microcirculation by Rubenstein et al.
4.

Reference Books:

1. **Applied Fluid Mechanics, 8th edition Joseph A. Untener , Robert L. Mott ,Pearson**
2. Biofluid Dynamics Principles and Selected Applications by C. Kleinstreuer
3. Introductory Biomechanics - From Cells to Organisms by C.R. Ethier and C.A.Simmons

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Internal Combustion Engines and Pollution (TET-320)

L:T:P::3:0:0 Credits-3

Course Objectives:

- To impart knowledge about the S.I. & C.I engines
- To introduce the fundamental concepts relevant to pollutant emissions.
- To enable the students to understand the factors that cause the effects of emissions.

Course Outcomes:

Upon successful completion of the course, the students will be able to

CO1: Understand the underlying principles of operation of different I.C engines and components.

CO2: Provide knowledge on pollutant formation, control, recent trends etc.

Course Contents:

UNIT I (10 Hours)

Introduction: IC engines and components of IC engine, Comparison of two stroke & four stroke engines, Comparison between SI & CI engines, Valve and port timing diagram, Working cycles-otto, Diesel and dual cycle, Problem solving, Testing and performance, Measurement of brake power, Measurement of friction power, Requirement of cooling of the engine, Types of cooling.

Fuel: Fuel- structure & composition of IC engine fuel, Properties of SI and CI engine fuel, Fuel rating, Fuel additives and non-petroleum fuels (alternative fuels). Fuel air requirement for ideal normal operation, Maximum power & quick acceleration, Simple carburetor and its parts, Problem solving.

UNIT II (8 Hours)

Fuel Injection System and Ignition: Petrol injection, Lucas petrol injection system, Electronic petrol injection system, Requirements & type of diesel injection system, Fuel pump, Types of injectors, Ignition system- requirements of ignition system, Battery and magneto ignition system, Ignition timing, Spark plug, Spark advance mechanism, Comparison between conventional ignition system, Electronic ignition system, Factors affecting energy requirement of ignition system.

UNIT III (6 Hours)

Combustion: Stages of SI engine combustion, Effect of engine variables on ignition lag flame front propagation, Abnormal combustion, Pre-ignition & detonation, Theory of detonation, Effect of engine variables on detonation, Stages of CI engine combustion, Effect of engine variables on delay periods, Stages of CI engine combustion, Effect of engine variables on delay periods.

UNIT IV (6 Hours)

Pollutant Emissions from IC Engines: Introduction to clean air, Pollutants from SI and CI engines, Generation and controlling the formation of NOX , HC, CO, CO2 , Smoke, Measurement of engine emissions instrumentation, Pollution control strategies, Emission norms-EURO and Bharat stage norms, Effect of emissions on environment and human beings.

UNIT V (10 Hours)

Control Techniques for Reduction of Emission: Design modifications, Optimization of operating factors, Fuel modification, Evaporative emission control, Exhaust gas recirculation, SCR–Fumigation,

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Secondary air injection, PCV system, Particulate trap, Exhaust treatment in SI engines, Thermal reactors, Catalytic converters, Catalysts, Use of unleaded petrol.

Recent Trends: Air assisted combustion, Homogeneous charge compression ignition engines, Variable geometry turbochargers, Common rail direct injection systems, Hybrid electric vehicles, NOx absorbers, Onboard diagnostics.

Books and References:

1. Internal Combustion Engine Fundamentals, J.B. Heywood, McGraw-Hill.
2. Internal Combustion Engines, Ganesan, V, Tata McGraw Hill Book Co.
3. Fundamental of Internal Combustion Engine, Z. Smith, Gill, Oxford & IBH Publishing Co. Pvt. Ltd.
4. Engineering Fundamentals of the Internal Combustion Engines, Willard W. Pulkrabek, Second Edition, Pearson Prentice Hall

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Environmental and Social Impact Assessment (TET-321)

L:T:P::3:0:0 Credits-3

Course Objectives:

To impart the knowledge and skills to identify, assess and mitigate the environmental and social impacts of developmental projects

Course Outcomes:

The students completing the course will have ability to

CO1: carry out scoping and screening of developmental projects for environmental and social assessments

CO2: explain different methodologies for environmental impact prediction and assessment

CO3: plan environmental impact assessments and environmental management plans

CO4: evaluate environmental impact assessment reports

UNIT I (8 Hours)

INTRODUCTION

Impacts of Development on Environment – Rio Principles of Sustainable Development- Environmental Impact Assessment (EIA) – Objectives – Historical development – EIA Types – EIA in project cycle – EIA Notification and Legal Framework.

UNIT I I (8 Hours)

ENVIRONMENTAL ASSESSMENT

Screening and Scoping in EIA – Drafting of Terms of Reference,Baseline monitoring, Prediction and Assessment of Impact on land, water, air, noise, flora and fauna - Matrices – Networks – Checklist Methods - Mathematical models for Impact prediction.

UNIT I II (8 Hours)

ENVIRONMENTAL MANAGEMENT PLAN

Plan for mitigation of adverse impact on water, air and land, water, energy, flora and fauna – Environmental Monitoring Plan – EIA Report Preparation – Public Hearing-Environmental Clearance

UNIT IV (8 Hours)

SOCIO ECONOMIC ASSESSMENT

Baseline monitoring of Socio economic environment – Identification of Project Affected Personal – Rehabilitation and Resettlement Plan- Economic valuation of Environmental impacts – Cost benefit Analysis

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UNIT V **(8 Hours)**

CASE STUDIES

EIA case studies pertaining to Infrastructure Projects – Roads and Bridges – Mass Rapid Transport Systems - Airports - Dams and Irrigation projects - Power plants.

BOOKS AND REFERENCES:

1. Canter, R.L, “Environmental impact Assessment “, 2nd Edition, McGraw Hill Inc, New Delhi,1995.
2. Lohani, B., J.W. Evans, H. Ludwig, R.R. Everitt, Richard A. Carpenter, and S.L. Tu, “Environmental Impact Assessment for Developing Countries in Asia”, Volume 1 – Overview, Asian Development Bank,1997.
3. Peter Morris, Riki Therivel “Methods of Environmental Impact Assessment”, Routledge Publishers,2009.
4. Becker H. A., Frank Vanclay,“The International handbook of social impact assessment” conceptual and methodological advances, Edward Elgar Publishing,2003.
5. Barry Sadler and Mary McCabe, “Environmental Impact Assessment Training Resource Manual”, United Nations Environment Programme,2002.
6. Judith Petts, “Handbook of Environmental Impact Assessment Vol. I and II”, Blackwell Science New York, 1998.
7. Ministry of Environment and Forests EIA Notification and Sectoral Guides, Government of India, New Delhi, 2010.

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Cryogenic System (TET-322)

L:T:P::3:0:0 Credits-3

Course Objectives:

- To provide the knowledge of evolution of low temperature science
- To provide knowledge on the properties of materials at low temperature
- To familiarize with various gas liquefaction and refrigeration systems and to provide design aspects of cryogenic storage and transfer lines

Course Outcomes:

The students completing the course will have ability to

CO1: The knowledge on the properties of both matter and fluid for better design of the process equipment in cryogenics application.

CO2: Understanding the gas liquefaction and refrigeration system

CO3: Instrumentation in cryogenic system is essential for measuring properties at low temperature

Course Contents:

Unit-I (8 Hours)

Introduction: Cryogenic engineering, Properties of Cryogenic Fluids like Oxygen, Nitrogen, Argon, Neon, Florin, Helium, Hydrogen; Properties of Cryogenic Materials - mechanical, thermal, and electrical; Super conductivity; Hazards and prevention – physical hazard, chemical hazard, physiological hazard and preventions, Safety in cryogenic fluid handling, storage and use.

Unit-II (8 Hours)

Applications of cryogenic systems: Super conductive devices such as bearings, motors, cryotrons, magnets, D.C. transformers, tunnel diodes, space technology, space simulation, cryogenics in biology and medicine, food preservation and industrial applications, nuclear propulsions, chemical propulsions.

Unit-III (10 Hours)

Cryogenic Refrigeration & Liquefaction: Refrigeration: Ideal isothermal and reversible isobaric source refrigeration cycles, Joule Thomson system, cascade or pre-cooled joule–Thomson refrigeration systems, COP, FOM Liquefaction: Introduction, Principle and Methods of production of low temperature thermodynamically ideal systems, Joule Thomson effect, liquefaction systems such as Linde Hampton, Precooled Linde Hampson, Claude System

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Cryogenic insulation: Various types such as expanded foams, gas filled & fibrous insulation, vacuum insulation, evacuated powder & fibrous insulation, opacified powder insulation, multi-layer insulation, comparison of performance of various insulations.

Unit-IV **(10 Hours)**

Cryogenic System Requirements: Cryogenics Heat Exchangers, Compressors, Expanders, Effect of various parameters in performance and system optimization, Storage equipment for cryogenic fluids, industrial storage and transfer of cryogenic fluids

Cryogenic instrumentation: Properties and characteristics of instrumentation, strain displacement, pressure, flow, liquid level, density and temperature measurement in cryogenic range.

Books and References:

1. Klaus D.Timmerhaus and Thomas M.Flynn, Cryogenic Process Engineering, Plenum Press, New York, 1989
2. K. D. Timmerhaus and T. M. Flynn, Cryogenic Process Engineering', Plenum Press
3. Randall F. Barron, Cryogenics Systems, Oxford University Press
4. Fundamentals of Cryogenic Engineering, Mamata Mukhopadhyay, PHI

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Alternative Fuels Technology (TET-323)

L:T:P::3:0:0 Credits-3

Course Objectives

- To impart knowledge about the importance of alternate fuels.
- To introduce the fundamental concepts relevant to Hydrogen & Fuel cells

Course Outcomes:

Upon successful completion of the course, the students will be able to

CO1: Identify the fuel thermo-chemistry and fuel quality effects on emissions.

CO2: Describe the modifications required and the effects of design parameters.

Course Contents:

Unit-I (6 Hours)

Introduction: Estimate of petroleum reserve, Need for alternate fuel, Availability and comparative properties of alternate fuels, CNG, LPG, Alcohol, Vegetable oil and Bio-gas.

Unit-II (10 Hours)

CNG AND LPG: Availability, Properties, Modifications required in SI and CI engines, Performance and emission characteristics, Storage, Handling and dispensing, Safety aspects, Alcohol, Manufacture of alcohol, properties, Blending of methanol and ethanol, Engine design modifications required and effects of design parameters, Performance and emission characteristics, Durability, Types of vegetable oils for engine application, Extraction process, Biogas, Properties, Engine performance and emission characteristics.

Unit-III (8 Hours)

Hydrogen and Fuel Cells: Production methods, Properties, Performance and emission characteristics, Storage and handling, Safety aspects, Working principle, Classification, Description of fuel cell systems, Fuel cell components, Properties of fuel cell, General performance characteristics, Emission characteristics, Merits and demerits, Vehicle design and layout aspects.

Unit-IV (10 Hours)

Emissions from SI & CI Engines and its Control: Emission formation in S.I. engines, Hydrocarbons, Carbon monoxide, Nitric oxide, Lead particulates, Polynuclear aromatic hydro carbon emission, Effects of design and operating variables on emission formation in spark ignition engines, Controlling of pollutant formation in engines, Thermal reactors, Catalytic converters, Charcoal canister control for evaporative emission, Positive crank case ventilation system for UBHC emission reduction, Chemical

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delay, Intermediate compound formation, Pollutant formation on incomplete combustion, Effect of operating variables on pollutant formation, Controlling of emissions, Driving behavior, Fumigation, Exhaust gas recirculation, Air injection, Cetane number effect.

Unit-V **(6 Hours)**

Emission Measurement and Test Procedure: Measurement of exhaust gases by NDIR, Dilution tunnel technique for particulate measurement, Procedures on engine and chassis constant volume sampling procedures.

Books and References

1. Internal Combustion Engines, Ganesan.V, Tata McGraw Hill.
2. Automotive Emission Control, Crouse. W.M, Anglin. A.L, McGraw Hill.
3. Engine Emissions & pollutant formation, G.S, Patterson. D.J, Plenum Press.
4. Alternative Fuel: Emission, Economic and Performance, Maxwell et al, SAE.

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Pollution Control Technologies (TET-324)

L:T:P::3:0:0 **Credits-3**

Course Objectives:

- To provide general understanding of quality of air and impact on local and global effects of air pollution on human, materials, properties and vegetation.
- To study the fate and transport of air pollutants and its measurement techniques.
- To discuss the various types of air pollution control equipment and their design principles and limitation

Course Outcome:

At the end of the course student will be able to

1. Classify and identify the sources of air pollutants and predict the effects of air pollutant on human health and environment.
2. Apply and relate the significance of various air pollution dispersion models.
3. Analyze the air quality and relate with air pollution regulation
4. Design various air pollution control equipment and evaluate its use.

Course Contents:

Unit-I **(8 Hours)**

Introduction: Introduction to air pollution, classification of pollutants, their effects, impact of environment on human.

Air Pollution Sources: Mobile and stationary sources, types of plume dispersion mechanisms, air quality measurement concepts.

Unit-II **(8 Hours)**

Control devices for particulate contaminants: gravitational settlement, centrifugal and wet collectors, fabric filters, cyclone separators, electrostatic precipitators

Unit-III **(8 Hours)**

Control devices for gaseous contaminants from stationary sources: adsorption, adsorption, condensation, combustion based pollution control systems.

Unit-IV **(8 Hours)**

Automotive Emission control: Types and construction of catalytic converters, emission control through operating parameters and engine design, alternative fuels for emission reduction.

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Unit-V **(8 Hours)**

Laws and regulations: National and international standards for mobile and stationary sources of air pollution.

Books and References:

1. Howard S. Peavy, Donald Rowe; Environmental Engineering; Tata Mc-Graw Hill, 1989.
2. Wark Kenneth and Warner C.F, "Air pollution its origin and control". Harper and Row Publishers, New York, 1997.
3. 2. Rao C.S., "Environmental pollution control engineering", New age international Ltd, New Delhi, 2007.
4. 3. Peavy, H.S., Rowe, D.R., Tchobanoglous, G. "Environmental Engineering", McGraw Hills, New York 1985.
5. 4. De Nevers, N., "Air Pollution Control Engineering", McGraw Hill, New Delhi, 1995 5. Rao M. N., "Air Pollution", Tata Mc-Graw Hill Publication

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Electrical and Hybrid Vehicles (TET-325)

L:T:P::3:0:0 Credits-3

COURSE OBJECTIVES:

- To understand the models, describe hybrid vehicles and their performance.
- To understand the different possible ways of energy storage.
- To understand the different strategies related to hybrid vehicle operation & energy management.

COURSE OUTCOMES: At the end of this course, students will demonstrate the ability to
CO1: Study the models to describe hybrid vehicles and their performance.
CO2: Implement the different possible ways of energy storage.
CO3: Adopt the different strategies related to hybrid vehicle operation & energy management.

Course Contents:

UNIT I: **(6 Hours)**

Introduction: Conventional Vehicles: Basics of vehicle performance, vehicle power Source characterization, transmission characteristics, and mathematical models to describe vehicle performance.

UNIT II: **(8 Hours)**

Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis.

UNIT III: **(9 Hours)**

Electric Trains: Electric Drive-trains: Basic concept of electric traction. Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.

UNIT IV: **(9 Hours)**

Energy Storage: Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices. Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, supporting subsystems

UNIT V: **(8 Hours)**

Energy Management Strategies: Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies and implementation issues of energy management strategies.

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BOOKS AND REFERENCES:

1. C. Mi, M. A. Masrur and D. W. Gao, "Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives", John Wiley & Sons, 2011.
2. Electric and Hybrid Electric Vehicles, James D. Halderman and Curt Ward 1st edition, Pearson
3. S. Onori, L. Serrao and G. Rizzoni, "Hybrid Electric Vehicles: Energy Management Strategies", Springer, 2015.
4. M. Ehsani, Y. Gao, S. E. Gay and A. Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design", CRC Press, 2004.
5. T. Denton, "Electric and Hybrid Vehicles", Routledge, 2016

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Energy Conservation Technologies (TET-326)

L:T:P::3:0:0 Credits-3

Course Contents:

UNIT I: (10 Hours)

Radiant Heating Equipment: Panel of heaters - steam - water, electrical radiant heaters, tubular radiant heaters, reflectors, heat transfer, comfort conditions, reduction of heat loss, installation.

Prime Movers and Generators: Energy conversion and efficiency, steam turbines, gas turbines, diesel and gas engines, electrical motors and DG-sets. Selection, factors affecting performance, load matching, PF improvement, maintenance practice.

UNIT II: (10 Hours)

Heat Pumps: General principles, appropriate conditions for using heat pumps, theoretical and practical COP, refrigerants, absorption heat pump, applications of heat pumps; gas driven heat pumps.

Heat Recuperators: Basic concepts, liquid/liquid heat exchangers, liquid/gas and gas/liquid heat exchangers, gas/gas exchangers, heat transfer calculations and area determination.

UNIT III: (10 Hours)

Heat Regenerators: Thermal wheel - basic principle- construction - flue gas as energy source -preheating combustion air - installation, regenerative heat recovery, double-effect operation and coupling of columns.

Heat Pipes: Basic concepts, design of heat pipes - heat transfer rate - thermodynamic efficiency - influencing factors- wick design - heat recovery from exhaust air, classification of heat pipes, practical applications.

UNIT IV: (10 Hours)

Heating Ventilation and Air Conditioning: Comfortable environment, effective temperature, heating and cooling systems, reheat systems, variable air volume, dual duct system, air water system, design considerations.

Cogeneration: Application for cogeneration, types of cogeneration processes stopping cycle plant bottoming cycle plant. Choice of configuration, effect of legislation-case studies.

Books and References:

1. R.M.E. Diamant, Energy Conservation Equipment, The Architectural Press, 1984.
2. S. David Hu, Handbook of Industrial Energy Conservation; Van Nostrand, Reinhold Pub., 1983.
3. S.C. Tripathy, Electrical Energy Utilization and Conservation, Tata McGraw Hill, 1986.