M. Tech Degree (Full Time) Programme

in

MECHANICAL ENGINEERING

(Specialisation: Thermal Engineering)

SCHEME OF EXAMINATION & SYLLABUS

SCHOOL OF ENGINEERING
COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY
COCHIN– 682 022

JULY – 2018

M. Tech Degree (Full Time) Programme in Mechanical Engineering

(Specialisation: Thermal Engineering)

SEMESTER I						
Sl No.	**Course Code**	**Course Name**	**Hours/Week**			**Credits**
			L	**T**	**P**	
1	18-450-0101	Advanced Fluid Mechanics	3	1	0	4
2	18-450-0102	Advanced Thermodynamics	3	1	0	4
3	18-450-01**	Elective I	3	1	0	3
4	18-450-01**	Elective II	3	1	0	3
5	18-450-0109	Thermal Engineering Laboratory I	0	0	3	1
6	18-450-0110	Seminar I	0	0	3	1
7	18-450-0111	Research Methodology and IPR	2	1	0	2
Total			14	5	6	**18**

SEMESTER II						
Sl No.	**Course Code**	**Course Name**	**Hours/Week**			**Credits**
			L	**T**	**P**	
1	18-450-0201	Advanced Heat and Mass Transfer	3	1	0	4
2	18-450-0202	Thermodynamics and Propulsion	3	1	0	4
3	18-450-02**	Elective III	3	1	0	3
4	18-450-02**	Elective IV	3	1	0	3
5	18-450-0209	Thermal Engineering Laboratory II	0	0	3	1
6	18-450-0210	Seminar II	0	0	3	1
7	18-450-0211	Mini Project	0	0	3	2
Total			12	4	9	**18**

SEMESTER III						
Sl No.	**Course Code**	**Course Name**	**Hours/Week**			**Credits**
			L	**T**	**P**	
1	18-450-03**	Elective V	3	1	0	3
2	18-450-03**	Elective VI	3	1	0	3
3	18-450-0307	Dissertation Phase – I	0	0	20	12
Total			6	2	20	**18**

SEMESTER IV						
Sl No.	**Course Code**	**Course Name**	**Hours/Week**			**Credits**
			L	**T**	**P**	
1	18-450-0401	Dissertation Phase – II	0	0	30	18
Total			0	0	30	**18**

***Electives must be selected from the following list for the corresponding semester*

Total credits for the M.Tech programme = **72**

ELECTIVES I & II (Semester I)

18-450-0103	Industrial Refrigeration and Air-Conditioning
18-450-0104	Incompressible and Compressible Flows
18-450-0105	Computational Methods in Engineering
18-450-0106	Hydrodynamics
18-450-0107	Conduction and Radiation
18-450-0108	Introduction to Combustion

ELECTIVES III & IV (Semester II)

18-450-0203	Combustion and Pollution
18-450-0204	Finite Element Analysis
18-450-0205	Convection and Two Phase Flows
18-450-0206	Principles of Turbo machinery
18-450-0207	Numerical Methods in Thermal Engineering
18-450-0208	Space Cryogenics

ELECTIVES V & VI (Semester III)

18-450-0301	Measurements in Thermal Engineering
18-450-0302	Statistical Methods for Engineering
18-450-0303	CFD and its Application
18-450-0304	Heat Exchanger Design
18-450-0305	Gas Turbines
18-450-0306	Introduction to Turbulence

SYLLABUS FOR

M. TECH DEGREE PROGRAMME IN MECHANICAL ENGINEERING

(Specialisation: Thermal Engineering)

SEMESTER – I

18-450-0101: ADVANCED FLUID MECHANICS

Course Outcomes:
On completion of this course the student will be able to:

1. *Understand the different flow patterns of ideal fluids*
2. *Demonstrate lift and drag for flow past a cylinder with and without rotation*
3. *Analyse viscous incompressible flows between parallel plates, along pipes and around sphere*
4. *Evaluate integral equations of laminar boundary layer*
5. *Explore the control of boundary layer separation and transition*
6. *Solve turbulent boundary layer equations and determine the coherent structures in the wall layer*

Module I
Flow of ideal fluids: Introduction, Uniform flow, Source and Sink, Vortex flow, Doublet, Flow about a cylinder without circulation, Lift and drag for flow past a cylinder without circulation, Flow about a rotating cylinder, Lift and drag for flow about a rotating cylinder

Module II
Viscous incompressible flows: Navier-Stokes Equations, Exact solutions of Navier–Stokes equations, Parallel flow in a straight channel, Couette flow between two parallel flat plates, Plane Poiseuille flow, Hagen Poiseuille flow through a pipe, Low Reynolds number flow around a sphere.

Module III
Laminar boundary layer: Boundary layer approximation and equations, Wall Shear and boundary layer thickness, Momentum – Integral equations for boundary layer, Separation of boundary layer, Entry flow in a duct, Control of boundary layer separation, Mechanism of boundary layer transition.

Module IV
Turbulent flow: Characteristics of turbulent flow, Reynolds Stresses, Turbulent flow near a wall, Turbulent boundary layers, Laminar – Turbulent transition, Turbulence production and cascade, Mean motion and fluctuations, Derivation of governing equations for turbulent flow, Turbulent boundary layer equations, Boussenesq approximation, Wall free shear flow, Wall bounded shear flow, Coherent structures in a wall layer.

References

1. Bachelor, G.K., An Introduction to Fluid Dynamics, London Cambridge University Press, 1967.
2. Shames, I. H., Mechanics of Fluids, McGraw Hill Book Company, New York, 1962.
3. Schlichting, H., Boundary Layer Theory, McGraw Hill Book Company, New York, 1953.
4. Mohanty, A. K., Fluid Mechanics, Prentice Hall of India Private Limited, New Delhi, 1986.
5. Som S. K., and Biswas G., Introduction to Fluid Mechanics & Fluid Machines, Tata McGraw Hill, 1998.
6. Frank M.White, Fluid Mechanics, Tata McGraw Hill, 1986.
7. Pijush K Kundu and Ira M. Cohen, Fluid Mechanics, Elsevier, 2001.
8. Tennekes H., and Lumley J. L., Introduction to Turbulence, MIT Press, 1972.
9. Biswas G., and Eswaran V., Turbulent flows, Narosa Publishing House, 2002.

18-450-0102: ADVANCED THERMODYNAMICS

Course Outcomes:

On completion of this course the student will be able to:

1. *Understand the fundamentals of availability, irreversibility and second law efficiency for a system*
2. *Apply the generalized equation for determining the changes in entropy, enthalpy and internal energy of systems*
3. *Analyse the fundamental property relations for systems of variable composition*
4. *Model equilibrium in multiphase systems*
5. *Apply first and second law analysis of reacting systems*
6. *Explore degeneracy of energy levels*

Module I

Availability, Irreversibility and second law efficiency for a closed system, Control volume, Availability analysis of simple cycles, Thermodynamic potentials, Maxwell relations, Generalised relation for changes in entropy, Internal energy and enthalpy, Generalised relations for *Cp* and *Cv*, Clausius-Claypeyron equation, Joule-Thomson coefficient, Bridgman tables for thermodynamic relations.

Module II

Different equations of state, Fugacity, Compressibility, Principle of corresponding states, Use of generalized charts for enthalpy and entropy departure, Fugacity coefficient, Lee-Kesler generalized three parameter tables, Fundamental property relations for systems of variable composition, Partial molar prosperities, Real gas mixtures, Ideal solution of real gases and liquids, Equilibrium in multi phase systems, Gibbs phase rule for non-reactive components.

Module III

Thermo chemistry, First law analysis of reacting systems, Adiabatic flame temperature, Entropy change of reacting systems, Second law analysis of reacting systems, Criterion for reaction equilibrium composition, Conjugate fluxes and forces, Entropy production, Onsager's reciprocity relations, Thermo-electric phenomena and formulations, Thermodynamics of high gas flow.

Module IV

Microstates and macro-states, Thermodynamic probability, Degeneracy of energy levels, Maxwell-Boltzman, Fermi-Dirac and Bose-Einstein statistics, Microscopic interpretation of heat and work, Evaluation of entropy, Partition function, Calculation of the microscopic properties from partition functions, Collision theory and transport properties.

References

1. WanWylen, Gordon J and Sonntag, Fundamental of Classical thermodynamics, John Wiley International, 1994.
2. Yunus A Cengel, Introduction to Thermodynamics and Heat Transfer, McGraw Hill, 1996.
3. Robert Balmer, Thermodynamics, Jaico Publication, 1998.
4. Russell and Adebiyi, Classical Thermodynamics, Saunders College Publication, 1993.
5. Rayner Joel, Basic Engineering Thermodynamics, Addison Wesley, 1996.
6. Bejan Adrian, Advanced Engineering Thermodynamics, John Wiley & Sons, 1998.

ELECTIVES I & II (18-450-0103 to 18-450-0108)

18-450-0103: INDUSTRIAL REFRIGERATION AND AIR-CONDITIONING

Course Outcomes:

On completion of this course the student will be able to:

1. *Understand the fundamental thermal-fluid science behind working of HVAC equipment*
2. *Explain the vapour compression and vapour absorption refrigeration cycles for both theoretical and practical cycles, properties of refrigerants, and selection criteria for refrigerants*
3. *Understand about the chilling and freezing theories and methods*
4. *Explain psychrometry and air-conditioning systems*
5. *Calculate heat load for comfort and industrial air conditioning system*
6. *Select HVAC system type and configuration*

Module I

Methods of producing cold: thermodynamic basics, Capacity, Coefficient of Performance, Vapour compression systems, ideal and actual cycles: single stage, multistage and cascade systems. Vapour absorption systems: aqua ammonia and lithium bromide - water systems, Electrolux system, comparison between vapour compression and absorption systems.

Module II

Refrigerants and environmental issues, Ozone Depletion Potential (ODP) and Global Warming (GW), Montreal and Kyoto protocols Total Equivalent Warming Index (TEWI) Azeotropic and zeotropic mixtures, alternative to existing CFC and HCFC refrigerants. Non- conventional refrigeration systems: air refrigeration cycles, Steam jet refrigeration, thermo-electric, vortex tube refrigeration, pulse tube refrigeration magnetic refrigeration and cryogenic refrigeration.

Module III

Theories and methods of chilling and freezing. Temperature -Time graph of freezing process, freezing time, Refrigeration load in freezers, Microbiology of Food Products, Factors of importance in refrigerated storage, freezing characteristics of foods, factors affecting the quality of frozen foods.

Module IV

Introduction to thermal comfort and parameters of indoor environment quality; Psychrometric properties, Psychrometric chart; Basic process in air-conditioning: Humidification and Dehumidification processes; Introduction to evaporative cooling and cooling towers. Comfort and industrial air conditioning, Summer and Winter air conditioning systems, central and unitary systems, human comfort, comfort chart and limitations, Fundamentals of duct design.

References

1. Roy J. Dossat, Principles of Refrigeration, Pearson Education Asia, 2001.
2. W. F. Stoecker and J.W. Jones, Refrigeration and Air Conditioning, 2nd Edition, Tata McGraw-Hill, 1982.
3. C. P. Arora, Refrigeration and Air Conditioning, 2nd Edition, Tata McGraw-Hill, 2007.
4. R. C. Arora, Refrigeration and Air Conditioning, Prentice Hall India, 2010.
5. P. N. Anantanarayan, Basic Refrigeration and Air Conditioning, 4th Edition, Tata McGraw-Hill, 2013.
6. T.H.Kuehn, J W Ramsey and J L Therelkeld, Thermal Environmental Engineering, Prentice Hall, 2000.
7. Shan K. Wang, Handbook of air-conditioning and refrigeration, McGraw Hill, 2000.
8. Gosney W, Principles of Refrigeration, Cambridge University Press, 1982.
9. ASHRAE Handbook, Cold Storage Application, ASHRAE, 2003.

18-450-0104: INCOMPRESSIBLE AND COMPRESSIBLE FLOWS

Course Outcomes:

On completion of this course the student will be able to:

1. *Understand the governing equations for fluid flow*
2. *Apply the differential and integral forms of governing equations*
3. *Analyse turbulence models and closure problems in turbulence*
4. *Compare Isentropic, Fanno and Raleigh flows*
5. *Apply governing equations for normal and oblique shocks and analyse shock interactions*
6. *Explore the possibilities of the combination of Isentropic, Fanno and Rayleigh flows*

Module I

Concept of a fluid, Fluid as a Continuum, Variation of viscosity with temperature, Stream function, Vorticity and circulation, Eulerian and Lagrangian formulations, Reynolds transport theorem, Bernoullis equation, Newtonian and Non-Newtonian fluids, Integral relations for a control volume, Differential relations for fluid flow, Continuity equation, Momentum equation, Energy equation, Reynolds averaging, RANS equation.

Module II

Turbulence models and flow equations, Steady and Unsteady Turbulent boundary layers, Universal structure of mean velocity profile in turbulent boundary layer, Effect of roughness, Moody's chart, Eddy viscosity concept, Mixing length models, Mass and Momentum equation for fluctuating quantities.

Isentropic flow with variable area: Stagnation and Critical conditions, Mass flow rate, Geometric chocking, Isentropic flow through Convergent nozzle and Convergent Divergent nozzle.

Module III

Fanno flow : Adiabatic flow in constant area duct with friction, Fanno line, Friction chocking and its consequences, Variation of Mach number with duct length.

Rayleigh flow : Frictionless flow in constant area duct with heat transfer, Raleigh line, Thermal chocking and its consequences, Maximum heat transfer.

Module IV

Normal Shocks: Fundamental relations, Prandtl Meyer relation for normal shock, Impossibility of shock in subsonic flow.

Oblique Shocks and Expansion waves: Fundamental relations, Prandtl's relation, θ-β-M diagram, Shock Reflections and Interactions, Detached shocks, Expansion of supersonic flow, Supersonic flow around a convex corner, Prandtl Meyer angle.

References

1. Frank M White, Fluid Mechanics, Tata Mc Graw Hill Publishing Company Ltd., 2008.
2. Schlichting H, Boundary Layer Theory, McGraw Hill Book Company, NewYork, 1979.
3. Shapiro A. H., The Dynamics and Thermodynamics of Compressible Flow, Ronald Press Company, New York, 1953.
4. Babu V., Fundamentals of Gas dynamics, Ane publishers, New Delhi, 2007.
5. John D Anderson, Modern Compressible flow, Mc Graw Hill, 2003.
6. Biswas and Eswaran, Turbulent Flows, Narosa Publishers. 2002.
7. James John and Theo Keith, Gas Dynamics, Pearson Education, 2006.

18-450-0105: COMPUTATIONAL METHODS IN ENGINEERING

Course Outcomes:

On completion of this course the student will be able to:

1. *Apply computational methods in Engineering and Technology using CAS (Computer Algebra Systems)*
2. *Understand errors and their propagation and the measures to control errors in the application of computational methods*
3. *Apply numerical methods to solve linear algebra problems*

4. *Apply numerical methods for interpolation, differentiation, integration, and integral transforms*
5. *Understand ordinary and partial differential equations and apply finite difference (FDM) method to solve them*
6. *Understand calculus of variations and Finite Element Method (FEM). Apply FEM to solve Ordinary Differential Equations (ODE)*

Module I

Approximations: Accuracy and precision, definitions of round off and truncation errors, error propagation.

Introduction to CAS programs like Matlab/Mathematica/Maple/Python and their application to solve numerical examples of the topics included below.

Algebraic equations: Formulation and solution of linear algebraic equations, Gauss elimination, LU decomposition, iteration methods (Gauss – Siedel), convergence criteria, Eigen values and Eigen vectors.

Module II

Interpolation methods: Newton's divided difference, interpolation polynomials, Lagrange interpolation polynomials, Differentiation and Integration: High accuracy differentiation formulae, extrapolation, derivatives of unequally spaced data, Gauss quadrature and integration.

Transform techniques: Continuous Fourier series, frequency and time domains, Laplace transform, Fourier integral and transform, Discrete Fourier Transform (DFT), Fast Fourier Transform (FFT).

Module III

Differential equations: Initial and boundary value problems, Eigen value problems, Partial differential equations.

Numerical solutions differential equations: Formation of difference equations, types of difference equations and their solutions. Laplace and Poisson's equations. Iterative methods for solutions of parabolic, elliptic and hyperbolic types of Partial Differential Equations.

Module IV

Calculus of variations: Introduction to maxima and minima, variational notations, functional and Euler's equations, constraints and Lagrange multipliers, Hamiltonian
Principles.

Finite Element theory: Introduction to finite element theory, generalization of finite element concept, variational approaches, steady state field problems such as heat conduction, electrical and magnetic potential, fluid flow, failure mechanics, etc.

References

1. Steven C Chapra, Applied Numerical Method with Matlab for Engineers and Scientists, McGraw-Hill, 2017.
2. Schilling R.J and Harris S. L, Applied Numerical Methods for Engineering using Matlab and C, Brooks/Cole Publishing Co., 2003.
3. S. S. Sastry, Introduction to Numerical Methods, Prentice-Hall, 1999.
4. Fon Sneddon, Introduction to Integral Transforms, McGraw Hill, 2016.

5. R. Forsythe, Calculus of Variation, Cambridge University Press, 1927.
6. David V Hutton, Fundamentals of Finite Element Analysis, McGraw- Hill, 2003.
7. Gerald and Wheatley, Applied Numerical Analysis, Pearson Education, 1998.

18-450-0106: HYDRODYNAMICS

Course Outcomes:
On completion of this course the student will be able to:
1. *Understand symmetric and anti-symmetric tensors and their notations*
2. *Describe vorticity equations in rotating and non-rotating frames of reference*
3. *Model low Reynolds number flow with linearity and reversibility*
4. *Analyse stress conditions at fluid-fluid interface*
5. *Evaluate pressure and surface tension driven micro flows*
6. *Explore micro fluidic devices such as valves and pumps*

Module I
Cartesian Tensors: tensor notation - rotation of axes – multiplication of matrices – second or tensor – Kronecker Delta and alternating tensor – Vector, dot, and cross products – Gradient, divergence, and Curl – symmetric and anti-symmetric tensors.
Vorticity dynamics: Introduction – Kelvin’s Circulation theorem – Helmholtz’s Vortex theorems – Vorticity equation in a non-rotating and rotating frame of references- Vortex sheet.

Module II
Low Reynols number flow: Introduction – Stokes equation – Boundary conditions - Linearity and Reversiblity – Minimum dissipation theorem – Lorentz Reciprocal theorem – Plane low Reynold number flows – Squeezed film flow – Lubrication approximation – Hele Shaw flow – the slider bearing.

Module III
Physics of interfacial phenomena: Laplace-Young equation – Contact angle and factors affecting it – Stress conditions at a fluid-fluid interface – Rotating and rolling drops – Capillary rise dynamics – Marangoni flows – Surfactant induced marangoni flows – bubble motion – fluid jets-Plateau-Rayleigh instability – wetting of a surface – hydrophobic and hydrophilic cases – Spreading of drops on solids – Immiscible drops at an interface.

Module IV
Microfluidics: Introduction – microfluidics versus traditional fluidics – Interfacial boundary conditions : slip versus no slip – conservation equations – pressure driven, surface tension driven and rotationally actuated microflows – microfluids of drops and bubbles – Electrokinetics: Electro-osmosis, Electrophoresis, dielectrophoresis – microfabrication techniques – microfluidic devices: valves and pumps.

References
1. Kundu, Cohen, Fluid Mechanics, Academic Press, 2012.

2. Drew Myres, Surfaces, interfaces and colloids: principles and applications, Wiley, 1991.
3. Patrick Tabeling, Introduction to microfluidics, Oxford University Press, 2005.
4. Suman Chakraborty, Microfluidics and microfabrications, Springer, 2010.
5. Milton J. Rosen, Joy T. Kunjappu, Surfactants and Interfacial Phenomena, John Wiley & Sons, 2012.
6. Happel, Brenner, Low Reynolds number hydrodynamics, Springer Science & Business Media, 1983.

18-450-0107: CONDUCTION AND RADIATION

Course Outcomes:
On completion of this course the student will be able to:
1. *Understand the heat equation in Cartesian, Cylindrical and Spherical coordinates*
2. *Apply numerical method in the analysis of steady two dimensional heat conduction*
3. *Model unsteady heat transfer in lumped systems*
4. *Analyse the fundamental laws of radiation and the relation between shape factors*
5. *Evaluate radiative heat exchange among diffuse, grey and non-grey surfaces*
6. *Explore radiation transfer in enclosures containing absorbing and emitting media*

Module I
Conduction Heat Transfer – Heat equation in Cartesian, cylindrical and spherical coordinates, Overall heat transfer coefficient, Critical thickness of insulation, Cylinder with heat sources, Analysis of steady two dimensional heat conduction, Numerical method of analysis.

Module II
Unsteady heat transfer in lumped systems, Governing equations, General solution, Heat transfer from extended surfaces, Solution of fin equation, variable area fins, Numerical solution of a fin problem, transient conduction, conduction with phase change, integral method, integral transforms and numerical methods.

Module III
Radiation Heat Transfer, Fundamental laws of thermal radiation, Radiation shape factor, Relation between shape factors, Plank distribution, Surface properties, Spectral and hemispherical surface properties, Angle dependent surface properties, Radiative heat exchange among diffuse, grey and non-grey surfaces separated by non-participating media.

Module IV
Radiation in enclosures, Evacuated enclosure with gray diffuse walls, Radiation shields, Gas radiation and radiation transfer in enclosures containing absorbing and emitting media, Radiation in participating media, Modelling of gas radiation, Interaction of radiation with conduction and convection.

References

1. Frank Kreith and Mark S. Bohn, Principles of Heat Transfer, Harper and Row Publishers, 1986.
2. Frank P. Incropera and David P. Dewitt, Fundamentals of Heat and Mass Transfer, John Wiley and Sons, 1981.
3. Ozisik N.M, Heat transfer – A basic approach, McGraw-Hill, 1985
4. Holman J.P, Heat Transfer, McGraw-Hill, 1990
5. Taine and Petit, Heat Transfer, Prentice Hall, 1993.
6. Yunus A. Cengel, Heat transfer – A Practical Approach, McGraw Hill, 1997.
7. Venkateshan S. P., Heat Transfer, Ane books Pvt. Ltd., 2009.

18-450-0108: INTRODUCTION TO COMBUSTION

Course Outcomes:

On completion of this course the student will be able to:

1. *Understand the thermodynamics of combustion*
2. *Apply the equations of species mass, momentum and energy in mass transfer*
3. *Model basic reaction kinetics and simplification of reaction mechanism*
4. *Analyse laminar premixed combustion*
5. *Evaluate turbulent premixed combustion and flame stabilization*
6. *Explore the diagnostics of combustion, chemical species, particle and spray diagnostics*

Module I

Introductory concepts, Review of thermodynamics, Thermodynamics of combustion, Stoichiometry of combustion, heats of reaction and formation, Mass transfer definitions: Fick's law, Equations of conservation of species mass, momentum, and energy; multi-component diffusion equation adiabatic flame temperature.

Module II

Chemistry of Combustion: Basic Reaction Kinetics, Elementary reactions, Chain reactions, Multistep reactions, simplification of reaction mechanism, Global kinetics.

Physics of Combustion: Fundamental laws of transport phenomena, Conservations Equations, Transport in Turbulent Flow.

Module III

Laminar Premixed combustion, non-premixed (diffusion) combustion, partially premixed combustion. Turbulent premixed combustion, non-premixed (diffusion) combustion, partially premixed combustion. Droplet and spray combustion, Flame stabilization

Module IV

Combustion Measurements, Flow field diagnostics, Temperature diagnostics, Chemical species diagnostics, Particle and spray diagnostics

References

1. Stephen R Turns, An Introduction to Combustion, Mc-Graw Hill, 2nd edition, 2006.
2. Mukunda H. S., Understanding Combustion, University Press, 2nd Edition 2009.
3. Kanury A Murty, Introduction to Combustion Phenomena, Gordon and Breach, 1975.
4. Kenneth K Kuo, Principles of Combustion, John Wiley and Sons, 1986.
5. Forman A Williams, Combustion Theory: The Fundamentals, Benjamin and Cummings publishing, 2nd edition, 1985.
6. Irvin Glassman and R A Yetter, Combustion, Academic press, 4th edition, 2008.
7. Roger A Strehlow, Combustion Fundamentals, Mc-Graw Hill, 1984.
8. Law C. K., Combustion Physics, Cambridge University Press, 2006.
9. Kohse-hoinghaus Katharina, Applied combustion diagnostics, Taylor & Francis, 2002.
10. Eckbreth A.C, Laser diagnostics for combustion temperature & species, Gordon Breach publishers, 1996.
11. Raffel M., Willert, C.E., Wereley S.T., Kompenhans, J, Particle Image Velocimetry, A Practical Guide, Springer, 2007.

18-450-0109: THERMAL ENGINEERING LABORATORY I

Course Outcomes:

On completion of this course the student will be able to:

1. *Acquire hands on experience on the various test-rigs, experimental set-up*
2. *Measure the various technical parameters by instrument and by mathematical relationship*
3. *Identify the effect of various parameters on the system and able to correlate them*

Syllabus contents:

Free Convection Heat Transfer;
Forced Convection of Heat Transfer;
Calibration of Wedge Probe;
Performance studies on Centrifugal Fan;
Performance Studies on an Axial Flow Fan;
Measurement and Analysis of combustion parameters in I.C engines;
Study of various transducers used in I.C engines;
Parallel and Series operation of pumps;
Cavitation test on a centrifugal pump;
Performance and emission measurements in 2 & 4 stroke S.I. engines;
Performance and emission measurements in Diesel engines;
Performance test on Centrifugal pumps;
Performance test on a Hydro turbine;
Simulation of incompressible flows using CFD software.

18-450-0110: SEMINAR I

Course Outcomes:

1. *On completion of this course the student will be able to:*
2. *Improve communicative skills*
3. *Overcome performance anxiety in front of an audience*
4. *Widen the knowledge of thrust area*
5. *Develop the skill for preparing presentation material*
6. *Improve self confidence*

Students shall individually prepare and submit a seminar report on a topic of current relevance related to the field of Thermal and Fluid Engineering. The reference shall include standard journals, conference proceedings, reputed text books and technical reports. The references shall be incorporated in the report reflecting the state-of-the-art in the topic selected. Each student shall present a seminar for about 30 minutes duration on the selected topic. The report and presentation shall be evaluated by a team of internal examiners comprising of 2 teachers based on style of presentation, technical content, adequacy of references, depth of knowledge and overall quality of the seminar report.

References

1. David F. Griffiths, Desmond J. Higham, Learning LaTeX, Society for Industrial and Applied Mathematics, 2016.
2. Lalit Mali, Libre office 5.1 Impress, Draw, Base book, Vol. 2, Notion Press, 2017.

18 -450-0111 RESEARCH METHODOLOGY AND IPR

Course Outcomes:

On completion of this course the student will be able to:

1. *Demonstrate knowledge of research processes (reading, evaluating, and developing)*
2. *Perform literature reviews using print and online databases*
3. *Summarize and discuss important issues and trends within the actual research area.*
4. *Write a scientific article within a limited topic but with a quality such that the article could be accepted for presentation in a conference or workshop*
5. *Create a scientifically sound and reasonable and well documented plan for a Masters thesis project of excellent quality.*
6. *Understand the basics of the four primary forms of intellectual property rights.*
7. *Compare and contrast the different forms of intellectual property protection in terms of their key differences and similarities.*

Module I

Meaning of research problem, Sources of research problem, Criteria and Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.

Approaches to investigation of solutions for research problem - data collection, analysis, interpretation. Necessary instrumentation.

Module II

Effective literature review approaches, Plagiarism, Research ethics.

Effective technical writing. How to write a good report and a paper?

Developing a Research Proposal, Format of research proposal, Presentation and assessment by a review committee.

Module III

Nature of Intellectual Property: Patents, Industrial Designs, Trademark and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development.

International Scenario: International cooperation on Intellectual Property. Procedure for grant of patents, Patenting under Patent Cooperation Treaty (PCT).

Module IV

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indication of goods.

New Developments in IPR: Administration of Patent System. IPR of Biological Systems, Computer Software etc. Traditional knowledge: Indigenous, medicinal and bioprospecting knowledge, Need for protection. Case Studies.

References

1. Stuart Melville and Wayne Goddard, Research methodology: An introduction for Science & Engineering students, Juta & Co Ltd, 1996.
2. Ranjit Kumar, Research Methodology: A Step by Step Guide for beginners, 2nd Edition, Pearson, 2005.
3. Gopalakrishnan N S, and Agitha T G, Principles of Intellectual Property, 2nd Edition, Eastern Book Company, 2015.
4. Bansal K and Bansal P, Fundamentals of Intellectual Property for Engineers, BS Publications, 2013.
5. Deborah E. Bouchoux, Intellectual Property: The Law of Trademarks, Copyrights, Patents, and Trade Secrets, 4th Edition, Cengage Learning, 2012.
6. Markel, Mike, Technical Communication. 11th Edition, Mac Millan, 2015.

SEMESTER - II

18-450-0201: ADVANCED HEAT AND MASS TRANSFER

Course Outcomes:

On completion of this course the student will be able to:

1. *Understand the fundamentals of both steady and unsteady heat transfers and heat transfer through extended surfaces*
2. *Apply finite difference method and solve 1D and 2D conduction equations*
3. *Analyse steady laminar and turbulent heat transfer in external and internal flows*
4. *Model laminar and turbulent forced convection in ducts and plates*
5. *Evaluate heat transfer with phase change*
6. *Explore radiation characteristics of particle systems*

Module I

Review of Heat Transfer fundamentals, Transient conduction, Use of Heisler and Grober chart, General lumped capacitance analysis, Extended surface Heat Transfer, Overall surface efficiency, Steady state analysis and optimization. Introduction to finite difference method to solve conduction equations. 1-D, 2-D conduction, Unsteady conduction solutions.

Module II

Thermal boundary layers, Momentum and energy equations, Integral method to solve heat transfer from flat plate laminar case. Steady Laminar and Turbulent Heat Transfer in External and Internals Flows, Heat Transfer at high speeds.

Module III

Laminar and Turbulent Forced Convection in Ducts and Plates, Forced convection over cylinders, spheres and bank of tubes, Two Phase Flow correlations, Heat transfer with phase change, Condensation and boiling heat transfer, Heat transfer in condensation, Effect of non-condensable gases in condensing equipments, Flow boiling correlations.

Module IV

Radiation basics, Gas Radiation, Radiative exchange in furnaces, Radiation network, Radiation characteristics of particle systems, Thermal radiation of a luminous fuel oil and gas, Diffusion and Convective Mass Transfer.

References

1. Frank P. Incropera and David P. Dewitt, Fundamentals of Heat and Mass Transfer, John Wiley and Sons, 1981.
2. R. Byron Bird, Warren E. Stewart and Edwin N. Lightfoot, Transport Phenomena, John Wiley & Sons, 1994.
3. W. M. Kays and M. E. Crawford, Convective Heat and Mass Transfer, McGraw Hill Inc., 1993.
4. Frank Kreith and Mark S. Bohn, Principles of Heat Transfer, Harper and Row Publishers, 1986.

18-450-0202: THERMODYNAMICS AND PROPULSION

Course Outcomes:

On completion of this course the student will be able to:

1. *Understand the fundamentals of the governing equations related to propulsion*
2. *Classify the different forms of jet engines and summarise their working principle*
3. *Analyse the engine cycle by considering the efficiencies of each components*
4. *Explain the working of rocket engines when compared with jet engines*
5. *Distinguish between solid and liquid propellants and their properties*
6. *Explore the aspects of launching and orbital mechanics*

Module I

Fundamentals of thermodynamics, Thermodynamic processes, Reaction principle, Features of propulsive devices, Momentum theory applied to propulsive devices, Types of propulsive devices-Turbo prop, Turbo jet, Turbo fan, Turbo shaft, Ram jet, Scramjet, Combustion in jet engines, Types of combustion chambers, Factors limiting turbine design, Materials for turbine blades, Thrust augmentation, Noise suppression, Comparative study of performance characteristics, Supersonic inlets, Starting problem.

Module II

Thrust equation, Analysis of Turbo jet engine cycle, Component efficiencies, Diffuser efficiency, Compressor efficiency, Burner efficiency, Turbine efficiency, Nozzle efficiency, Analysis of Turboprop, Turbofan and Ramjet engine cycles, Calculation of thrust, thrust power, propulsive efficiency, thermal efficiency, transmission efficiency and overall efficiency.

Module III

Rocket equation, Burn out velocity, Specific Impulse, Specific Propellant Consumption, Characteristic Velocity, Comparison of Air Breathing and Rocket Propulsion Systems, Classification of Rockets, Nozzle Expansion, Real Nozzles, Thrust vector control, Solid propellant Rocket Motors, Grain configuration, Propellant area ratio, Burning Rate, Temperature Sensitivity, Erosive burning, Igniters – Pyrotechnic & Pyrogen Igniters.

Module IV

Liquid propellant Rocket engines, Gas pressure feed systems, Turbo-pump feed system, Cryogenic fluids as rocket propellants, Feed systems, Injectors, Combustion Mechanisms, Combustion Instability, Cooling of Thrust Chambers – Radiation cooling, Ablative cooling, Regenerative cooling, Film cooling, Transpiration cooling, Testing of Rockets, Introduction to Hybrid, Solar, Electrical and Nuclear Rockets, Multi staging of Rockets, Boost dynamics, Aspects of Launching, Kepler's laws, Keplerian elements, Transfer orbits, Escape velocity, Orbit equation.

References

1. Sutton G. P. and Ross D. M., Rocket Propulsion Elements, John Wiley Publication, New York, 1991.
2. Zucrow M. J., Aircraft & Missile Propulsion, John Wiley & Sons, New York, 1958.

3. Hill P., and Peterson C., Mechanics and Thermodynamics of Propulsion, Addision Wesley, 1992.
4. Lefebvre, Gas Turbine Combustion, Taylor & Francis, Philedelphia, 1980.
5. Babu V., Fundamentals of Propulsion, Ane Publishers, 2008.
6. Barrere M., Janmotte A., Venbeke B. F., Vandenkerchove J., Rocket Propulsion, Elsevier Publications Company, London, 1960.
7. Cohen and Rogers, Gas Turbine Theory, Pearson Education, 1992.

Electives III & IV (18-450-0203 to 18-450-0208)

18-450-0203: COMBUSTION AND POLLUTION

Course Outcomes:
On completion of this course the student will be able to:

1. *Understand the conservation of mass and energy in chemical reactions*
2. *Apply the fundamental laws of transport phenomena*
3. *Analyse chemical kinetics from the equation for rate of reactions*
4. *Model 1D laminar and turbulent premixed flames*
5. *Evaluate the characteristics of spray combustion*
6. *Explore the theory of formation of combustion generated pollutants*

Module I
Principles of combustion, combustion chemistry, scope of combustion.
Thermodynamics of reactive systems - conservation of mass and energy in a chemical reaction. First and second law for reactive systems, Thermochemistry, adiabatic flame temperature, chemical equilibrium.
Chemistry of combustion - Chemical kinetics, elementary reactions, molarity and order of chemical reaction, general equation for rate of reaction, equation of Arrhenius, activation energy.
Physics of Combustion - Fundamental laws of transport phenomena, Conservations Equations, Transport in Turbulent Flow.

Module II
Premixed Flame: One dimensional combustion wave, Laminar premixed flame, Burning velocity measurement methods, Effects of chemical and physical variables on Burning velocity, Flame extinction, Ignition, Flame stabilizations, Turbulent Premixed flame

Module III
Diffusion Flame: Gaseous Jet diffusion flame, Liquid fuel combustion, fuel atomization, Characteristics of spray Combustion, Solid fuel combustion.

Module IV
Combustion generated pollutants: constituents and types of emission, mechanisms of hydrocarbon and particulate emissions, and theories of soot and NOx formation, industrial furnace emissions. Quantification of emission, emission control methods, modelling of emissions. Emission standards. Instrumentation to measure pollutants.

References

1. Law, C. K., Combustion Physics, Cambridge, Cambridge, 2010.
2. Stephen R Turns, An Introduction to Combustion, Mc-Graw Hill, 2nd edition, 2006
3. Mishra, D.P, Fundamentals of Combustion, Prentice Hall of India, New Delhi, 2008.
4. Kuo K.K, Principles of Combustion, John Wiley and Sons, 2005.
5. Strehlow R. A. Fundamentals of Combustion, McGraw Hill Book Company, 1984.
6. Thring, M.W, The science of Flames and Furnace, Chapman & Hill Ltd, London 1962.
7. Trinks, W, Indusrial Furnaces, Vol.1, 4th edition, John Wiley, New York 1951.
8. Irvin Glassman and R. A., Yetter, Combustion, Academic press, 4th edition, 2008.

18-450-0204: FINITE ELEMENT ANALYSIS

Course Outcomes:

On completion of this course the student will be able to:

1. *Understand variational and weighted residual approaches*
2. *Construct global stiffness matrix and load vector*
3. *Model two dimensional problems using constant strain triangle*
4. *Analyse selected problems of stress, vibration and structural stability*
5. *Model heat conduction and fluid flow problems*
6. *Explore the use of FEM codes in the evaluation of existing designs*

Module I

Finite element modelling, Variational and weighted residual approaches, Potential energy approach, Galerkins approach, Shape functions, natural co-ordinates system, element and global stiffness matrix, Assembly of global stiffness matrix and Load vector.

Module II

Finite element equations, Treatment of boundary conditions, errors, convergence and patch test, higher order elements, Application to solution of selected problems of stress analysis, dynamics and vibrations, structural stability, Two dimensional problems using constant strain triangles.

Module III

Treatment of material and geometric nonlinearities, contact problems, heat conduction and selected fluid problems, mesh generation, modelling; numerical techniques, errors and convergence.

Module IV

Axi-symmetric formulation, Iso-parametric elements and numerical integration, Use of commercial packages, Finite element evaluation of existing complete designs, Comparison with conventional analysis, model revision.

References

1. Zienkiewicz O. C., Taylor R. L., Zhu J.Z., The Finite Element Method: Its Basis and Fundamentals, Elsevier, 2005.

2. Reddy J. N., Introduction to finite element method, McGraw-Hill Higher Education, 1993.
3. Cook R. D., Concepts & applications of finite element analysis, Wiley, 1976.
4. Chandrupatla and Belegundu, An Introduction to Finite element method in Engineering, Pearson Education, 1996.
5. Chandrupala T, Finite Element Analysis for engineering and technology, Universities Press, 1997.
6. Krishnamoorthy C. S., Finite Element Analysis, Tata Mc Graw Hill, 1994.

18-450-0205: CONVECTION AND TWO PHASE FLOWS

Course Outcomes:
On completion of this course the student will be able to:
1. *Understand the fundamentals conservations laws in fluid dynamics*
2. *Derive different non-dimensional numbers*
3. *Analyse convection boundary layer and origin of plumes*
4. *Explain boiling and condensation*
5. *Construct two phase flow patterns and flow pattern maps*
6. *Explore the instability of vapour layers and jets*

Module I
Conservation laws, Navier Stokes equations, Differential and Integral forms; External laminar flows, Flat plate, Wedge flows, flow over cylinders, Separation, Internal Laminar Flow, Circular pipe, Free convection; Vertical plate cylinders, mixed convection, Physical mechanism of convection, Nusselt number, Schimidt number, Rayleigh number, Prandtl number, Peclet number, Grashof number

Module II
Laminar natural convection boundary layer, Rayleigh-Benard convection, convection through membrane and its formulation, thermal and concentration boundary layer, different regimes of convection and plume structure, concentration profile, the origin of plumes rising from a heated surface and membrane, boundary layer flow along a vertical wall, inclined walls and horizontal walls.

Module III
Boiling and condensation, Boiling heat transfer, pool boiling, boiling regimes and the boiling curve, heat transfer correlation in pool boiling, flow boiling, condensation heat transfer, film condensation, heat transfer correlations for film condensation, vertical plates, inclined plate, vertical tube, horizontal tubes and spheres, horizontal tube banks, drop-wise condensation.

Module IV
Two-phase flow patterns and flow pattern maps, Homogeneous flow, pressure gradient in homogeneous flow, Two-phase multipliers, Pressure drop in two-phase flow-overall methods for separated flow, pressure gradient in separated flow, Methods of measuring the momentum flux,

frictional pressure gradient, flooding in two-phase flow, critical heat flux in pool boiling, instability of the vapour layer, instability of vapour jets.

References

1. Kays W. M., and Crawford M. E., Convective Heat and Mass Transfer, McGraw Hill Inc., 1993.
2. Frank Kreith and Mark S. Bohn, Principles of Heat Transfer, Harper and Row Publishers, 1986.
3. Massoud Kaviany, Principles of convective heat transfer, Springer, 2001.
4. Collier J. G., and Thome J. R., Convective boiling and condensation, Oxford University Press, 1996.
5. Whalley P. B., Two-phase flow and heat transfer, Oxford University press, 1996.

18-450-0206: PRINCIPLES OF TURBO MACHINERY

Course Outcomes:

On completion of this course the student will be able to:

1. *Understand transfer of energy in turbo machinery and performance characteristics*
2. *Apply Euler's equation of turbo machinery and extend it to multi stage turbo machines*
3. *Explain the working of centrifugal fans and fan stage parameters*
4. *Develop design parameters for blade angle and blade shape*
5. *Analyse the performance of turbo machinery*
6. *Explore cascade theory on blade efficiency*

Module I

Classification of turbo machines, Energy transfer in turbo machines, Losses and efficiencies, Performance characteristics, Specific work, Representation of specific work in T-S and h-S diagrams, Internal and external losses, Relationship between fluid mechanics and thermodynamics of turbo-machinery process.

Module II

Euler's equation of turbo machinery, Ideal and actual velocity triangles, Slip and its estimation, General velocity triangle for a rotor, Multi stage turbo machines, Axial flow fans, Construction and operation, types of stages, performance of fans, Applications, Centrifugal fans, Construction and operation, fan stage parameters.

Module III

Impulse and reaction type machines, Degree of reaction, Effect of outlets blade angle on blade shape, Blade design parameters: Flow and loading coefficients, Degree of reaction, blade cascades and nomenclature – lift and drag coefficients, Elementary concept of three dimensional flow, Free and forced vortex.

Module IV
Model laws, specific speed and shape number, Special features of hydro, steam and gas turbines, performance characteristics of turbo machines, Cavitation, Surge and Stall, Thin aerofoil theory, Cascade mechanics.

References

1. Shepherd, D. G., Principles of Turbomachinery, Macmillan Co., New York, 1957.
2. Csanady, G. T., Theory of Turbomachines, McGraw Hill, New York, 1964.
3. Dixon, S. L., Fluid Mechanics, Thermodynamics of Turbomachinery, 3rd Ed., Pergamon Press, Oxford, 1978.
4. Yahya, S. M., Turbines, Compressors and Fans, Tata McGraw Hill, New Delhi, 1983.
5. Lazarkiewicz, S. and Trosklanski, Impeller Pumps, Pergamon Press, Oxford, 1965.
6. Nechleba, M., Hydraulic Turbine, Artia Publishers, Prague, 1957.

18-450-0207: NUMERICAL METHODS IN THERMAL ENGINEERING

Course Outcomes:
On completion of this course the student will be able to:
1. *Understand the solution techniques for linear and non-linear algebraic equations*
2. *Apply the solution techniques in thermal radiation and chemical equilibrium calculations*
3. *Determine the nature of partial differential equations and time marching solutions*
4. *Evaluate finite difference applications in steady and transient conduction*
5. *Model convective heat transfer and diffusion*
6. *Explore incompressible and compressible flow simulations*

Module I
Governing equations for thermal systems, Solutions of linear and non-linear algebraic equations, LU decomposition, Bisection method, Newton-Raphson method, Runge Kutta methods, Applications in thermal radiation and chemical equilibrium calculations.

Module II
Time marching solutions, Equilibrium problems, Elliptic equations, Parabolic equations, Hyperbolic equations, Applications to reaction kinetics, Discretization of derivatives, Finite difference applications in steady conduction, Simulation of transient conduction by finite difference.

Module III
Introduction to gradient method, Steepest descent method, Congugate gradient method, Finite volume method, Applications in heat conduction, Transient one dimensional conduction, Two dimensional steady heat conduction, Applications in convective heat transfer, Modelling of convective diffusion.

Module IV

Incompressible flow simulation, Modelling of compressible flows, Simulation of reacting systems, Introduction to FEM, Incompressible flow simulation by FE, Turbulent flow modelling, Grid generation techniques.

References

1. Chung, Computational Fluid dynamics, Cambridge university press, 2002.
2. Ferziger J. H., and Peric M., Computational methods for fluid dynamics, Springer, 1999.
3. Muralidhar K., and Sundarajan T., Computational fluid flow & heat transfer, Narosa Publishing house, 2001.
4. Suhas V Patankar, Numerical heat transfer and Fluid flow, Hemisphere Publishing Corporation, 1980.

18-450-0208: SPACE CRYOGENICS

Course Outcomes:

On completion of this course the student will be able to:

1. *Understand the fundamentals of cryogenic liquefaction and refrigeration systems, properties of solids and cryogens*
2. *Explain various cryogenic liquefaction and refrigeration systems*
3. *Understand cryogenic insulation, transfer systems and lines*
4. *Design of Dewar vessels*
5. *Explain about cryocoolers, storage and handling of cryogens, safety aspects and thermal protection systems*

Module I

Applications of cryogenics, Cryogenic liquefaction and refrigeration systems, Refrigeration and liquefaction principles, Properties of cryogenic fluids, Mechanical, thermal, electric and magnetic properties of solids at cryogenic temperatures, Ortho-para conversion of Hydrogen, Super fluidity, Superconductivity, Fountain effect.

Module II

Cryogenic liquefaction systems: Linde – Hampson, Claude, Cascade, Heylandt, Kapitza, Collins, Simon; Separation and purification of air, Cryogenic refrigeration systems, Philips refrigerator, Slovay refrigerator, Gifford-McMahon refrigerator, Vuilleumier refrigerator. Magnetic cooling.

Module III

Cryogenic Fluid storage and transfer systems, cryogenic insulation, Storage of cryogenic liquids; Design considerations of storage vessel; Dewar vessels; Industrial storage vessels; Storage of cryogenic fluids in space, Transfer systems and Lines for cryogenic liquids; Cryogenic valves in transfer lines; Two phase flow in Transfer system; Cool-down of storage and transfer systems.

Module IV

Space cryogenics, Cryocoolers for space applications. Passive coolers, Active coolers, Cryogenics in Launch Vehicle Applications, Problems in storage and handling of cryogenic propellants: safety aspects, Thermal protection systems for stage tanks, Thermal stratification destratification, Geysering effect, geysering elimination, Zero “g” problems – restart mechanism.

References

1. Barron R. F., Cryogenic Systems, Oxford University Press 1985.
2. Mukhopadhyay M., Fundamentals of Cryogenic Engineering, Prentice Hall India, 2010.
3. Thipse S. S., Crogenics - A Text book, Narosa Book Distributors, 2012.
4. Bose A., and Sengupta P., Cryogenics: Applications and Progress, Tata McGraw Hill, 1987.
5. Flynn T.M., Marcel Dekker, Cryogenic Engineering, Wiley, 1997.
6. Weisend J. G., II, Handbook of Cryogenic Engineering, Taylor and Francis, 1998.
7. Haselden G.G., Cryogenic Fundamentals, Academic Press, 1975.
8. Moss R. J., Gabriel S. B., A critical review of space-cooling techniques, Advances in Space Research, 17(1), 1996, pp. 119-122.
9. Collaudin B., Rando N., Cryogenics in space: A review of the missions and of the technologies, Cryogenics 40, 2000, pp. 797-819.

18-450-0209: THERMAL ENGINEERING LABORATORY II

Course Outcomes:

On completion of this course the student will be able to:

1. *Acquire hands on experience on the various test-rigs, experimental set-up*
2. *Measure the various technical parameters by instrument and by mathematical relationship*
3. *Identify the effect of various parameters on the system and able to correlate them*

Syllabus contents:

Measurement of density and Viscosity of oils;
Measurements of Gas Flow through pipe lines;
Radiation Heat Transfer;
Boiling Heat Transfer;
Performance evaluation of vapour compression refrigeration;
Measuring Instruments for Refrigeration & air-conditioning applications;
Measurement of very low temperature;
Performance evaluation of thermoelectric refrigerator and heat pump;
Calibration of 5-hole Probe;
Evaluation of the Calorific value of gaseous and liquid fuels;
Burning velocity measurements in laminar flames;
Modelling and Meshing of computational domains;
Simulation of steady state conduction, convection & radiation;
Simulation of compressible flows using CFD software.

18-450-0210: SEMINAR II

Course Outcomes:

On completion of this course the student will be able to:

1. *Improve communicative skills*
2. *Overcome performance anxiety in front of an audience*
3. *Widen the knowledge of thrust area*
4. *Develop the skill for preparing presentation material*
5. *Improve self confidence*

Students shall individually prepare and submit a seminar report on a topic of current relevance related to the proposed project work. The reference shall include standard journals, conference proceedings, reputed text books and technical reports. The references shall be incorporated in the report reflecting the state-of-the-art in the topic selected. Each student shall present a seminar for about 30 minutes duration on the selected topic. The report and presentation shall be evaluated by a team of internal examiners comprising of 2 teachers based on style of presentation, technical content, adequacy of references, depth of knowledge and overall quality of the seminar report.

References

1. David F. Griffiths, Desmond J. Higham, Learning LaTeX, Society for Industrial and Applied Mathematics, 2016.
2. Lalit Mali, Libre office 5.1 Impress, Draw, Base book, Vol. 2, Notion Press, 2017.

18-450-0211: MINI PROJECT

Course Outcomes:

On completion of this course the student will be able to:

1. *Get an opportunity to work in actual industrial environment if they opt for internship*
2. *Solve live problems using software/ analytical/ computational tools during mini projects*
3. *Learn to write technical reports*
4. *Develop skills to present and defend their work in front of technically qualified audience*

Students can take up small problems in the field of thermal and fluid engineering as mini project. It can be related to solution to an engineering problem, verification and analysis of experimental data available, conducting experiments on various engineering subjects, material characterization, studying a software tool for the solution of an engineering problem etc.

SEMESTER- III

ELECTIVES V & VI (18-450-0301 to 18-450-0306)

18-450-0301: MEASUREMENTS IN THERMAL ENGINEERING

Course Outcomes:

On completion of this course the student will be able to:

1. *Understand basics of measurements for scientific and engineering applications*
2. *Explain the basic sensors in the measurement of temperature, pressure and flow*
3. *Apply regression analysis for developing correlations and estimation of error*
4. *Describe the measurements of field quantities and derived quantities*
5. *Explore pollution monitoring techniques*

Module I

Introduction to measurements for scientific and engineering applications, Need and goal, Basic sensors and principles in temperature, pressure and flow measurements.

Module II

Broad category of methods for measuring field and derived quantities, Principles of measurement, parameter estimation, regression analysis, correlations, Error estimation and data presentation, Analysis of data.

Module III

Measurement of field quantities, thermometry, heat flux measurement, measurement of force, pressure, flow rate, velocity, humidity, noise, vibration, measurement of derived quantities, torque, power.

Module IV

Thermo physical properties, Radiation and surface properties, .Analytical methods and pollution monitoring, mass spectrometry, chromatography, spectroscopy.

References

1. Benedict R. P., Fundamentals of Temperature, Pressure and Flow Measurement, John Wiley, New York, 1977.
2. Doebelin E. O., Measurement Systems – Application and Design, 3rd Edn., McGraw Hill, 1983.
3. Young H. D., Statistical Treatment of Experimental Data, McGraw Hill, 1962.
4. Eckert E. R. G., and Goldstein R. J., Measurements in Heat Transfer, 2nd Edn., McGraw Hill, 1976.
5. Tae Woo Lee, Thermal and Flow Measurements, CRC Press, 2008.

18-450-0302: STATISTICAL METHODS FOR ENGINEERING

Course Outcomes

On completion of this course the student will be able to:

1. *Apply statistical software like R for statistical analysis and exploration*
2. *Identify and apply principles of data collection and description*
3. *Illustrate business problems with appropriate probability distributions and statistical terms to make better decisions*
4. *Distinguish between the various statistical tests and apply an appropriate test in the context of the problem*
5. *Develop critical and integrative thinking in order to communicate the results of the analysis clearly in the context of the problem*

Module I

Statistical Packages/Programs: - Introduction to R Program and its application to solve examples of the topics included below.

Data Description: Graphical presentation of data - Numerical description of data - Exploratory data analysis.

Probability distributions: - Introduction to probability and random variables - Binomial distribution, Poisson distribution, Geometric distribution, Hyper Geometric distribution, Normal distribution, Log-Normal distribution, Uniform distribution, Exponential distribution, Gamma distribution, Beta distribution and Weibull distribution - Random samples and sampling distributions of mean and variance.

Module II

Parameter Estimation: Point estimation - Properties of estimators, The method of maximum likelihood, The method of moments, Confidence interval estimation of mean, and variance.

Statistical hypothesis tests: Operations characteristic curve, Tests of hypothesis on the mean of a Normal Distribution, Tests of hypothesis on the means of two Normal distributions, The paired t-test, Tests of hypothesis on one variance, Tests of hypothesis for the equality of two variances, The testing for goodness of fit. Analysis of Variance (ANOVA).

Module III

Design and Analysis of Experiments: - Fundamental assumptions of analysis of variance, Single factor experiments – Fixed/random effects model – Model adequacy checking - Multiple comparisons - Design of experiments with several factors - Two factor factorial experiments - General factorial experiments - The 2k Factorial design –Introduction to response surface method in optimal design of parameters.

Module IV

Non-Parametric Statistics: - The sign test - The Wilcoxon signed rank test, The Wilcoxson Rank-sum test. Taguchi Approach to Design of Experiments - The Loss Function – Orthogonal array – Signal-to-Noise ratio.

References

1. Mark Gardener, Beginning R., The Statistical Programming Language, John Wiley and Sons, 2012.
2. Garcia-Diaz, A and Phillips, D. T., Principles of Experimental Design and Analysis, Chapman & Hall, New York, 1995.
3. Hines, W. W, and Montgomery, D. C., Probability and Statistics in Engineering and Management Science, John Wiley and Sons, New York, 1990.
4. Freund, J. E., Mathematical Statistics, Prentice Hall of India, New Delhi, 1990.
5. Hicks C. R., and Turner, K.V., Fundamental Concepts in the Design of Experiments, Fifth Edition, Oxford University Press, 1999.
6. Anderson, M. J., and Whitcomb, P. J., DOE Simplified: Practical Tools for Effective Experimentation, Productivity Press, 2000.
7. Levin, R. I., and Rubin, Statistics for Management, Seventh Edition, Prentice Hall International edition, 1997.

18-450-0303: CFD AND ITS APPLICATION

Course Outcomes:

On completion of this course the student will be able to:

1. *Understand the equations of mass, momentum, energy and species balance*
2. *Apply turbulent flow models in log-law, outer and viscous sub layer*
3. *Model partial differential equations based on explicit, implicit and semi implicit schemes*
4. *Analyse criteria for numerical stability and convergence*
5. *Solve one and two dimensional heat equations using finite volume method*
6. *Explore the application of CFD codes in modelling compressible and incompressible flows*

Module I

Review of fluid dynamic processes in flows, Equations of mass, momentum, energy and species balance, Specification of boundary conditions, Turbulent flow models, Turbulence kinetic energy, Free turbulent flows, Viscous sub layer, Log-law layer, Outer layer.

Module II

Application of Finite Difference Methods, Discretization, Taylor series method, Central differencing, Forward and Backward differencing, Estimation of truncation and discretization errors, Explicit, Implicit and Semi-Implicit Techniques, Crank Nicolson scheme, Criteria for numerical stability, Convergence analysis.

Module III

Flux formulation for Finite Volume Method, Transient one dimensional conduction, Two dimensional steady heat conduction, Convective diffusion, Incorporation of variable properties, Upwinding and artificial diffusion, QUICK and SIMPLE Algorithms, Solution of discretized equation, Tri Diagonal Matrix Algorithm.

Module IV

Modelling of flow problems; Simulation of incompressible and compressible flows; Implementation of Boundary conditions, Inlet and Outlet Boundary conditions, Wall Boundary condition, Symmetry and Periodic Boundary conditions, Fundamentals of grid generation; Structured and unstructured grids, Introduction to the use of commercial software; Use of commercial CFD software in simulation, Case studies.

References

1. Muralidhar K., and Sundarajan T., Computational fluid flow & heat transfer, Narosa Publishing House, 1995.
2. Suhas V. Patankar, Numerical heat transfer and Fluid flow, Hemisphere Publishing Corporation, 1980.
3. Versteeg H. K., and Malalasekera W., An Introduction to Computational Fluid Dynamics, Pearson, 1995.
4. John D Anderson, Computational fluid dynamics, McGraw Hill, 1995.
5. Tu Jiyuan, Yeoh Guan Heng and Liu Chaoqun, Computational Fluid Dynamics: A Practical Approach, Elsevier, 2012.

18-450-0304: HEAT EXCHANGER DESIGN

Course Outcomes:

On completion of this course the student will be able to:

1. *Understand the basic design methods and codes for heat exchangers*
2. *Describe the evaluation and maintenance of heat exchangers*
3. *Develop detailed design procedure for shell and tube heat exchangers*
4. *Model compact heat exchangers*
5. *Apply optimization of pinch temperature based on energy targeting*
6. *Explore networking of heat exchangers*

Module I

Classification of heat exchangers, Basic design methods for heat exchangers, Overall heat transfer coefficient, Log mean temperature difference, Effectiveness - NTU method, Parallel flow, Counter flow and Cross flow heat exchangers, Fouling of heat exchangers, Testing, Evaluation and maintenance of heat exchangers, Codes for mechanical design of heat exchangers.

Module II

Design of shell and tube heat exchangers. Design codes, Detailed design procedure for shell and tube heat exchangers, Bell Delaware Method of Design. Estimation of number of tubes, other geometry parameters, Selection of materials, Design considerations.

Module III

Compact heat exchangers, Plate heat exchangers, Plate type heat exchangers with heat transfer enhancement. Wavy fins, offset strip fins, louvered fins, Core pressure drop in compact heat exchangers. Re-generator design.

Module IV

Heat exchanger networking – hot composite curve, cold composite curve, grand composite curve, problem table algorithm, energy targeting, heat exchanger network synthesis meeting energy target. Optimization of pinch temperature.

References

1. Arthur P Fraas, Heat exchanger design, Wiley, 1989.
2. Kuppan T., Heat Exchanger Design Handbook, Marcel Dekker, 2000.
3. Shah R, K., and Dusan P. S., Fundamentals of heat exchanger design, John Wiley & Sons, 2003.
4. Fraas A. P., and Ozisik M. N., Heat exchanger design, Wiley, 1965.
5. Saunders E. A. D., Heat Exchangers: Selection, Design & Construction, Longman Scientific & Technical, 1988.
6. Uday V. Shenoy, Heat Exchanger Network Synthesis: Process Optimization by Energy and Resource Analysis, Gulf Professional Publishing, 1995.

18-450-0305: GAS TURBINES

Course Outcomes:

On completion of this course the student will be able to:

1. *Understand the combined cycles and cogeneration schemes in gas turbines*
2. *Analyse inter-cooled and reheat cycles with multi-spool arrangements*
3. *Describe factors affecting combustor design and performance*
4. *Calculate stage performance for axial flow and centrifugal compressors*
5. *Evaluate the overall performance of axial flow and radial flow turbines*
6. *Explore the blade cooling strategies in turbojet engines*

Module I

Open and Closed Cycle Gas Turbines, Combined cycles and cogeneration schemes, Thermodynamic analysis of gas turbine cycles, Simple, inter-cooled and reheat cycles, Multi-spool arrangements, Gas turbine design procedure.

Module II

Performance of practical gas turbine cycles, P-V and T-S diagrams, Gas turbine combustion systems, Factors affecting combustor design, Combustion process, Combustion chamber performance, Gas turbine emissions.

Module III

Axial flow compressors, elementary theory, factors affecting stage pressure ratio, degree of reaction, design procedures, Blade design, Calculation of stage performance, Centrifugal compressors, work done and pressure rise, compressor characteristics.

Module IV

Axial and radial flow turbines, vortex theory, choice of blade profile pitch and chord, estimation of stage performance, overall turbine performance, Blade cooling, Aircraft applications, Performance evaluation of single spool turbo jet engine.

References

1. Saravanamuttoo, Cohen and Rogers, Gas Turbine Theory, Pearson Education, 2001.
2. Meherwan P. Boyce, Gas Turbine Engineering Handbook, 3rd edition, Gulf Professional Publishing, 2006.
3. Hill and Peterson, Mechanics & Thermodynamics of Propulsion, Addison-Wesley, 1992.
4. Lefebvre A. H., Gas turbine combustion, Taylor & Francis, 1999.
5. Norman Davey, The gas turbine – Development and Engineering, Watchmaker publishing, 2003.

18-450-0306: INTRODUCTION TO TURBULENCE

Course Outcomes:

On completion of this course the student will be able to:

1. *Understand the ubiquitous nature of turbulence*
2. *Solve scales in turbulence and Navier Stokes equation*
3. *Analyse vorticity dynamics and anisotropy in turbulence*
4. *Evaluate Reynolds stresses and explore closure problem in turbulence*
5. *Apply different forms of turbulence models*
6. *Explore the features of direct numerical simulation, large eddy simulation and RANS simulations*

Module I

Ubiquitous nature of turbulence – the experiments of Taylor and Benard, flow over a cylinder, Reynolds experiment, ubiquitous nature of turbulence, different scales in turbulent flow, Kolmogorov scales, closure problem of turbulence, Navier stokes equation, molecular diffusion, turbulent eddy diffusion

Module II

Rate of dissipation of energy in viscous fluid, Vorticity dynamics, Kelvins theorem, vorticity and angular momentum, isotropic and anisotropic turbulence, Origin and nature of turbulence

Module III

Turbulent shear flows and simple closure models, Reynolds stress and closure problem of turbulence, prandtl mixing length, Boussinesq approximation, transfer of energy from the mean flow to the turbulence, k-epsilon, k-omega models, wall bounded shear flows and log-law of the wall, turbulence boundary layer, coherent structures, planar jets and wakes, round jets

Module IV

Reynolds stress model, time and length scales in turbulence, turbulent diffusion, direct numerical simulation, Large eddy simulation, Reynolds averaging, density based averaging, velocity correlation.

References

1. Wilcox, Introduction to turbulence, DCW Industries, 1993.
2. Davidson P. A., Introduction to Turbulence, Oxford, 2004.
3. Tennekes and Lumley, Introduction to turbulence, MIT Press, 1972.
4. Biswas and Easwaran, Turbulent Flows – Fundamentals, Experiments and Modeling, Narosa Publishing Company, 2002.

18-450-0307: DISSERTATION PHASE - I

Course Outcomes:

On completion of this course the student will be able to:

1. *Get exposed to self-learning various topics*
2. *Learn to survey the literature such as books, national/international refereed journals and contact resource persons for the selected topic of research*
3. *Learn to write technical reports*
4. *Develop oral and written communication skills to present and defend their work in front of technically qualified audience*

Guidelines:

The Project work will start in the 3rd semester and should preferably be a problem with research potential and should involve scientific research, design, generation/collection and analysis of data, determining solutions and must preferably bring out the individual's contribution. The Project seminar conducted should be based on the area in which the candidate has undertaken the dissertation work. The examination shall consist of the preparation of report consisting of a detailed problem statement and a literature review. The preliminary results (if available) of the problem may also be discussed in the report. The work has to be presented in front of the examiners panel consisting of internal examiner and project guide as set by the Head and PG course coordinator. The candidate has to be in regular contact with his guide and the topic of dissertation must be mutually decided by the guide and student. Each student shall individually carry out a project in an Industry / R&D institution / University department. The project work shall be reviewed and evaluated periodically during the 3rd semester and continued in the 4th semester. The evaluation shall be based on the technical content and presentation of the work.

SEMESTER - IV

18-450-0401: DISSERTATION PHASE - II

Course Outcomes:

On completion of this course the student will be able to:

1. *Use different experimental techniques*
2. *Use different software/ computational/analytical tools*
3. *Design and develop an experimental set up/ equipment/test rig*
4. *Conduct tests on existing set ups/equipments and draw logical conclusions from the results after analyzing them*
5. *Either work in a research environment or in an industrial environment*
6. *Become conversant with technical report writing*
7. *Present and convince their topic of study to the engineering community*

Guidelines:

It is a continuation of Project work started in the 3rd semester. He/She has to submit the report in prescribed format and also present a seminar. The dissertation should be presented in standard format as provided by the department. The candidate has to prepare a detailed project report consisting of introduction of the problem, problem statement, literature review, objectives of the work, methodology (experimental set up or numerical details as the case may be) of solution and results and discussion. The report must bring out the conclusions of the work and future scope for the study. The work has to be presented in front of the examiners panel consisting of an approved external examiner, internal examiner and project guide as decided by the Head and PG course coordinator. The candidate has to be in regular contact with his guide. The project work shall be reviewed and evaluated periodically during the semester. A detailed project dissertation in the prescribed format shall be submitted at the end of the semester. All the test results, relevant design and engineering documentation shall be included in the dissertation. The evaluation shall be based on (i) Presentation of the work, (ii) Quality and content of the dissertation and (iii) Viva Voce.

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