Advanced Heat & Mass Transfer - ME5101

Description

The aim of the course is to help students build a solid foundation in heat transfer exposing them to the three basic modes namely conduction, convection and radiation. Rigorous treatment of governing equations and solution procedures for the three modes will be provided together with solving problems of practical interest in heat transfer. The course will also briefly cover boiling and condensation and a treatment of two kinds of problems in heat exchangers namely analysis and design. Outcome

(1) Modelling of situations involving conduction heat transfer with convection and or radiation boundary conditions for one dimensional and two dimensional conduction followed by a solution of the governing equations to obtain the temperature field for both steady and unsteady heat transfer.

(2) Approximate solution to unsteady conduction heat transfer in a few geometries by the use of charts.

(3) Performing scale analysis for forced and free convection heat transfer problems to identify pertinent dimensionless parameters governing convection.

(4) Approximate solutions to laminar boundary layer equations (momentum and energy) for both internal and external flow

(5) Estimating heat transfer rates in laminar and turbulent flow situations using appropriate correlations for simple geometries for free and forced convection, boiling and condensation.

(6) Calculation of radiation heat transfer between surfaces using radiative properties, view factors and the radiosity method.

(7) Analysis and design of heat exchangers with both the LMTD and the e-NTU method.

Course Content

Introduction and Review of Heat Transfer Fundamentals Conduction Review of One-dimensional Steady state conduction Heat Transfer from Extended Surfaces Two Dimensional Steady State Conduction in Cartesian and Cylindrical Coordinates Transient Conduction Convection Velocity and Thermal Boundary layers Laminar and turbulent boundary layers - Blasius solution, Similarity solutions, Integral technique. Heat transfer correlations for External flows Developed flow inside ducts and pipes- Nusselt number for constant heat flux and constant wall temperature- turbulent flow in pipes Natural convective heat transfer from a heated plate Radiation Basics - black and gray body radiation - radiation in enclosures Fundamentals of condensation and boiling- pool boiling curve- flow boiling Basics of mass transfer- mass averaged and mole averaged velocities and fluxes- Fick’s law of diffusion.

Text Books

1. F.P.Incropera, D.P. Dewitt, T.L Bergman and A.S Lavine, Principles of Heat and Mass Transfer, John Wiley, Sixth Edition, 2018.

2. Yunus A Cengel, Heat Transfer : A Practical Approach, Second Edition, McGraw Hill, 2008.

Reference Books

1. A. Bejan, Heat Transfer John Wiley, 1993.

2. J.H.Lienhard V and J.H.Lienhard IV A Heat Transfer Textbook, Fourth Edition, 2011, Dover Publications, New York (free online edition available for download).
3. J.P.Holman, Heat Transfer, Eighth Edition, McGraw Hill, 1997.
4. Massoud Kaviany, Principles of Heat Transfer, John Wiley, 2002.

Incompressible Fluid Flow - ME5103

Description

To gain a post-graduate level understanding of the fundamental concepts of incompressible fluid flows including turbulent flows.

Course Content

1. Introduction and Basic Concepts - Definition of fluid and concept of continuum; Properties of fluids; Flow field, streamlines, path lines and streak lines; Kinematics of fluid motion; Eulerian and Lagrangian formulations

2. Governing Equations of Fluid Flow - Reynolds transport theorem; Mass and momentum conservation; Navier-Stokes equation; Analytical solutions to simple flows; Euler and Bernoulli equation

3. Potential Flow - Stream function and velocity potential; Elementary plane flows; Superposition of elementary plane flows; Concept of lift and drag

4. Boundary Layer Theory - Concept of boundary layer; Derivation of boundary layer equations; Boundary layer flow over a flat plate; Boundary layer flow with non-zero pressure gradient; Flow separation and drag; Free shear flow

5. Turbulent flows - Characteristics of turbulent flows; Concept of averaging; Reynolds Averaged Navier Stokes (RANS) equations; Turbulent internal flows; Turbulent external flows

Text Books

1. Fundamentals of Incompressible Fluid Flow by V. Babu, Ane Books, 2010

2. Elementary Fluid Dynamics by D. J. Acheson, Oxford University Press, 1996.

3. Fundamental Mechanics of Fluids by I. G. Currie, 3rd Edition, Marcel Dekker, 2005.

4. Boundary Layer Theory by H. Schlichting and K. Gersten, Eighth Edition, Springer 2000.

5. Physical Fluid Dynamics by D. J. Tritton, Oxford University Press, 1988.

6. Fluid Mechanics by F. M. White, Fifth Edition, McGraw-Hill Higher Education, 2003.

7. Viscous Fluid Flow by F. M. White, Second Edition, McGraw-Hill International Editions, 1991

Applied Thermodynamics - ME5105

Description

Postgraduate level understanding of thermodynamics concepts as applied to various areas of thermal engineering

Course Content

(1) Second Law Analysis1.1 Review of entropy1.2 Second law analysis for a control volume1.3 Irreversibility and availability 1.4 Exergy balance equation and Exergy analysis
(2) Thermodynamic relations for homogeneous phase 2.1 Maxwell relations, Relations involving enthalpy, internal energy and entropy2.2 Equilibrium between two-phases of a pure substance2.3 Clausius- Clapeyron equation
(3) Review of Ideal Gas, Ideal gas mixtures and mixing rules3.1 Real gas behavior 3.2 Real gas equations of state3.3 Property relations for mixtures and Psychrometry
(4) Combustion4.1 Combustion reactions - Stoichiometry 4.2 First law analysis, Heat calculations, Adiabatic flame temperature
(5) Chemical Equilibrium5.1 Chemical potential5.2 Second law analysis of reacting systems5.3 Chemical equilibrium5.4 Free energies5.5 Equilibrium flame temperature 5.6 Equilibrium products of combustion
(6) Gas Dynamics6.1 Basic ideas in compressible flow 6.2 Normal shocks 6.3 Flow of perfect gases through nozzles 6.4 Flow of wet steam – Supersaturation, Wilson line and condensation shock

Text Books

1. Moran, M. J. and Shapiro, H. N. Fundamentals of Engineering Thermodynamics, 5th edition, 203, John Wiley Sons
2. Sonntag, R. E, Borgnakke, C and Van Wylen, G. J. and., 1976, Fundamentals of Classical Thermodynamics, Wiley Eastern Ltd.
3. Jones, J. B. and Hawkins, G. A., 1986, Engineering Thermodynamics, John Wiley Sons
4. Nag, P.K, 1986, Engineering Thermodynamics, Tata McGraw-Hill Publishing Co, Ltd
5. Fundamentals of Gas Dynamics by V Babu, 2nd edition, Athena Publishers, 2015

Measurement in Thermal Engg - ME5109

Description

The main objective of this course is to provide a good understanding of the measurements techniques related to thermal engineering and analysis of experimental data.

Course Content

Introduction to measurements. Measurement categories-primary and derived quantities, intrusive and non-intrusive methods; Analysis of experimental data- types of errors, uncertainty analysis, propagation of uncertainty; Statistical analysis of experimental data-normal error distributions (confidence interval and level of significance, Chauvenet's criterion), Chi-square test of goodness of fit, method of least squares (regression analysis, correlation coefficient), multivariable regression, Students' t-distribution, graphical analysis and curve fitting. Static and dynamic characteristics; System response- first and second order systems and analysis, Measurement of temperature- thermoelectric thermometry, resistance thermometry, pyrometry, liquid in glass, bimetallic and liquid crystal thermometer, temperature sensors for measurement of transient temperature; Measurement of pressure-U-tube manometer, Bourdon gage, pressure transducers, measurement of transient and vacuum pressures. Measurement of volume flow rate-variable area type flow meter-orifice plate meter, flow nozzle, venture meter, rotameter. Measurement of Velocity-Pitot static and impact probes, velocity measurement based on thermal effect, Doppler velocimeter, Time of flight velocimeter.

Text Books

1. S P Venkateshan, Mechanical Measurements, Anne Books Pvt. Ltd., 2015.2. J P Holman, Experimental Methods for Engineers, McGraw-Hill, 2011.

Reference Books

1. J R Taylor, An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurements, University Science Books, 1997
2. Doebelin, Measurement System, Tata McGraw-Hill Education, 1984
3. Beckwith, Mechanical Measurements, Pearson Education India, 2007

Numerical Methods in Thermal Engg - ME5107

Description

To learn methods for obtaining numerical solutions for linear, non-linear algebraic, ordinary and partial differential equations.

Course Content

1. Solution of Linear Algebraic Equations1.1. Gaussian elimination1.2. LU decomposition1.3. Pivoting strategies1.4. Operation Count1.5. Matrix inversion1.6. Special cases1.6.1. Tridiagonal and block tridiagonal systems1.7. Well-conditioned and Ill conditioned system1.8. Matrix and Vector norms1.9. Condition Number and its implications2. Solution of Non-linear Algebraic Equations

2.1. Bisection, Newton-Raphson and Secant method2.2. System of non-linear equations3. Basics of finite difference method

3.1. Discretization of spatial and time derivatives using Taylor's series 3.2. Truncation error and order of discretization3.3. Fourier (von Neumann) stability analysis4. Solution of Ordinary Differential Equations

4.1. Initial Value problems4.1.1. Euler explicit and implicit methods4.1.2. Runge-Kutta method 4.1.3. Predictor-Corrector methods4.2. Boundary value problem4.2.1. Shooting method4.2.2. Finite difference method applied to pin fin heat dissipation4.3. Stiff problems4.3.1. Meaning of stiffness4.3.2. Further insights into stiffness by the application of Euler explicit and implicit method to a stiff problem4.3.3. Solution of stiff problem 4.3.4. Example - Chemical kinetics5. Solution of Elliptic Partial Differential Equations

5.1. Physical problems governed by elliptic PDE's5.2. Five-point and nine-point discretization’s of Poisson's equation5.3. Iterative methods5.3.1. Point Iterative methods - Jacobi, Gauss-Seidel, and SOR5.3.2. Detailed theory of the convergence of iterative methods 5.3.3. Global Iterative methods - Steepest Descent and Conjugate Gradient

6. Classification of PDEs and characteristics of a PDE 7. Solution of Parabolic Partial Differential Equations

7.1. Physical problems governed by parabolic PDE's Operator splitting and ADI methods

Text Books

1. Numerical Mathematics and Computing, by Ward Cheney and David Kincaid, International Thomson Publishing Company

2. Applied Numerical Analysis, by Curtis Gerald and Patrick Wheatley, Addison-Wesley

3. Analysis of Numerical Methods, by E. Isaacson & H. B. Keller, John Wiley & Sons

4. Numerical Solution of Partial Differential Equations: Finite Difference Methods, by G. D. Smith, Oxford University Press, 1985

5. Matrix Computations, by G. H. Golub, Johns Hopkins University Press6. Numerical Recipes, by W. H. Press et al

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Approved Details

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