MME311: Heat Transfer

Programme: B. Tech. (MME) Year: 2016 Semester: 5th
Course: Core Credits: 3 Hours: 42

Course Context and Overview (100 words):

Heat transfer is the thermal energy in transit due to a spatial temperature difference. The topic of heat transfer has enormous applications in mechanical engineering, ranging from cooling of microelectronics to design of jet engines and operations of nuclear power plants. In this course,
1. Students will learn about what is heat transfer, what governs the rate of heat transfer and importance of heat transfer.
2. They will also learn the three major modes of heat transfer viz., conduction, convection, and radiation. In addition to these three main modes of heat transfer, students will also learn the phenomena of heat transfer during phase change (boiling and condensation heat transfer).
3. The course provides practical exposure to the heat transfer equipment's like, heat exchangers, heat pipes, fins, etc

Prerequisites Courses: None

Course outcomes (COs):
1. Formulate basic equations for heat transfer problems.
2. Apply heat transfer principles to design and evaluate performance of thermal systems.
3. Calculate the effectiveness and rating of heat exchangers.
4. Calculate heat transfer by radiation between objects with simple geometries.
5. Calculate and evaluate the impact of boundary conditions on the solutions of heat transfer problems.
6. Evaluate the relative contributions of different modes of heat transfer.

Course Topics:

Topics	Lecture Hours
UNIT – I: Introduction to Heat and Mass Transfer	
Modes of heat transfer. Basic laws of heat transfer, Introduction to combined modes of heat transfer, Thermal conductivity and its variation with temperature for various Engg. Materials (Description only).Nano fluids. Derivation of Generalized differential equation of Heat Conduction in Cartesian co-ordinates, its reduction to Fourier, Laplace and Poisson's equations. Generalized Heat conduction equation in cylindrical and spherical coordinates (no derivation) **One dimensional steady state heat conduction without heat generation:** Reduction of Generalized differential equation of Heat Conduction to one dimension (1D), Heat conduction through plane wall, cylinder, sphere; electrical analogy; concept of thermal resistance and conductance, composite slab, composite cylinder and composite sphere, critical radius of insulation for cylinder and sphere. Critical radius of insulation for cables and pipes.	8

UNIT -II : Heat Conduction with Heat Generation and Unsteady State Heat Conduction	
One dimensional steady state heat conduction with heat generation One dimensional steady state heat conduction with uniform heat generation for plane wall cylinder, and sphere. **One dimensional unsteady state heat conduction** Lumped Heat capacity Analysis, Biot and Fourier number and their significance, (Numerical based on Lumped Heat capacity Analysis).Use of Hiesler and Grober Charts (No numerical based on Hiesler and Grober Charts).	6
UNIT – III: Boundary Conditions and Extended Surfaces	
Heat transfer through extended surface: Types of fins, Governing Equation for constant cross sectional area fins, solution (with derivation) for infinitely long & adequately long (with insulated end) fins and short fins (without derivation), efficiency & effectiveness of fins, limitation of an extended surfaces, Thermo-well and its error analysis. **Boundary and initial conditions:** Temperature boundary condition, heat flux boundary condition, convection boundary condition, radiation boundary condition.	7
UNIT – IV : Convection	
Fundamentals of convection: Mechanism of natural and forced convection. Concept of Hydrodynamic and thermal boundary layer, Local and average convective coefficient for laminar and turbulent flow for flat plate and pipe **Forced convection: Dimensional** analysis, Physical significance of dimension less numbers, Reynolds analogy for laminar flow, Correlations for forced convection over flat plate and closed conduits. **Natural or free convection:** Dimensional analysis, Physical significance of dimensionless numbers, correlations for natural convection over vertical plate cylinder sphere and flow patterns.	7
UNIT-V : Radiation	
Nature of thermal radiation, absorptivity, reflectivity, transmissivity, emissive power and emissivity, spectral and total concept, blackbody, gray body, and white body Kirchoff's law, Wein's law and Planck's law, and deduction of Stefan Boltzmann law. Lambert cosine rule, Intensity of radiation. Energy exchange by radiation between two black surfaces with non-absorbing medium in between and in absence of reradiating surfaces. Shape factor and its characteristics .Energy exchange by radiation between two gray surfaces without absorbing medium, concept of radiosity and irradiation. Radiation network method, network for two surfaces which see each other and nothing else, radiation shields	7
UNIT-VI : Heat Exchangers and Phase Change Phenomenon	
Heat Exchangers : Classification and types of Heat exchangers, Fouling factor, and Overall heat transfer coefficient, Heat Exchanger Analysis using LMTD and NTU methods for parallel and counter flow, Design consideration of Heat exchangers and introduction to design standards like TEMA. **Boiling and Condensation (Descriptive treatment only):** Types of boiling, Pool boiling	7

and Forced convection boiling, Nusselt's theory of condensation for vertical plate, Condensation correlations for practical applications, Film wise and drop wise condensation, promoters.	

Textbook references.

Text Book:

1. "Heat Transfer", J.P. Holman, Tata McGraw Hill Book Company, NewYork, 2nd Edition.
2. "Fundamentals of Heat and Mass Transfer",R.C. Sachdeva, Willey Eastern Ltd.,
3. "A Text Book on Heat Transfer", Dr. S. P. Sukhatme, Orient Longman Publication Hyderabad
4. "Heat and Mass Transfer", S.C.Arrora and S. Dokoundwar, Dhanpat Rai and Sons, Delhi.
5. "Fundamentals of Heat and Mass Transfer",C.P. Kothandaraman.
6. "Heat and Mass Transfer", R.K.Rajput, S. Chand and Company Ltd., New Delhi.,5th Edition.
7. "Heat and Mass Transfer", Dr.D.S. Kumar, S.K.Kataria and Sons,Delhi.
8. "Heat Transfer", P.K.Nag, TataMcGraw hill Publishing Company Ltd., New Delhi.

Reference books:

1. "Heat Transfer – A Practical approach",Yunus. A .Cengel, Tata McGraw Hill.
2. "Heat Transfer" Chapman A.J., Tata McGraw Hill Book Company, NewYork.
3. "Fundamentals of Heat and Mass Transfer", Frank P.Incropera, David P.Dewitt,Wisley India. 5th Edition.

Additional Resources (NPTEL, MIT Video Lectures, Web resources etc.):

Evaluation Methods:

Item	Weightage
Teacher's assessment (Project/case/assignment/quiz attendance etc.)	20 %
Midterm	30 %
Final Examination	50 %

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