Course-Plan

School : ENGINEERING
Department : Mechanical Engineering
Course Code : ME 549
Course Name : Conduction and Radiation heat transfer

Instructor: Prof. Tapan Kr. Gogoi
Ms. Shikha Bhuyan

1. Abstract:

ME 549 is an elective course offered for the M. Tech. programme in Thermal Engineering under the Department of Mechanical Engineering. The main focus of the course is on the methods for solving Conduction and Radiation heat transfer problems. The emphasis is on the analytical and the numerical methods for the study of Conduction heat transfer. Also, a condensed overview of radiation heat transfer, focusing primarily on radiant exchange between surfaces and the prediction of radiation transfer in absorbing, emitting, and scattering media is made.

2. Objective:

The course shall be taught with the following objectives:

i. To introduce the students to the initial and boundary value problems
ii. Familiarize the students with the physics and calculations involving transient conduction
iii. Teach the mathematical behavior of steady and unsteady 1D and 2D heat conduction equation
iv. Orient the students towards research fields in experimental and computational fluid dynamics and Heat transfer.
v. Give exposure to the Radiative heat transfer in non-participating and participating media.

3. Prerequisites of the course:

Elementary knowledge of Heat transfer course (Bachelor Degree).

4. Course outline:

Conduction: Derivation of energy equation for conduction in three dimensions – Initial and boundary conditions. Transient conduction- Concept of Biot number – Lumped capacitance formulation unsteady conduction from a semiinfinite solid-solution by similarity transformation method, Solution of the general 1D unsteady problem by separation of variables, integral methods of analysis for transient conduction, lumped and partially lumped capacitance methods, boundary value problems and orthogonal functions, Fourier and Chebyshev series, solution using separation of variables, semi-infinite and infinite domains, Duhamel's theorem, Laplace transforms, Green's functions, Solution of steady state 2D problem – solution by variable separable method – concept of superposition and homogeneous boundary conditions.

Numerical solution of conduction problems: Basic ideas of finite difference method – forward, backward and central differences – Discretization for the unsteady heat equation. Solution of the 1D unsteady heat conduction equation

Radiation: Laws of thermal radiation. Radiation properties of surfaces, Concept of view factors, Radiation exchange in black and diffuse grey enclosures, Radiation effects in temperature measurement, Enclosure theory for surfaces with wall temperatures that are continuous functions of space. Spectrally diffuse enclosure surfaces. Specularly reflecting surfaces

Radiation in participating media: The equation of radiative heat transfer in participating media; radiative properties of molecular gases and particulate media; exact solutions of one-dimensional grey media; Approximate solution methods for one-dimensional media (optically thin and optically thick approximations). Concept of combined Conduction and Radiation with examples such as spacecraft radiator, solar radiation etc.

5. (a)Time-Plan

Tentative Lecture	**Topics**
5 lectures	**Introduction to Conduction-** Recapitulation: Steady and Transient conduction; Fins, Lumped parameter and semi-infinite solid approximations, Heisler and Grober charts; 3-D conduction, isotropic, orthotropic and anisotropic solids.
12 lectures	**Analytical Methods-** Mathematical formulations, analytical solutions, variation of parameters, integral method, periodic boundary conditions, Duhamels theorem and Greens function etc.
6 lectures	**Applications to Specific Problems-** Stationary and moving heat sources and sinks. Moving boundary problems. Inverse heat conduction problems
6 lectures	**Introduction to radiation-** Recapitulation: Radiative properties of opaque surfaces, Intensity, emissive power, radiosity, Planck's law, Wien's displacement law, Black and Gray surfaces, Emissivity, absorptivity, Spectral and directional variations, View factors.
3 lectures	**Enclosure with Transparent Medium-** Enclosure analysis for diffuse-gray surfaces and non-diffuse, nongray surfaces, net radiation method.
4 lectures	**Enclosure with Participating Medium-** Radiation in absorbing, emitting and scattering media. Absorption, scattering and extinction coefficients, Radiative transfer equation
4 lectures	**Introduction to different radiation model-** Discrete transfer method, discrete ordinates method, finite volume method
2 lectures	**Combined Heat Transfer Modes-** Combined mode heat transfer and method of their calculation

Text Books:

1. F. P. Incropera, D. P. DeWitt, Fundamental of Heat and Mass Transfer, 5th Edition, John Wiley & Sons, Inc., 2016
2. D. Poulikakos, Conduction Heat transfer, Prentice Hall, 1994
3. M.N. Ozisik, Heat Conduction, 2nd edition, John Wiley & Sons, 1993
4. R. Siegel and J.R. Howell, Thermal Radiation Heat Transfer, Taylor and Francis, 2002

Reference Books:

1. G.E. Mayers, Analytical methods in Conduction Heat Transfer, McGraw Hill, 1971
2. V S Arpaci, Conduction Heat Transfer, Addison-Wesley, Reading, MA, 1966

5. (b) Evaluation Plan:

Test No.	Marks	Duration (minutes)
I	25	30
II	25	--
III (Major I)	40	60
IV (Assignment type)	25	-
V	25	30
Major II	60	120
Total Marks	200	

All the tests will be held as per the schedule notified by the Controller of Examinations, Tezpur University

6. Pedagogy:

Teaching-learning methods to be used:
Lecture and Discussion
Presentations
Assignments
Class Tests/Quiz

7. Expected outcome:

The contents which are covered in "**Conduction and radiation heat transfer**" are highly mathematical in nature. Towards the end of the course the student would be able to

i. Deal with Transient heat conduction equation
ii. Solve 1D unsteady problem with separation of variable method and integral method
iii. Carry out calculations related to two-dimensional unsteady flow
iv. Explain the background physics of the radiation heat transfer
v. Analyze Radiation exchange in black and diffuse grey enclosures
vi. Analyze Radiative heat transfer in participating media.