ESE-905 Analytical and Numerical Techniques in Heat Transfer

Course Objectives

1. The course is designed to achieve the following objectives
   a. To develop a strong physical and conceptual understanding of heat transfer processes.
   b. Apply scientific and engineering principles to analyze and design thermos-fluid aspects of engineering systems.
   c. Use appropriate analytical and computational tools to investigate heat and mass transport phenomena of different geometries.
   d. Thermal design; recognize the broad technological context of heat transfer, especially related to energy technology.
   e. To apply the associated heat transfer theories to simple engineering cases, with focuses on modeling establishment and problem closures.

Course Contents

2. Contents with suggested contact hours

No.	Topics	Contact Hours
a.	**Steady State Heat Conduction** • One-Dimensional Steady State Conduction • 1-D Steady State Conduction without generation • 1-D Steady State Conduction without generation • Numerical Solution to Steady State 1-D Conduction by using EES and Matlab • Analytical and Numerical Solutions for constant/non-constant cross-section Extended Surfaces • 2-D Steady State Conduction • Analytical and Numerical Solution to Steady State Heat Conduction Problems with EES and Matlab • Finite Element Solution	10
b.	**Transient Conduction** • Analytical Solutions to 0-D Transient	6

	Conduction • Numerical Solutions to 0-D Transient Conduction • Semi-Infinite 1-D Transient Conduction • Laplace Transform • Separation of Variables for Transient Problems • Analytical Solutions to 1-D Transient Conduction • Numerical Solutions to 1-D Transient Conduction	
c.	**External Forced Convention** • Laminar Boundary Layers • Boundary Layer Equations • Dimensional Analysis in Convection • Turbulent Boundary Layer • Reynolds Averaged Equation • Laws of Walls • Analytical Solutions to External Forced Convention • Numerical Solutions to External Forced Convention	6
d.	**Internal Forced Convention** • Internal flow Concept • Internal Flow Correlation • Energy Balance • Analytical Solution for Internal flows • Numerical Solution for Internal flows	6
e.	**Natural Convention** • Natural Convention Concept • Correlations for Natural Convention • Analytical Solution for Natural Convention • Numerical Solution for Natural Convention	4

f.	**Boiling and Condensation** • Pool Boiling • Flow Boing • Film Condensation • Analytical Solution for Boiling and Condensation • Numerical Solution for Boiling and Condensation	6
g.	**Heat exchangers** • Heat Exchangers • Logarithmic Mean Temperature Difference • Effectiveness NTU • Pinch Point Analysis • Numerical Model of Parallel, Counter and Cross Flow Heat Exchanger • Plate Type Heat Exchanger • Regenerators	7
h.	**Radiation Heat Transfer** • Radiation • Emission of Radiation by a Blackbody • Radiation Characteristics of real surfaces • Radiation with heat transfer mechanism • Monte Carlo Method	

Outcomes

3. This course is designed to introduce the students with phenomena of advanced heat and mass transfer, to develop methodologies for solving a wide variety of practical thermal engineering problems, and to provide useful information concerning the performance and design of particular systems and processes. A knowledge-based design problem requiring the formulations of solid conduction and fluid convection and the technique of numerical computation progressively elucidated in different chapters will be assigned and studied in detail.

4. **Recommended Reading (including Textbooks and Reference books).**

S. No.	Title	Author(s)	Remarks
a.	Heat Transfer	Gregory Nellis, Stanfered Klein	Text
b.	Heat and Mass Transfer A practical approach	Yunus A. Çengel	Reference
c.	Advanced Heat and Mass Transfer	Amir Faghri, Yuwen Zhang, John Howell	Reference
d.	Computational Methods for Heat and Mass Transfer	Pradip Majumdar, Pradip Majumdar	Reference
e.	Heat Exchangers: Selection, Rating, and Thermal Design,	Sadik Kakaç, Hongtan Liu	Reference
f.	Engineering Heat Transfer	William S. Janna	Reference
g.	Transient Heat Transfer	Annaratone, Donatello	Reference