Advanced Heat and Mass Transfer ESE-905

Background

1. Thermal processes are crucial to the operation of many engineering systems, such as nuclear reactors, gas-turbines, domestic heating systems, cooling of electronics and electrical components and many others. Heat transfer addresses the transport of energy due to conduction, convection and radiation and impacts nearly every area of industrial practice, including aerospace, automotive, biotechnology, chemical and materials processing, electronics, energy and environmental engineering, combustion, materials and manufacturing, and many others. This course will develop in-depth understanding of the physical processes involved in the transfer of thermal energy and mass, in a range of phenomena encountered engineering applications and also of the analytical techniques that can be applied.

Rationale

2. Rationale for offering/launching the new course

This course requires that students have; the ability to apply advanced mathematics through multivariate calculus and differential equations; the ability to work professionally in thermal systems areas including the design and realization of the thermal energy systems.

Educational Objectives

3. The course is designed to achieve the following objectives

- To develop a strong physical and conceptual understanding of heat and mass transfer processes.
- Apply scientific and engineering principles to analyze and design thermos-fluid aspects of engineering systems.
- Use appropriate analytical and computational tools to investigate heat and mass transport phenomena of different geometries.
- Thermal design; recognize the broad technological context of heat transfer, especially related to energy technology.

- To apply the associated heat transfer theories to simple engineering cases, with focuses on modeling establishment and problem closures.

Input Obtained from Industry/Corporate Sector/Subject Specialists/Academia

4. Attach details of the input, if received.

International Practice

5. Specify the universities of repute where the proposed course is being conducted.

UC Los Angeles,
UT San Antonio,
Univ. of Alaska

Proposed Timeframe of Commencement

6. Specifying semester with year.

Fall 2015

Course Contents

7. Give details of the course, on the following lines:

a. Course Code ESE-905

b. Title Advanced Heat and Mass Transfer

c. Credit Hours 3

d. Objectives (explained under heading 3)

e. Outcomes

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.

f. Contents with suggested contact hours

No.	Topics	Book	Contact Hours
1.	**Conduction Heat transfer** • Differential equations for heat conduction in solid materials. • Solutions for different special cases. Fin efficiency for different fin designs • Two and three-dimensional cases at stationary conditions. • Laplace equation. The form factor. Numerical solution methods and analogy methods. Numerical solutions of unsteady conduction and steady conduction • Non-stationary cases. Solutions for flat surfaces and cylinders • The "Lumped heat capacity" method. • Unsteady state conduction in solids with infinite thermal conductivity, infinite thick-solids, periodic variation	YA,AF & AD	12
2.	**Convection heat transfer** • Forced convection inside tubes and ducts • Forced convection over exterior surfaces • Heat transfer at natural (free) convection, Grashof's number. Boundary layer equations in integral form with solutions for natural convection for vertical plates • Empirical relationships for laminar and turbulent boundary layers at vertical and horizontal plates, cylinders and slots • Transitional Flow in tubes • Eddy heat diffusivity, Reynold’s analogy between skin friction and heat transfer	YA,AF & AD	10
3	**Radiation Heat Transfer**	YA&	7

	• Heat transfer at radiation • The "black body" concept. Emission and absorption numbers. Radiant efficiency, angular factor. • Heat transfer at irradiated surfaces • Heat transfer at condensation • Nusselt's theory, condensation on and in horizontal pipes • Heat transfer at boiling Various types of boiling, the boiling curve	AF	
4.	**Heat exchangers** • Different types of heat exchangers, Fouling Factor, logarithmic mean temperature difference, temperature effectiveness, NTU, Selection Techniques of the heat exchangers	YA; SK & AF	8
5.	**Mass Transfer** • Introduction, Fick's law, General equation of mass diffusion steady state, diffusion through a plain membrane, diffusion of water vapor through air, Mass transfer coefficient, convective mass transfer **Heat Pipe** • Introduction, Working of Heat pipe, Different types of Heat Pipe, Detail of Heat Pipe components, Advantages of Heat Pipe, Application of Heat Pipe, Performance of Heat Pipe, Limitation of Heat Pipe, Analysis and Design of Heat Pipe.	YA& AF	8

g. Details of lab work, workshops practice (if applicable).

NA

h. Recommended Reading (including Textbooks and Reference books).

S. No.	Title	Author(s)	Assigned Code	Remarks
1.	Heat and Mass Transfer A practical approach	Yunus A. Çengel	YA	Reference

2.	Advanced Heat and Mass Transfer	Amir Faghri, Yuwen Zhang, John Howell	AF	Reference
3.	Computational Methods for Heat and Mass Transfer	Pradip Majumdar, Pradip Majumdar	PM	Reference
4.	Heat Exchangers: Selection, Rating, and Thermal Design,	Sadik Kakaç, Hongtan Liu	SK	Reference
5.	Engineering Heat Transfer	William S. Janna	WS	Reference
6.	Transient Heat Transfer	Annaratone, Donatello	AD	Reference