Approval: 9th Senate Meeting

Course Name: Convective Heat and Mass Transfer

Course Number: ME 616

Credits: 3-0-0-3

Prerequisites: ME-210: Fluid Mechanics, ME-303: Heat Transfer, IC110: Engineering Mathematics

Intended for: UG/PG

Distribution: Elective

Semester: odd/even

Preamble:

This course assumes that the students have undergone UG courses in Engineering Mathematics, Thermodynamics, Heat Transfer and Fluid Mechanics and are familiar with the use of experimentally derived CORRELATIONS for estimating heat/mass transfer coefficient in a variety of flow situations. The purpose of this course is to justify the basis and the form of these correlations on the basis of fundamental transport laws governing heat/mass transfer. The treatment is highly mathematical and, through assignments, students are expected to formulate and solve problems to derive expressions for the heat/mass transfer coefficient in different situations. The course will interest students wishing to embark on a research career in heat/mass transfer.

Course Modules:

1. **Governing Equations**: Continuity, Momentum and Energy Equations, reduction of equations for various fluid flow systems, boundary layer approximations to momentum and energy, scale analysis, Introduction to nano-heat transfer **(6L)**
2. **Laminar external flow and heat transfer:** Scale analysis, similarity solutions for flat plate (Blasius solution), scale analysis of thick and thin thermal boundary layer, Integral method solutions for flow over an isothermal flat plate, flat plate with constant heat flux and with varying surface temperature, flows with pressure gradient. **(6L)**
3. **Laminar internal flow and heat transfer:** (a) Exact solutions to N-S equations for flow through channels and circular pipe, Fully developed forced convection in pipes with different wall boundary conditions, Forced convection in the thermal entrance region of ducts and channels (Graetz solution), heat transfer in the combined entrance region, (b) Integral method for internal flows with different wall boundary conditions. **(8L)**
4. **Natural convection heat transfer:** Governing equations for natural convection, Boussinesq approximation, Scale analysis: thermal and hydrodynamic boundary layers, Scale analysis in flow in vertical plate, Walls different boundary conditions: constant temperature and heat flux, Similarity and integral solutions, effects of inclination, Natural convection in enclosures, mixed convection heat transfer past vertical plate and in enclosures. **(10L)**
5. **Turbulent convection:** Governing equations for averaged turbulent flow field (RANS), Analogies between heat and Mass transfer (Reynolds, Prandtl-Taylor and von Karman Analogies), Turbulence Models (Zero, one and two equation models), Turbulent flow and heat transfer across flat plate and circular tube, Turbulent natural convection heat transfer, Empirical correlations for different configurations. **(6L)**
6. **Convective mass transfer:** Mass conservation, mass diffusivities, laminar forced convection, internal forced convection, natural convection: mass and heat transfer driven flows, turbulent flows: time averaged concentration equation, effect of chemical reaction, concept of boiling and condensation phenomena. **(6L)**

Text books:

1. Adrian Bejan, *Convective Heat Transfer* , John Wiley & Sons; 4^{th} Edition edition (17 May 2013).
2. Kays W M and Crawford M E, *Convective Heat and Mass Transfer*, McGraw Hill Int Edition, 3^{rd} edition, 1993.
3. Spalding D B, *Introduction to Convective Mass Transfer*, McGraw Hill, 1963.

References:

1. Louis C. Burmeister, *Convective Heat Transfer*, Wiley-Interscience; 2^{nd} edition (September 10, 1993)
2. Arpaci & Larcen, *Convective Heat Transfer*, Prentice Hall; First Edition edition (February 1984).
3. Sadik Kakac, Yaman Yener, Anchasa Pramuanjaroenkij, *Convective Heat Transfer*, CRC Press; 3 edition (December 17, 2013)
4. Bird R. B., Stewart W. E. and Lightfoot E. N., *Transport Phenomena*, John Wiley and sons, Inc., 1960.
5. Schlichting H., *Boundary Layer Theory*, Sixth edition, McGraw Hill , 1968.