MEG612: Advanced Convection and Two-phase Heat Transfer

Course Title	Advanced Convection andTwo-phase Heat Transfer
Course Code	MEG612
Credit Hours	3
Pre-requisites (if any)	MEG501 fluid mechanics, MEG 507 Advanced Heat Transfer, MEG511 Advanced Engineering Mathematics.
Co-requisites (is any)	None
Name of Faculty	
E-mail of Faculty	
Office hours of Faculty	TBD
Brief Course Description	Advanced treatment of fundamental aspects of convection and 2-phase heat transfer. Topics covered include: conservation laws, laminar and turbulent convection, mass transfer including phase change and moving boundary problems. Problems and examples include theory and applications drawn from a spectrum of engineering design and manufacturing problems.
Learning Outcomes of the Course	• Student will gain a deeper understanding of fluid-dynamic mechanisms involved in convection and two-phase heat transfer. • Solution techniques involving first and second-order ODEs will be mastered as well as problems requiring PDEs solved via separation of variables • Student will be equipped with the analytical and model synthesis skills needed to apply the fundamentals to a wide variety of complex engineering problems.

Week	**Course Topics and Contents**
1	Review Eulerian and Lagrangian reference; Conservation of mass, momentum, energy
2	Laminar Convection: inviscid, viscous flow; Velocity, temperature profiles;
3	Convection review; Heat transfer coefficient; origins of correlations
4	Integral Method: Momentum, Energy Integral;
5	Internal Flow: Laminar, Fully-Developed Flow in Tubes
6	Natural Convection: Scaling; Integral Method; Correlations
7	Turbulence, Eddy Diffusivity; Heat transfer in turbulent flow;
8	Cause and onset of turbulence; Quiz 1;
9	Laminar Condensation on a Vertical Surface; Subcooling; Generalized Laminar Condensation
10	Wavy Laminar and Turbulent Condensation; Dropwise condensation
11	Nucleate Boiling; Critical heat flux; Film Boiling; Bubble Growth;
12	Forced Convection Boiling and Condensation—external and internal;
13	presence of low vapor-pressure liquid, non-condensing gas
14	Melting and solidification; moving boundary problems
15	Three-phase problems; packed beds with evaporation & condensation
16	Review; Quiz 2

Relationship of course objectives to IDDP program outcomes	
Program Outcome 1	Demonstrate appropriate depth and breadth of knowledge that is at the frontier of their disciplines
Program Outcome 2	Use interdisciplinary skills of process system engineering to integrate multiple perspectives for advanced energy research
Program Outcome 3	Understand and value diverse approaches to solving critical problems in research and to creating new knowledge judged by international standards
Program Outcome 4	Work effectively in a multidisciplinary collaborative environment using highly developed cognitive and creative expert skills and intellectual independence

Out-of-class assignments and dues dates for submission	PS1 – Introduction and Conservation Eqns. (week 2) PS2 – Laminar forced convection flow (week 3) PS3 – Natural convection (week 5) PS4 – Turbulence (week 7) PS5 – Condensation (week 8) PS6 – Boiling (week 10) PS7 – Forced condensation/boiling in tubes(week 12) PS8 – three-phase heat transfer (week 13)
Methods and dates of student evaluation, including relative weight of various assessment methods in determining course grade	Class/tutorial participation (10%); Quiz 1 (30%); Quiz 2 (30%); Problem Sets 30%. Quiz 1: Natural & Forced Convection, Integral methods (week 8) Quiz 2: Boiling, Condensation, Freezing, Melting, 3-phase (week 16)
Teaching and learning methodologies	Emphasis is on underlying principles—e.g. molecular basis of continuum view and fluid dynamic basis of heat transfer correlations and analogies—to provide a deeper understanding of thermofluid processes that can be applied to situations where correlations do not exist. Weekly tutorials will give the student practice in problem solving techniques. Problem sets and tests further motivate the student to apply first principles in deriving results that cannot be found in handbooks.
Main course texts	*Heat Transfer*, A.F. Mills; *A Heat Transfer Textbook*, J. H. Lienhard
Recommended readings	Kuo, Sindo. *Transport Phenomena and Materials Processing*, Wiley Spiegel, M.R., 1999. *Advanced Mathematics for Engineers and Scientists*, Schaum's *Heat and Mass Transfer*, A.F.Mills, 1995, Irwin *Viscous Fluid Flow*, F. M. White, 1991, McGraw-Hill *Convective Heat and Mass Transfer*, W.M. Kays and M.E. Crawford, 1993, McGraw-Hill *Convective Heat Transfer*, A. Bejan, 1984, Wiley