ME 315
HEAT AND MASS TRANSFER

Course Outcomes [Related ME Program Outcomes in brackets]

1. Develop the ability to identify the relevant *transport processes* (heat, momentum and energy) when confronted with a particular problem. [1, 7]
2. Develop the ability to *model* and *analyze* heat and mass transfer processes. [1, 2, 3, 5, 7]
3. Augment the ability to *design* and *conduct experiments* to solve open-ended engineering problems. [2, 3, 5, 6, 7]
4. Reinforce technical *written and oral communication skills* through a formal project report. [3, 4, 5]

Thermodynamics & Fluid Mechanics Fundamentals (1.5 wks)

Conservation Laws (mass, momentum, energy), Boundary Layer Concept, Velocity Distribution, Laminar and Turbulent Flows, Friction Factor, Pressure Difference, Head Loss, etc.

Heat & Mass Transfer Fundamentals (1.5 wks)

Rate Equations (Fourier's Law, Newton's Law of Cooling, Stefan-Boltzmann Law, Planck's Law, Fick's Law)

Conduction Heat Transfer (4 wks)

1. Introduction, Rate Equations
2. Rate Equations Combined with Conservation Equations*
3. Introduction to Conduction, Generalized Transient Conduction Relationships*
4. 1D Steady State Conduction, Thermal Resistance
5. Radial Conduction
6. Thermal Generation
7. Extended Surfaces*
8. 2D Steady State Conduction
9. Finite Difference Method (steady state)
10. Transient Conduction-Lumped Capacitance
11. Analytical Results (wall, cylinder, sphere, semi-infinite case)
12. Finite Difference Method (transient)

Convection Heat & Mass Transfer (4 wks)

1. The Convection Transfer Problem (local & average coefficients)
2. Convection Equations
3. Dimensionless Forms, Dimensionless Parameters, Similarity
4. Heat-Mass Analogy*
5. External Flow (flat plate*, cylinder, etc.)
6. Internal Flow
7. Free Convection
8. Two-Phase Heat Transfer (boiling & condensation)
9. Heat Exchangers (LMTD and NTU methods)

Radiation Heat Transfer (4 wks)

1. Thermal Radiation, Spatial & Spectral Effects
2. Energy Balances Incorporating Emission, Absorption & Transmission
3. Blackbody Emission
4. Real Surface Emission
5. Isothermal Enclosure, Kirchhoff's Law
6. Gray and Non-Gray Surfaces plus Environmental Radiation
7. View Factor
8. Blackbody Radiation Exchange
9. Diffuse-Gray Surface Radiation Exchange
10. Multimode Processes Involving Radiation

Semester Project (8 wk duration) – Typical Projects

- Windshield Defogger
- Heat Exchanger
- Heat Sink
- Pizza Bag
- Jet Impingement
- Dimmer Switch (Overheating)
- Silicon Wafer
- Thermal Conductivity
- Dynamic Braking

COURSE NUMBER: ME 315 **COURSE TITLE:** Heat and Mass Transfer

REQUIRED COURSE OR ELECTIVE COURSE: Required

TERMS OFFERED: Fall and Spring

TEXTBOOK/REQUIRED MATERIAL: T. Bergman, A.S. Lavine, F.P. Incropera, D.P. DeWitt, *Fundamentals of Heat and Mass Transfer*, 7th ed, Wiley, 2011.

PRE-REQUISITES: ME 308 Fluid Mechanics
ME 365 Systems and Measurements

CO-REQUISITES: MA 303 Differential Eqns and Partial Differential Eqns for Engineering and the Sciences
ME 30801 Fluid Mechanics Laboratory

COORDINATING FACULTY: J.H. Choi

COURSE DESCRIPTION: Fundamentals of heat transfer by conduction, convection, and radiation; mass transfer by convection. Relevance to engineering applications.

COURSE OUTCOMES [Related ME Program Outcomes in brackets]:

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4. Reinforce technical *written* and *oral communication* skills through a formal project report. [3, 4, 5]

ASSESSMENTS TOOLS:

1. Homework
2. 2 90-minute semester exams.
3. Final exam.
4. Laboratory experiment preparation, assignments and summary reports.
5. 8-week open-ended design project.
6. Oral presentations.
7. Final report.

PROFESSIONAL COMPONENT:

1. Engineering Topics: Engineering Science – 2 credits (50%)
   Engineering Design – 2 credits (50%)

RELATED ME PROGRAM OUTCOMES:

1. Engineering fundamentals
2. Engineering design
3. Communication skills
4. Ethical/Professional responsibilities
5. Teamwork skills
6. Experimental skills
7. Knowledge acquisition skills

NATURE OF DESIGN CONTENT: Problems associated with complicated physical systems which require identifying and rationalizing assumptions. Design-type project on a topic defined by an industrial collaborator or our own staff.

COMPUTER USAGE: Data acquisition software, LabVIEW, for experiment observations and spread-sheet and/or equation solver software for data analysis and results presentation. Solution of open-ended problems, parameter-sensitivity studies and design-type assignments. Preparation of summary reports for five laboratory experiments and two team project reports. Reports require word processed text and computer-generated graphics.

COURSE STRUCTURE/SCHEDULE:

1. Lecture - 3 days per week at 50 minutes
2. Laboratory - 1 day per week at 100 minutes.

PREPARED BY: J.H. Choi **REVISION DATE:** 10 October 2018