ME 5403

Theory of Conduction and Convection

General Overview

Instructor: Prof. Michael Wendl

Assistant: Zichen Du

Time: Tuesdays and Thursdays 7:00 pm to 8:30 pm

Location: Whitaker Hall, Room 216

Synopsis: This course is a continuation of the introductory principles of heat transfer by conduction and convection, being a more comprehensive and essentially analytical study of those topics. It covers the systematic mathematical formulation and analysis of steady and unsteady conduction in single and multiple dimensions, including the annular fin and the Dirichlet, Robbins, and Rayleigh problems, emphasizing the classical techniques of Frobenius' method, separation of variables, and similarity transforms, as well as associated issues regarding solution uniqueness and evaluation. Various integral transform techniques for more complex problems are discussed. The conduction equation for a medium at rest is generalized to allow for motion, leading to the equations for convection in terms of conservation of mass, momentum, and energy. Various forms of these equations are examined, including those for boundary layer flows and those where viscous dissipation of mechanical energy are important. Classical internal flow problems are examined, including the circular duct having constant heat flux, as well as the Couette problem for rectangular ducts. The non–linear boundary layer convection problem is examined using both the Karman–Pohlhausen integral procedure and the Piercy–Preston successive integration method. Free convection will be examined, time permitting.

Textbook: The primary text is the e–book "Theoretical Foundations of Conduction and Convection Heat Transfer", which is available as a free PDF download from the URL `http://wendl.weebly.com/textbook.html`. This text will be followed rather closely, so it is strongly suggested that you print it and carry it to class.

Prerequisites: Advanced Engineering Mathematics (ESE 317, JEM 3170, or equivalent); Introduction to Fluid Dynamics (MEMS 3410, JME 3700, or equivalent); Principles of Heat Transfer (MEMS 342, JME 3710, or equivalent)

Goals for ME 5403

1. Gain a fundamental understanding of the underlying concepts and the governing equations for conduction and convection heat transfer in terms of conservation of mass, momentum, and energy.

2. Gain proficiency in framing application problems mathematically, including formulation of appropriate boundary and initial conditions, and appropriate use of simplified equations, e.g. boundary layer approximations.

3. Gain proficiency in applying the traditional techniques of mathematical physics, including similarity analysis, separation of variables, techniques for ODEs, and integral transforms.

Grading Basis

Formula: The following basis will be used in determining final grades for the course:

Part	Component
Midterm Exam	30%
Final Exam	30%
Combined Homeworks	25%
Participation	15%
Total	100%

Midterm Format: One in–class open–book quiz will be given during the semester (see syllabus). It will stress conceptual understanding and problem–solving capability. Rote memorization of formulas and/or equations is not expected. Any student who cannot appear for the midterm quiz must inform the instructor at least a week prior to the exam in order to be eligible to take a make–up midterm during reading week (the week before final exams).

Final Exam Format: Same as for midterm, except the final will cover only material presented in the second half of the course and there will be no make–up available.

Combined Homeworks: Check the syllabus for the homework schedule. Problems are to be done on standard 8.5" × 11" paper in a neat and legible manner. You are permitted to work with others, but the work handed in *must be your own work!* Homeworks will nominally be due in class one week after being assigned. However, this is an informal deadline. This will give you some slack on particularly busy weeks with your other classes, but I urge you not to fall behind! Homeworks will **NOT** be accepted after

their solutions are posted. **There will be no exceptions!** No make–up homeworks will be assigned, nor will extra credit be available. Again, **no exceptions**.

Participation: Your grade will also depend upon the instructor's somewhat subjective judgment of "participation", which includes in–class attendance and verbal participation. Attendance is not tracked, but missing a lot of classes will certainly be noticed.

Policies and Procedures

Academic Integrity: You are bound by the School's code of academic integrity. The proprieties of this code will be strictly observed. Infractions are grounds for failing the course.

Help Sessions: The instructor will be available briefly after class periods to answer any additional questions regarding homework, etc. If there is a need for a regular weekly help session, one will be arranged.