SYLLABUS

CAM 389C / EM 397: INTRODUCTION TO MATHEMATICAL MODELING IN SCIENCE AND ENGINEERING

Fall Semester 2010

Professor J. Tinsley Oden
Meeting TT 12:30-2pm, ETC4.150
ACE 4.427, oden@ices.utexas.edu, Office Hours: TT 2:30-3:30 pm

Course Description

This course is designed to provide an introduction to the elements of classical mechanics, physics and chemistry needed to begin work in interdisciplinary programs in computational engineering and sciences, and to lay down fundamental principles underlying models of events and different scales affecting material behavior. The course develops from first principles of the classical mathematical theories underlying many of the models of physical phenomena important in modern applications. The course also provides an introduction to Area C concentrations in the CSEM Ph.D. program.

Prerequisites

The course is taught at a senior-beginning graduate level for students with some background in mathematics, science, and engineering. Students are expected to have a familiarity with vector calculus and linear algebra. While not necessary, some familiarity with elementary probability theory, classical mathematical methods in physics and engineering, and advanced calculus are helpful or may be studied in parallel with this course.

Course Outline

1. NON-LINEAR CONTINUUM MECHANICS

1.1 Kinematics of Continua
1.2 Mass and Momentum
1.3 Force and Stress in Deformable Bodies
1.4 The Principles of Balance of Linear and Angular Momentum
1.5 Transport Phenomena
1.6 The Principle of Conservation of Energy
1.7 Thermodynamics of Continua and the Second Law
1.8 Constitutive Equations
1.9 Examples and Applications

2. ELECTROMAGNETIC FIELD THEORY

2.1 Coulomb's Law, Electric Field and Electric Flux, Gauss' Law for Electricity.
2.2 Electrostatic Potential.
2.3 Electric Dipole, Polarization and Dielectrics. Gauss' Law for Dielectrics.
2.4 Ampere's Force Law, Current Element and Biot-Savart Law.
2.5 Maxwell’s Equations
2.6 Electromagnetic Waves

3. INTRODUCTION TO QUANTUM MECHANICS

3.1 Wave and Particle Mechanics
3.2 Heisenberg's Uncertainty Principle
3.3 Schrödinger's Equations
3.4 Dynamical Variables and Observables
3.5 The Harmonic Oscillator and the Hydrogen Atom
3.6 Spin and Pauli's Principle
3.7 Atomic and Molecular Structure
3.8 Ab-Initio Methods: Approximate Methods and Density Functional Theory

4. INTRODUCTION TO STATISTICAL MECHANICS

4.1 Basic Concepts: Ensembles, Distribution Functions, and Averages
4.2 Ergodic Theory: Phase Functions and Time Averages
4.3 Microcanonical, Canonical, and Grandcanonical Ensembles
4.4 Statistical Mechanics Basis of Classical Thermodyamics
4.5 Entropy and the Partition Function
4.6 Maxwell-Gibbs Relations
4.7 Introduction to Molecular Dynamics
4.8 Boltzman's Equations: Non-Equilibrium Thermodynamics

GRADING: Homework 20%, Mid-Term Examination 20% (2x), Final Examination, 40%.