University Of California, Berkeley
Department of Mechanical Engineering

ME C202: Computational Design of Multifunctional/Multiphysical Composite Materials (3 units)

Graduate Course

Syllabus

CATALOG DESCRIPTION

The course is self-contained and is designed in an interdisciplinary manner for graduate students in engineering, materials science, physics and applied mathematics who are interested in methods to accelerate the laboratory analysis and design of new materials. Examples draw primarily from various mechanical, thermal, diffusive and electromagnetic applications.

COURSE DESCRIPTION

A key to the success of many modern industrial components is the tailored mechanical, thermal, diffusive and electromagnetic behavior of the material. A relatively inexpensive way to obtain macroscopic material responses is to enhance the properties of a base matrix material by the addition of foreign microscopic matter, such as particulates or fibers, producing a so-called "composite" material. Accordingly, in many modern engineering designs, materials with highly complex, heterogeneous, microstructures are now in use. The macroscopic response of such microscopically-modified base materials is the aggregate behavior of the assemblage of different "pure" components (particles or fibers suspended in a binding matrix material). Ideally, one would like to accelerate predictions of macroscopic material responses by theoretical and numerical analysis, with the goal being to reduce costly, time consuming, trial and error laboratory tests and design processes. The focus of the course is to develop analytical and numerical methods to model and design such materials. A primary theme is to determine relationships between the material microstructure and the macroscopic response or "macroscale property".

COURSE PREREQUISITES

An undergraduate degree in the applied sciences or engineering.

TEXTBOOK(S) AND/OR OTHER REQUIRED MATERIAL:

Reader and notes. No text.

COURSE OBJECTIVES :

To endow students to model the connection between the material microstructure and the macroscale property.

DESIRED COURSE OUTCOMES:

An introduction to material design for mechanical, thermal and electromagnetic systems, as well as coupled problems.

TOPICS COVERED

The following topics are discussed:

1. Essentials of continuum mechanics
2. Foundations of homogenization theory
3. Analytical estimates of the overall mechanical, thermal and diffusive properties of microheterogeneous materials
4. An introduction to Electrodynamics and Maxwell's equations
5. Homogenization of electromagnetic media
6. Analytical estimates of the overall electromagnetic properties of microheterogeneous materials
7. Inverse material design problems and numerical methods based upon: (1) Local Convex optimization (gradient-based methods) and (2) Global Nonconvex optimization (non-derivative "genetic" methods)
8. Multifunctional composites: mechanically, thermally, diffusively and electromagnetically coupled materials
9. Computational homogenization methods based on Finite Element (FE) discretization
10. Computational homogenization methods based on Finite Difference Time Domain (FTDT) discretization
11. Computational homogenization methods for coupled multiphysics problems
12. TIME PERMITTING: noninvasive biological applications
13. TIME PERMITTING: optical and other high-frequency applications
14. TIME PERMITTING: multiscale methods, global-local (macromicro) coupling
15. TIME PERMITTING: domain decomposition for parallel processing

CLASS/LABORATORY SCHEDULE

3 Lectures per week.

CONTRIBUTION OF THE COURSE TO MEETING THE PROFESSIONAL COMPONENT:

Material design is an integral part of most engineering components.

ASSESSMENT OF STUDENT PROGRESS TOWARD COURSE OBJECTIVES

(a) 6-8 projects worth 75 % and (b) final worth 25 %

PERSON(S) WHO PREPARED THIS DESCRIPTION

Professor Tarek Zohdi
February 16, 2011

ABBREVIATED TRANSCRIPT TITLE (19 SPACES MAXIMUM): COMP DES COMP MAT
TIE CODE: LECT
GRADING: Letter
SEMESTER OFFERED: Fall and Spring
COURSES THAT WILL RESTRICT CREDIT: None
INSTRUCTORS: Prof. Tarek Zohdi

DURATION OF COURSE: 14 Weeks
EST. TOTAL NUMBER OF REQUIRED HRS OF STUDENT WORK PER WEEK: 9
IS COURSE REPEATABLE FOR CREDIT? No
CROSSLIST: MSE C287