University of California, Berkeley
Engineering Science

E150 – Basic Modeling and Simulation Tools for Industrial Research Applications (3 units)

Undergraduate Elective

Syllabus

CATALOG DESCRIPTION

The course emphasizes elementary modeling, numerical methods and their implementation on physical problems motivated by phenomena that students are likely to encounter in their careers, involving biomechanics, heat-transfer, structural analysis, control theory, fluid-flow, electrical conduction, diffusion, etc. The course will help students develop intuition about the strengths and weaknesses of a variety of modeling and numerical methods. The course will help students develop intuition about modeling physical systems and strengths and weaknesses of a variety of numerical methods, including:

- Discretization of differential equations,
- Methods for solving nonlinear systems,
- Gradient-based methods for optimization,
- Machine learning algorithms for optimization and
- Statistics and ncertainty quantification

COURSE PREREQUISITES

E7 or CS 61A, Physics 7a, Math 53, Math 54

TEXTBOOK(S) AND/OR OTHER REQUIRED MATERIAL

Free reader and notes provided. No textbook.

COURSE OBJECTIVES

Comprised of an introduction to essential mathematical modeling and simulation tools. Afterwards, 8-10 industry-motivated projects are studied, applying the modeling and simulation tools.

DESIRED COURSE OUTCOMES

Coverage of the modeling and simulation of modern engineering systems and their synthesis. The goal of this course is to provide students with the general multipurpose tools needed for successful industrial research. The course will help students develop intuition about modeling physical systems and strengths and weaknesses of a variety of numerical methods. Instructor’s class notes will be used. Some commonly recurring mathematical tools needed are

- Discretization of differential equations,
- Recursion based methods for solving nonlinear systems,
- Gradient based methods for solving nonlinear systems,
- Gradient-based methods for optimization,
- Machine learning algorithms for optimization and
- Statistics, sensitivity analysis and uncertainty quantification

TOPICS COVERED

See weekly topics.

CLASS/LABORATORY SCHEDULE

3 Hours of lecture per week

RELATIONSHIP OF THE COURSE TO ABET PROGRAM OUTCOMES

(a) an ability to apply knowledge of mathematics, science, and engineering
(b) an ability to design and conduct experiments, as well as to analyze and interpret data
(c) an ability to design a system, component, or process to meet desired needs within realistic constraints
(d) an ability to function on multi-disciplinary teams
(e) an ability to identify, formulate, and solve engineering problems
(f) an understanding of professional and ethical responsibility
(g) an ability to communicate effectively
(h) the broad education necessary to understand the impact of engineering solutions
(i) a recognition of the need for, and an ability to engage in life-long learning
(j) a knowledge of contemporary issues
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

ASSESSMENT OF STUDENT PROGRESS TOWARD COURSE OBJECTIVES

(a) Midterm 10 %
(b) 7-8 projects worth 55 %
(c) Final worth 35 %

SAMPLE OF WEEKLY AGENDA

See below.

PERSON(S) WHO PREPARED THIS DESCRIPTION
T. Zohdi. 3/1/2018

ABBREVIATED TRANSCRIPT TITLE (19 SPACES MAXIMUM): [ss completes]
TIE CODE: [ss completes]
GRADING: Letter and/or P/NP
SEMESTER OFFERED: Fall and/or Spring
COURSES THAT WILL RESTRICT CREDIT:
INSTRUCTORS:
DURATION OF COURSE: 14 Weeks
EST. TOTAL NUMBER OF REQUIRED HRS OF STUDENT WORK PER WEEK: Varies
IS COURSE REPEATABLE FOR CREDIT? Yes
CROSSLIST: None

Sample Weekly Schedule

WEEK 1: Models that arise from physical systems in engineering and basic numerical methods

THEME: MODELING AND SIMULATION OF THE DYNAMICS OF COMPLEX SYSTEMS

WEEK 2:Case study-modeling and simulation of the dynamics of a swarm
WEEK 3:Case study-modeling and simulation of the mechanics of an explosion
WEEK 4:Case study-modeling and simulation of ballistic armor

THEME: MODELING OF SIMULATION OF HIGH-PERFORMANCE MATERIALS IN INDUSTRY

WEEK 5:Case study-modeling and simulation of next-generation turbine blades
WEEK 6:Case study-modeling and simulation of functionalized material design
WEEK 7:Case study-modeling and simulation of a multifunctional fluid

THEME: MODELING AND SIMULATION OF BIOLOGICAL SYSTEMS

WEEK 8:Case study-modeling and simulation of bio-flow and disease progression
WEEK 9:Case study-modeling and simulation of electrical trauma
WEEK 10:Case study-modeling and simulation of the biomechanical movement of an athlete

THEME: MODELING AND SIMULATION OF ADVANCED MANUFACTURING

WEEK 11:Case study-modeling and simulation of the design of 3D printing materials
WEEK 12:Case study-modeling and simulation of laser-processing of materials
WEEK 13:Case study-modeling and simulation of a robotic 3D printer

WEEK 14: Review