University Of California, Berkeley
Department of Mechanical Engineering

ME 284 – Theory of Elasticity (3 units)

Graduate Course

Syllabus

CATALOG DESCRIPTION

This course is a general introduction to the theory of elasticity. This is the single most important branch of solid mechanics. It encompasses the mechanical behavior of an enormous variety of engineering and natural materials and provides a template for the formulation of more advanced models of complex material behavior, such as plasticity, growth and thermomechanics. The first half of the course is devoted to the nonlinear theory, including the basic concept of elasticity, its relationship to work and energy, the concepts of frame invariance and material symmetry, simple solutions that facilitate correlation of theory with experiment, applications to polymers and bio-tissues, and the concept of elastic stability. The second half of the course emphasizes the linear theory, derived by systematically linearizing the general theory. This is useful in the small-deformation regime characterizing the majority of engineering applications, including wave propagation and vibrations. A wide variety of sophisticated analytical methods are applicable to the linear theory and their coverage constitutes the balance of the course.

COURSE PREREQUISITES

ME 185/287 or a comparable introductory course on Continuum Mechanics.

TEXTBOOK(S) AND/OR OTHER REQUIRED MATERIAL

R.J. Atkin and N. Fox, 2005, An Introduction to the Theory of Elasticity. Dover, NY.

COURSE OBJECTIVES

This is a core required course for graduate students in the fields of Solid Mechanics and Continuum Mechanics. It provides students with the background necessary to undertake advanced work in these disciplines.

DESIRED COURSE OUTCOMES

Students will gain a deep understanding of the concepts and methods underlying modern elasticity theory. The course is designed to equip students with the background needed to pursue advanced graduate work in allied fields.

TOPICS COVERED

Brief review of relevant continuum mechanics; concept of an elastic material: experimental facts, constitutive postulate, frame invariance, strain-energy function; the initial-boundary-value problem; constrained materials: incompressibility, inextensibility; material symmetry: isotropy and anisotropy, useful strain-energy functions; applications to bio-elasticity; universal relations of use in experimental verification: controllable deformations; some explicit solutions; stability criteria and their implications for constitutive equations, strong ellipticity; equations of classical linear elasticity: derivation from the general theory; simple problems involving spherical and axial symmetry; fundamental theorems: Betti's theorem. minimum energy and complementary energy, applications; torsion of prismatic bars: complex-variable solution; 2-D elasticity: anti-plane strain, plane strain and generalized plane stress, complex-variable methods; dislocations and crack-tip fields; displacement potentials and stress potentials in 3D; plane harmonic waves, reflection and transmission, vibrations.

CLASS/LABORATORY SCHEDULE

3 hours of lecture/week, 4-5 hours of homework/week, 1 3-hour session for project presentations scheduled during RRR week.

CONTRIBUTION OF THE COURSE TO MEETING THE PROFESSIONAL COMPONENT

The course equips students with the knowledge and tools necessary to model and analyze a very wide range of problems in the Engineering and Applied Sciences. It provides students with a firm foundation for a thorough understanding of existing developments in these areas and for extending them in response to the emerging needs and demands of the engineering profession.

ASSESSMENT OF STUDENT PROGRESS TOWARD COURSE OBJECTIVES

Homework (50%), term project (50%).

SAMPLE OF WEEKLY AGENDA

Week 1	Brief review of relevant continuum mechanics
Week 2	Concept of an elastic material, experimental facts
Week 3	Constitutive postulate, frame invariance, strain-energy function, the initial-boundary-value problem
Week 4	Constrained materials: incompressibility, inextensibility
Week 5	Material symmetry: isotropy and anisotropy, useful strain-energy functions, applications to bio-elasticity
Week 6	Universal relations of use in experimental verification: controllable deformations, some explicit solutions
Week 7	Stability criteria and their implications for constitutive equations, strong ellipticity
Week 8	Equations of classical linear elasticity, preservation of frame invariance
Week 9	Simple problems involving spherical and axial symmetry
Week 10	Fundamental theorems: Betti's theorem. minimum energy and complementary energy
Week 11	Torsion of prismatic bars: St. Venant's theory
Week 12	2-D elasticity: anti-plane strain, plane strain and generalized plane stress, complex-variable methods, dislocations and crack-tip fields
Week 13	Displacement potentials and stress potentials in 3D
Week 14	Plane harmonic waves, reflection and transmission, vibrations
Week 15	RRR: Students present term projects
Week 16	Final Week: no activity

PERSON(S) WHO PREPARED THIS DESCRIPTION
David Steigmann, March 16, 2018

ABBREVIATED TRANSCRIPT TITLE (19 SPACES MAXIMUM): THRY ELASTICITY
TIE CODE: LECT
GRADING: Letter
SEMESTER OFFERED: Fall and Spring
COURSES THAT WILL RESTRICT CREDIT: ME 282
INSTRUCTORS: Steigmann
DURATION OF COURSE: 15 Weeks
EST. TOTAL NUMBER OF REQUIRED HRS OF STUDENT WORK PER WEEK: 9
IS COURSE REPEATABLE FOR CREDIT? No
CROSSLIST: None