University Of California, Berkeley
Department of Mechanical Engineering

ME 127 – Introduction to Composite Materials (3 units)

Undergraduate Elective

Syllabus

CATALOG DESCRIPTION

Imagine a material that offers mechanical properties that are competitive with aluminum and steel but are at fractions of their weight – these materials are termed as composites. Composites are defined as materials composed of two or more constituents with significantly different physical or chemical properties that, when combined, produce a new material with characteristics different from the individual components. Composite materials are used for many applications such as spacecrafts, aircrafts, racing car bodies, and many others for their capability to be stronger, lighter, and cheaper when compared to traditional materials. In this class, students will delve into the theory and micromechanics on how to design composite structures, processing techniques on how to manufacture them, and structural testing methods for validation. Starting from traditional composite materials (such as fiber-reinforced), this course will also bring in concepts of new composite designs inspired by nature (bioinspired) and developed by algorithms (using artificial intelligence). At the same time, students will gain exposure to a broad range of composite applications with seminars and hands-on experience on actually designing, fabricating, and experimentally testing a composite component using advanced computation and additive manufacturing with a final project.

COURSE PREREQUISITES

ME C85/CE C30 or equivalent course in mechanics of materials;

TEXTBOOK(S) AND/OR OTHER REQUIRED MATERIAL

Title: An Introduction to Composite Materials, Authors: D. Hull and T.W. Clyne

Title: Principles of Composite Material Mechanics, Author: Ronald Gibson

COURSE OBJECTIVES

The course objectives are to train students to be able to design composite structures, select composite materials, conduct stress analyses of selected practical applications using laminated plate theories and appropriate strength criteria, and be familiar with the properties and response of composite structures subjected to mechanical loading under static and cyclic conditions.

DESIRED COURSE OUTCOMES

Students completing this course will have the facility for designing robust composite structures subjected to various types of loads. Students will also be able to assess the effects of long-term loading, including damage generation, delamination fracture and fatigue failure. Additionally, students will be exposed to how composites are used in various applications in aerospace, biomedical, sports, among other fields.

TOPICS COVERED

Composite applications; fiber and matrix materials; processing, manufacturing, and testing; bioinspired composites; laminated plate theory; failure criterion; micromechanics; damage; fatigue; design and modeling of composites; nanocomposites

CLASS/LABORATORY SCHEDULE

Three hours of lecture per week.

COURSE SUPPORT

20-hour GSI and a 10-hour reader support for this course.

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 such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
(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 in a global, economic, environmental, and societal context
(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

20%: Homework assignments
40%: 2 midterm exams
40%: Final project

SAMPLE OF WEEKLY AGENDA

Week 1	Introduction to composites
Week 2	Fiber and matrix materials
Week 3	Processing, manufacturing, and testing
Week 4	Bioinspired composites
Week 5	Analysis of a lamina
Week 6	Laminated plate theory
Week 7	Failure criterion
Week 8	Composite micromechanics
Week 9	Damage in composites

Week 10	Fatigue of composite materials
Week 11	Composite design, modeling, and optimization
Week 12	Nanocomposites
Week 13	Project presentations
Week 14	Applications in aerospace, biomedical, sports, among other fields
Week 15	RRR
Week 16	Final Week

ADDITIONAL COMMENTS/CONCERNS

PERSON(S) WHO PREPARED THIS DESCRIPTION

Grace Gu   October 5, 2019

DETAILED WEEKLY SCHEDULE OF TOPICS

Week 1	Introduction to composites (definition, applications) **Reading**: Gibson Chapter 1
Week 2	Fiber and matrix materials (carbon fiber, glass fiber) **Reading**: D. Hull and T.W. Clyne Chapter 1 and 2
Week 3	Processing, manufacturing, and testing (open molding, additive manufacturing) **Reading**: Gibson Chapter 10
Week 4	Bioinspired composites (seashells, bone, teeth, bamboo composites) **Reading:** Yang et al., Recent progress in biomimetic additive manufacturing technology: From materials to functional structures, *Advanced Materials*, 2018
Week 5	Analysis of a lamina (introduction) **Reading**: Gibson Chapter 2
Week 6	Laminated plate theory (isotropic, anisotropic) **Reading**: Gibson Chapter 3 and 4
Week 7	Failure criterion (max stress/strain, Tsai-Hill criterion, von Mises) **Reading**: Groenwold et al., Optimization with non-homogeneous failure criteria like Tsai-Wu for composite laminates, *Structural and Multidisciplinary Optimization*, 2006
Week 8	Composite micromechanics **Reading**: Gibson Chapter 7
Week 9	Damage in composites (matrix cracking, delamination, fiber pullout) **Reading**: Gibson Chapter 9
Week 10	Fatigue of composite materials **Reading**: Degrieck et al., Fatigue damage modeling of fiber-reinforced composite materials: Review, *Applied Mechanics Review*, 2001
Week 11	Composite design, modeling, and optimization (methods of modeling using Ansys) **Reading**: Li et al., Global convergence of splitting methods for nonconvex composite optimization, *SIAM Journal on Optimization*, 2015
Week 12	Nanocomposites (modeling, testing, examples) **Reading**: R Young et al., The mechanics of graphene nanocomposites: A review, *Composites Science and Technology*, 2012
Week 13	Project presentations
Week 14	Applications in aerospace, biomedical, sports, among other fields
Week 15	RRR

Week 16	Final Week

ABBREVIATED TRANSCRIPT TITLE (19 SPACES MAXIMUM): [ss completes]
TIE CODE: [ss completes]
GRADING: Letter
SEMESTER OFFERED: Fall and Spring
COURSES THAT WILL RESTRICT CREDIT: None
INSTRUCTORS: Gu
DURATION OF COURSE: 15 Weeks
EST. TOTAL NUMBER OF REQUIRED HRS OF STUDENT WORK PER WEEK: Varies
IS COURSE REPEATABLE FOR CREDIT? No
CROSSLIST: None