UC Berkeley Departments of Mechanical Engineering and Bioengineering
ME C176 and BIOE C119 (4 units) Fall 2010
"Orthopaedic Biomechanics"

Professor Tony M. Keaveny, 6175 Etcheverry Hall tmk@me.berkeley.edu
Office Hours: TU 8:45–10:00 AM; W 4:00-5:45 PM

Graduate Student Instructor: Arnav Sanyal arnavsanyal@berkeley.edu
Office Hours: TU 3:30-5:00 PM; W 2:30–4:00 PM; Hesse Hall Rm. 136

URL: bspace.berkeley.edu

Prerequisites: ME C85 (or CEE C30) or BIOE 102 (concurrent enrollment acceptable); or equivalent.

Working knowledge of MATLAB is required. Prior knowledge of biology or anatomy is not assumed. Open for undergraduates and graduates.

Lectures: TU TH 11:00–12:30 PM; 3107 Etcheverry Hall.

Discussion: M 04:00–05:00 PM,
TU 12:30-01:30 PM,
W 12:00–01:00 PM; 2105 Etcheverry Hall.

Computer Lab: 2105 Etcheverry Hall.

Textbook: Bartel DL, Davy DT, and Keaveny TM: *"Orthopaedic Biomechanics: Mechanics and Design in Musculoskeletal Systems"* Pearson Prentice Hall, New Jersey, 2006.

CC # (lec): ME: 55706; BIO ENG: 06615

COURSE DESCRIPTION

From a biomechanical perspective, the healthy human skeleton is an optimal structure that has adapted its form in response to its function. Studying the mechanics of the skeleton therefore provides information that can be used not only to design artificial prostheses and materials — and thus address specific health care issues — but also to aid in the design of more traditional engineering structures by understanding the behavior and underlying design features of this complex dynamic structure. Thus, the purpose of this course is twofold:

- develop expertise in orthopaedic biomechanics;
- enhance fundamental skills in mechanical engineering and bioengineering by analyzing the mechanical behavior of various complex biomedical problems.

Examples of engineering concepts that will be used include statics, dynamics, optimization theory, composite beam theory, beam-on-elastic-foundation theory, Hertz contact theory, and materials behavior. The course has three main themes: Skeletal Forces and Motion; Tissue and Organ Mechanics; and Implant Design and Analysis. Specific biomechanics topics will include loads on human joints; dynamic analysis of human motion; mechanical properties of musculoskeletal tissues including bone, cartilage, tendon, ligament, and muscle; osteoporosis fracture-risk prediction of bones; composition and mechanical behavior of orthopaedic biomaterials; and design/analysis of artificial joint, spine, and fracture fixation prostheses. Students will be challenged with a MATLAB-based course project to integrate the course material in an attempt to gain insight into contemporary design/analysis problems, which will be prefaced by simpler MATLAB-based and analytical biomechanics assignments.

The course is ideal for students interested in biomechanical engineering, those wishing to further develop technical skills in design and analysis of mechanical systems, and those interested in addressing contemporary engineering design and analysis problems directly related to human healthcare.

DATE	LECTURE TOPIC	MATLAB	READING*
Skeletal Forces and Motion			
Aug. 26	Introduction; basic anatomy		2–21
Aug. 31	Static analysis of skeletal systems I		23–35
Sep. 2	Static analysis of skeletal systems II		
Sep. 7	The force distribution problem		35–44
Sep. 9	Kinematics and dynamics I		44–58
Sep. 14	Kinematics and dynamics II		64–65
Sep. 16	Joint stability	**MTLB 1 (due 9/30)**	58–64
Tissue and Organ Mechanics			
Sep. 21	Viscoelasticity I		154–163
Sep. 23	Viscoelasticity II		
Sep. 28	Tissue mechanics I		71–116
Sep. 30	Tissue mechanics II		121–147
Oct. 5	Muscle mechanics		147–153; 163–164
Oct. 7	**MID-TERM EXAM** *(all course material through Sep 30; closed-book)*		
Oct. 12	Composite beam theory (Symmetric beams)		168–176
Oct. 14	Composite beam theory (Unsymmetrical beams)	**MTLB 2 (due 10/28)**	177–182
Oct. 19	Case studies: whole bone mechanics		183–198
Oct. 21	Impact biomechanics		
Implant Design and Analysis			
Oct. 26	Orthopaedic implants: materials		235–245
Oct. 28	Orthopaedic implants: design principles		245–259
Nov. 2	Beam-on-elastic-foundation theory I		203–213
Nov. 4	Beam-on-elastic-foundation theory II	**Final Project Part A (due 11/18)**	304–310
Nov. 9	Contact stresses		223–231; 335–349
Nov. 11	VETERANS HOLIDAY		
Nov. 16	Design of knee prostheses		314–332
Nov. 18	Project discussion	**Final Project Part B (due 12/02)**	
Nov. 23	Design of hip prostheses		290–304; 310
Nov. 25	THANKSGIVING HOLIDAY		
Nov. 30	Design of spine and fracture fixation prostheses		261–287
Dec. 2	Translational issues; closure		
Dec. 15	FINAL EXAM, 8:00–11:00 AM, Location TBA *(all course material; closed-book)*		

** Reading assignments refer to the course textbook. Please do reading **in advance** of class. Check the course website regularly for weekly homeworks and any other assignments or announcements. Late homeworks or projects will not be accepted without prior approval from Professor Keaveny. Topic of Final Project is same for all students.*

Grading:	Weekly homeworks	5%
	Matlab assignments (2 + course project)	30% (2.5+7.5+20.0)
	Mid-term exam	25%
	Final exam	40%