ENG ME 521/BE 521 Continuum Mechanics for Biomedical Engineers

2008-2009 Catalog Data:

ENG ME 521/BE 521 Continuum Mechanics for Biomedical Engineers Prereq: ENG ME 309 or ENG ME 424 and either ENG ME 304, ENG ME 421, ENG ME 422, ENG BE 420, ENG BE 436, or consent of instructor. The main goal of this course is to present a unified, mathematically rigorous approach to two classical branches of mechanics: the mechanics of fluids and the mechanics of solids. Topics will include kinematics, stress analysis, balance laws (mass, momentum, and energy), the entropy inequality, and constitutive equations in the framework of Cartesian vectors and tensors. Emphasis will be placed on mechanical principles that apply to all materials by using the unifying mathematical framework of Cartesian vectors and tensors. Illustrative examples from biology and physiology will be used to describe basic concepts in continuum mechanics. The course will end at the point from which specialized courses devoted to problems in fluid mechanics (e.g., biotransport) and solid mechanics (e.g., cellular biomechanics) could logically proceed; students may not receive credit for both. 4 cr.

Class/Lab Schedule: 4 lecture hours per week

Status in the Curriculum: Elective

Textbook(s) and/or Other Required Material: Holzapfel, Nonlinear Solid Mechanics. Aris, Vectors, Tensors, and the Basic Equations of Fluid Mechanics (recommended).

Coordinator: Paul Barbone, Associate Professor, Mechanical Engineering

Prerequisites by topic:
1. Graduate standing, undergraduate mechanics.

Goals:
Students learn mechanics of continua, and gain a systematic approach to modeling mechanics of continua.

Course Learning Outcomes:

As an outcome of completing this course, students will:

i. Become proficient with indicial notation and master manipulation of Cartesian vector and tensor equations.
ii. Understand tensorial strain and stress measures.
iii. Understand Eulerian and Lagrangian descriptions of kinematic quantities.
iv. Know how to systematically formulate constitutive equations for fluid and/or solid continua.
v. Gain facility to solve simple elementary field problems in continuum mechanics.

Course Learning Outcomes mapped to Program Outcomes:

Program:	A	B	C	D	E	F	G	H	I	J	K	L	M	N
Course:	i-v				i-v				iv	iv	i-v			
Emphasis:	5	1	1	1	5	1	1	1	4	4	5	1	1	1

Topics (time spent in weeks):
1. Cartesian vectors and tensors: algebra of vectors and tensors (index notation, products, calculus of vectors and tensors). (1.5)
2. Kinematics of deformation and motion: deformation gradient, stretch, strain, rotation, shear, rigid motion, local and global length, area and volume changes, principal strains and principal directions, strain deviators, material and spatial time derivatives, flow-lines, stretching, vorticity, transport theorems, circulation. (4)
3. Stress analysis: surface and body forces, traction and stress (Cauchy theorems, normal and shear stress, hydrostatic and deviatoric stress, principal stresses, Piola-Kirchhoff stress). (2.5)
4. Field equations: conservation of mass, balance of linear and angular momenta, balance of energy, principle of virtual work, entropy inequality. Some of these concepts will be illustrated through examples (e.g. stress distribution in solids due to gravity, hydrostatic stress distribution in fluids, etc.). (2)
5. Constitutive equations: basic principles (determinism, local action, material frame indifference); material symmetry (isotropy); Hookean solids and Newtonian fluids. (3)

Contribution of Course to Meeting the Professional Component:
Engineering topics: 100%

Status of Continuous Improvement Review of this Course:
Prepared by: Paul Barbone **Date**: June 9, 2009