Engineering Faculty Document No. 45-06

TO: The Engineering Faculty

FROM: The Faculty of the School of Mechanical Engineering

DATE: March 29, 2007

RE: New Course Approval ME 612 Continuum Mechanics

The Faculty of the School of Mechanical Engineering has approved the following course for a permanent course number. This action is now submitted to the Engineering Faculty with a recommendation for approval.

ME 612 Continuum Mechanics, Sem. 1. Class 3, cr. 3. Prerequisites: Graduate standing.

A unified and exact mathematical treatment of the mechanics of solids and fluids. Cartesian tensor algebra and calculus; stress tensor, principle stresses and invariants; material and spatial coordinates, deformation gradient, strain and stretch tensors; balance of mass, momentum, and energy; constitutive equations of elasticity, hyperelasticity, viscous fluids and viscoelasticity.

Reason: This course deals with advanced topics in Continuum Mechanics, specifically in the areas of cartesian tensors, kinematics, balance laws, and constitutive equations and their applications. The course has been offered three times with enrollments of 17 students in fall 2004, 7 students in fall 2005, 12 students in fall 2006.

Details of the course are provided in the attached course map and description.

James D. Jones
Associate Professor and Associate Head
School of Mechanical Engineering

ME 612
CONTINUUM MECHANICS

Course Outcomes

1. Learn the *unified and exact mathematical basis* as well as the *general principles* of stress and deformation in solids and fluids.
2. Extend and generalize the understanding of *two-dimensional elasticity theory*.
3. Prepare the student for advanced studies in *viscoelasticity*, *viscous fluids*, *fracture mechanics* and *plasticity*.

Cartesian Tensors (4.5 wks)

1. Review of matrix concepts
2. Index notation, Kronecker delta and permutation symbol
3. Vector transformation
4. Cartesian tensors
5. Inner and outer products
6. Special properties of 2^{nd} order tensors
7. Algebra of dyads and polyads
8. Tensor calculus
9. Gradient, divergence and curl

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Kinematics (3.5 wks)

1. Small strain and rotation in 2-D
2. Material and spatial coordinates; displacement, velocity and acceleration fields
3. Deformation gradient tensor
4. Green and Almansi strain tensors
5. Geometrical interpretation of strain tensors
6. Polar decomposition and stretch tensors
7. Principal stretches

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Balance Laws (3 wks)

1. Body forces, surface forces and stress components
2. Cauchy tetrahedron, symmetry of stress tensor
3. Conservation of mass
4. Conservation of linear and angular momenta
5. Cauchy's equation of motion, Piola stresses
6. Balance of mechanical energy and thermal effects

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Constitutive Equations and Applications (4 wks)

1. Elasticity
2. Anisotropy: orthotropic, transversely isotropic, and isotropic behaviors
3. Frictionless and linearly viscous fluids
4. Plane elasticity in rectangular coordinates
5. Airy stress function
6. Polynomial solutions

COURSE NUMBER: ME 612 **COURSE TITLE:** Continuum Mechanics

REQUIRED COURSE OR ELECTIVE COURSE: Elective

TERMS OFFERED: Fall (Alternate Years)

TEXTBOOK/REQUIRED MATERIAL: L.E. Malvern, *Introduction to the Mechanics of a Continuum Medium*, Prentice-Hall, 1969.

PRE-REQUISITIES: Graduate Standing

COORDINATING FACULTY: G. Subbarayan

COURSE DESCRIPTION: A unified and exact mathematical treatment of the mechanics of solids and fluids. Cartesian tensor algebra and calculus; material and spatial coordinates, deformation gradient, strain and stretch tensors; stress tensor, Cauchy tetrahedron, principle stresses and invariants; balance of mass, momentum, and energy; constitutive equations of hyperelasticity, viscous fluids and viscoelasticity.

COURSE OUTCOMES:

1. Learn the *unified and exact mathematical basis* as well as the *general principles* of stress and deformation in solids and fluids.
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ASSESSMENTS TOOLS:

1. Weekly deliverables.
2. Two projects.
3. Two one-hour exams.
4. One comprehensive final exam.

RELATED ME PROGRAM OUTCOMES: N/A

PROFESSIONAL COMPONENT:

1. Engineering Topics: Engineering Science – 3.0 credits (100%)

NATURE OF DESIGN CONTENT: N/A

COMPUTER USAGE: Students are required to carryout symbolic calculations as part of project using either matlab or mathematica.

COURSE STRUCTURE/SCHEDULE:

1. Lecture – 3 days per week at 50 minutes.

PREPARED BY: G. Subbarayan **REVISION DATE:** April 17, 2007