TO: The Engineering Faculty

FROM: The Faculty of the School of Mechanical Engineering

DATE: July 22, 2003

RE: New Course Approval ME 517/ChE 517 Micro/Nanoscale Physical Process

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 517 **Micro/Nanoscale Physical Processes** (ChE 517) Sem. 2. Class 3, cr. 3. Prerequisite: ME 315, or consent of instructor.

Study of physical processes encountered in small scale systems like Micro-Electromechanical Systems (MEMS) and nanotechnology. Introduction of tools for micron to molecular scale analysis of statics, dynamics, electricity and magnetism, surface phenomena, fluid dynamics, heat transfer, and mass transfer. Quantitative analysis of specific MEMS devices using finite element analysis.

Reason: This course provides a fundamental foundation for students wanting to learn how to analyze physical phenomena that occurs in micro/nanoscale devices. With the growing emphasis in MEMS, this is an essential course to foster continued interest in this emerging area.

The course, with a temporary number ME 597, has been offered three times as a co-listed course with the School of Chemical Engineering. Enrollment in the course was 43 students in spring 2001, 28 students in spring 2002, and 20 students in spring 2003, with roughly 50% Mechanical Engineering students and 25% Chemical Engineering students, graduate and senior undergraduates.

Details of the course are provided below in the one page course map and ABET document.

E. Daniel Hirleman, Head
School of Mechanical Engineering

ME 517 Micro/Nanoscale Physical Processes (ChE 517)
Spring Semester

Proposed Course Desc.: ME 517 Micro/Nanoscale Physical Processes (ChE 517) Sem. 2. Class 3, cr. 3. Prerequisite: ME 315 or consent of instructor.

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Textbook:

1. *Fundamentals of Microfabrication*, MJ Madou, CRC Press, 1997. ISBN 0849394511.
2. *Schaum's Outline of Finite Element Analysis*, GR Buchanan, McGraw-Hill, 1995. ISBN 0070087148.

Reference:

1. *An Introduction to Microelectromechanical Systems Engineering*, Nadim Maluf, Artech House, 1999. ISBN 0890065810
2. *Micromechanics and MEMS: Classic and Seminal Papers to 1990*, W. Trimmer, IEEE, 1997. ISBN 0780310853.
3. *Micromachined Transducer Sourcebook*, GTA Kovacs, WCB/McGraw-Hill, 1998. ISBN 0072907223.
4. *Finite Element Analysis: Theory and Application with ANSYS*, S. Moaveni, Prentice Hall 1999. ISBN 0137850980.

Coordinator: Steve Wereley, Assistant Professor of M.E. **Prepared:** July 2003

Prerequisites by Topic: The student should be of advanced undergraduate or graduate standing. The student should have had experience at the undergraduate level with the following topics: statics, dynamics, electricity and magnetism, surface phenomena, fluid dynamics, heat transfer, and mass transfer.

Computer Usage: The students will need to use ANSYS to perform some of the computations necessary for the course. Matlab experience would be helpful but not necessary.

Laboratory Projects: No lab projects

Nature of the Design Content:
The design component of this course will consist of students designing a microscale system to meet a particular need. The students will solve several of these design problems as part of the regular course homework.

Assessment Methods: Grades will be based on a mid-term (15%), final (20%) and homework assignments (65%).

Category content as estimated by faculty member who prepared this course description:
Engineering Science: 2.4 credit or 80%
Engineering Design: 0.6 credit or 20%.

ME 517/CHE 517
Micro/Nanoscale Physical Processes

Course Objectives

1. To study physical processes in *micro/nanoscale systems*.
2. To determine *when to expect those processes to behave differently* than at macroscopic length scales.
3. To learn *how* and *when to use these behavior differences* to accomplish tasks at microscopic length scales.
4. To learn how to use *analysis tools* (ANSYS, Matlab) to study these systems and predict their behavior.

Introduction (2 weeks)

1. What is MEMS?
2. Why MEMS? Scaling laws.
3. Fundamentals of microfabrication;
   i. wet bulk micromachining

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Mechanics and Dynamics (2.5 weeks)

1. Steady state deformation of cantilevers and membranes
2. Dynamical behavior of cantilevers and membranes
3. Introduction to ANSYS
4. Applications: ANSYS analysis of atomic force microscopy and pressure sensing

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Electricity and Magnetism (3.5 weeks)

1. Maxwell's Equations
2. Applications: electrophoresis, electrostatic force transduction, and magnetic force

Heat and Mass Transfer (2.5 weeks)

1. Fourier's Law
2. Fick's Law
3. Convection
4. Applications: LIGA heat exchangers, magnetic

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Surface Phenomena (1.5 weeks)

1. Surface Tension/Adhesion
2. Surface forces: DLVO, hydration, hydrophobic
3. Applications: Electrosmosis, thermocapillarity, electrowetting

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Fluidics (3 weeks)

1. Low Reynolds number hydrodynamics: flow through a rectangular pipe
2. Nonlinear Phenomena: acoustical streaming
3. Applications: Electrohydrodynamics/ magnetohydrodynamics