

## Mechanical Engineering and Mechanics

# MEM 419/800 Microfluidics and Lab-on-a-Chip

Winter 2007

**Designation:** Elective

**Catalog Description:** Covers fundamentals and applications of microfluidic phenomena such as electrokinetic and electrohydrodynamic motion of fluids and particles in microchannels, surface energy-driven flow, and chromatographic separation, and review microfluidic devices such as microvalves, micropumps, and lab-on-a-chip systems.

**Prerequisite:** MEM 417/800 Introduction to Microfabrication

**Textbook:** *Fundamentals of Microfabrication*, Marc Madou, CRC Press, 2<sup>nd</sup> edition.  
*Fundamentals and Applications of Microfluidics*, Nam-Trung Nguyen  
Artech House (Reference)

**Objectives:**

1. Explain the microchannel flow and compare it with macroscale flow. Describe how the characteristics of microchannel flow can be advantages and disadvantages in the microfluidic applications.
2. Describe DC and AC electrokinetics and electrohydrodynamic phenomena. Explain how those phenomena can be used in microfluidic devices and lab-on-a-chip systems.
3. Explain the effect of surface energy on the fluid flow in microchannels. Describe chromatographic separation mechanisms using microchannels.
4. Classify microvalves and micropumps and describe the working principles.
5. List the sample preparation and detection methods used in lab-on-a-chip systems and explain the working principles and applications.
6. Design a microfluidic device or a lab-on-a-chip system, and the microfabrication process flow as term project.

**Topics:**

1. Introduction to Microfluidics and Lab-on-a-Chip
2. Microchannel flow and its characterization
3. Lab#1 (Microchannel flow, surface tension driven flow, and DC electrokinetics)
4. Electrokinetics and electrohydrodynamics in microchannels
5. Surface and separation sciences in microchannels
6. Lab#2 (AC electrokinetics and electrohydrodynamics)
7. Sample preparation and detection for lab-on-a-chip
8. Microvalves and micropumps
9. Lab#3 (Microvalve and micropump)
10. roject presentation

**Class Schedule:** 3 hours/week lecture (3 credits); 3 laboratory classes

**Contribution to Professional Component:**

Prepares students as microsystem engineers who can do design, fabrication, and testing of MEMS and microfluidic devices.

**RELATION TO ABET CRITERIA 3 OUTCOMES:**

0 = No content; 1 = Some content; 2 = Significant content

<b>Outcomes a – k</b>	<b>Content</b>	<b>Explanation</b>	<b>Evidence</b>
a. An ability to apply knowledge of mathematics, science and engineering	2	This course requires the students to apply engineering principles such as fluid mechanics, electrokinetics, and surface science to microfluidic phenomena and the design of microfluidic devices.	Lecture notes, Homework, Lab report, Project report, Final exam
b. An ability to design and conduct experiments as well as to analyze and interpret data	1	The students learn to analyze and interpret experimental results through lab classes.	Lab report
c. An ability to design a system, component or process to meet desired needs	2	The students learn to design microfluidic devices and lab-on-a-chip systems as well as their fabrication processes.	Lecture notes, Homework
d. An ability to function on multidisciplinary teams	1	Students from different departments learn to function as a team through term project.	Project report, Presentation
e. An ability to identify, formulate and solve engineering problems	1	The problems in homework and exam, and the term project require students to identify and solve engineering problems in microfluidic device design.	Homework, Final exam, Project report
f. An understanding of professional and ethical responsibility	0	N/A	
g. An ability to communicate effectively	2	The students learn communication skills through oral and written presentation of their term projects.	Project report, Presentation
h. The broad education necessary to understand the impact of engineering solutions in a global/societal context	1	The impact of lab-on-a chip device on the society is discussed.	Classroom discussion
i. A recognition of the need for and an ability to engage in lifelong learning	1	The need for lifelong learning of new technologies is emphasized.	Classroom discussion
j. A knowledge of contemporary issues	0	N/A	
k. An ability to use the techniques, skills and modern engineering tools necessary for engineering practice	2	The students are required to participate in three lab sessions in which they will have hands-on experience on microfab. and characterization tools.	Lab report

**Prepared by:**

Dr. Hongseok (Moses) Noh, 15 November 2006