University of Connecticut
Department of Chemical, Materials, and Biomolecular Engineering
Principles and Applications of Microfluidic Devices

GENERAL INFORMATION

Course Number	CHEG 4995-001 (undergraduate) CHEG 5395-001 (graduate) BME 4985-002 Special Topics in BME (undergraduate) BME 6086-006 Special Topics in Biomed Engr (graduate)
Instructor	Leslie M. Shor, Ph.D. Office: Room 209 Engineering II Phone: 860-486-3136 E-mail: Leslie.Shor@uconn.edu
Class Meeting	Tues 6-8:30 PM ITE 125
Office Hours	Thurs 2-3 PM and by appointment.
Course Credit	3 Semester Hours
Required Texts	Brian J. Kirby. 2010. Micro- and Nanoscale Fluid Mechanics: Transport in Microfluidic Devices, Cambridge University Press. Journal articles and other readings posted on HuskyCT
Reference Texts	Nam-Trung Nguyen and Steven T. Werely. 2006. Fundamentals and Applications of Microfluidics, 2nd Ed. Artech House, Inc. Marc J. Madou. 2002. Fundamentals of Microfabrication: The Science of Miniaturization, 2nd Ed. CRC Press. Sergey Edward Lyshevski. 2005. Nano- and Micro-Electromechanical Systems: Fundamentals of Nano- and Microengineering, 2nd Ed. CRC Press.
Pre-Requisites	Physics, Chemistry, Differential Equations Recommended Preparation: Fluid Mechanics, Microbiology

Summary This course highlights the power of miniaturization to understand, mimic and control fundamental physical, chemical, and biological processes. Students will be introduced to key physical, chemical, and biological phenomena occurring at the micron scale. Specific topics include design principles and scaling laws; micron-scale fluid mechanics; diffusion, dispersion, and mixing; electrostatics, dynamics and potential flow; surface and interfacial chemistry; colloid transport and particle separations. Next, students will learn principles current microfabrication techniques. Finally, the later portion of this course will be devoted to applications of microfluidic device technology, especially in the environmental and biomedical sectors. Student groups will have the opportunity to design, build, and test a microfluidic device to meet a specific application. This interdisciplinary course is recommended for interested students majoring in all fields of physical sciences and engineering.

Objectives **(i) Theory and Simulation:** Students will better understand the unique physical, chemical, and biological phenomena occurring at the micron scale. Students will learn to apply the major governing equations of micro-scale physics and chemistry, and will be introduced to the computer modeling package COMSOL to simulate transport phenomena in micro-scale geometries.

(ii) Techniques: Students will learn state-of-the-art microfabrication techniques for producing microfluidic devices and bio-Micro-Electro-Mechanical-Systems (Bio-MEMS). Knowledge of microfabrication techniques will enable students to better appreciate the possibilities and limitations of miniaturized engineered systems.

(iii) Applications: Student groups will review the technical literature on microfluidic devices used in a specific area of applied science or engineering. Students will understand how to conduct research using the primary literature, and critically review research papers. Student groups will design, build, and test their own microfluidic device. Students will judge for themselves the potential for microfluidic devices to continue to drive research and innovation in diverse fields of science and engineering.

COURSE POLICIES

Conduct Students are responsible for adherence to the University of Connecticut student code of conduct. http://www.dosa.uconn.edu/student_code.html

Academic dishonesty will not be tolerated. Acts of academic dishonesty include plagiarizing; failing to cite published work; providing or receiving unauthorized assistance on papers, projects, and examinations; and presenting the same or substantially the same work in two or more courses without the explicit permission of the instructors involved. A student who knowingly assists another student in committing an act of academic misconduct shall be equally accountable.

Absences Students involved in official University activities that conflict with class time must inform the instructor in writing prior to the anticipated absence and take the initiative to make up missed work in a timely fashion.

Students anticipating conflicts arising from religious observances should inform their instructor in writing within the first three weeks of the semester, and prior to the anticipated absence, and should take the initiative to work out with the instructor a schedule for making up missed work.

HuskyCT Course readings, lecture notes, assignments, solutions, and grades can be accessed throughout the semester on HuskyCT. Students are responsible for checking the course site frequently and complying with instructions. http://huskyct.uconn.edu

GRADING

Participation Attendance and participation is required. Students are expected to complete assigned material before class and to provide thoughtful, constructive contributions to class discussions. Class participation will constitute **5%** of the final grade.

Homework Completing homework is essential to understanding the material. Homework will not be graded, but solutions will be posted. Quizzes and the mid-term will closely follow the homework.

Quizzes Announced quizzes will be given throughout the semester. The goal of quizzes is to test comprehension of material covered in class and assigned as homework. Quizzes will count for **15%** of the total grade. All quizzes are OPEN book, open notes, open homework. The lowest quiz score will be dropped.

Mid-term There will be two exams together worth **30%** of the total grade.

Paper Pres. Current applications of microfluidic devices will be drawn directly from the primary research literature. Graduate students will select an article in consultation with the instructor, present the paper in class, and lead an in-class discussion. All students will be required to read every paper, participate in discussions, and evaluate the presenters. This portion of the course is worth **15%.** For graduate students, the grade will be based on paper presentation, leading class discussion, participation and peer evaluation. Undergraduates will be graded on participation and peer evaluation.

Project The course will culminate with a design project employing a **novel** microfluidic approach to solve a **specific engineering problem**. The project is worth **35%.** Teams of 3 or 4 students will form groups and identify a topic based on the suggested list or their own research interests. Early in the semester, a preliminary presentation is due where the group will present the research question the device is intended to answer, along with current microfluidics-related research in the area, and their own preliminary design ideas. Throughout the semester, periodic labs will occur covering topics including COMSOL simulation, technical drawing, photolithography, and micro-fabrication methods. After each lab, interim deliverables will be due, including (i) design calculations or simulations, (ii) technical drawings, (ii) prototype device. In the last weeks of the semester, student groups will deliver an oral presentation of at least 30 minutes describing the engineering problem, the chosen microfluidic solution, and the results. Groups will determine individual roles and allocation of work within the group. Students will complete evaluations of other groups, of the other members of their own group, and of themselves. Grades will be based on initial presentation, three interim deliverables, final presentation, and evaluations.

COURSE CALENDAR (Draft and subject to change)

Date	Topic	Work due
25-Jan	Course Structure & Objectives Overview, Fluid properties, Introductions	Intro Slide
1-Feb	Cancelled (Snow)	
8-Feb	Theory: Conservation, boundaries Techniques: Lithography Applications: Introduction of Project topics	Kirby Ch 0, 1
15-Feb	Theory: Micro-scale Pressure-driven Flow Applications: Cell Culture & Microcosms **Technique: COMSOL Lab**	Kirby Ch 2, **Quiz 1** Paper Pres 1-3
22-Feb	Theory: Diffusion, Dispersion & Mixing **Applications: In-class Presentations** **Technique: AutoCad Lab**	Kirby Ch 4, **Quiz 2** *Prelim. Presentation* *Simulation*
1-Mar	Theory: Surface & Interfacial Chemistry Techniques: Deposition & Etching Applications: Sensors **Mid-term Exam**	Kirby Ch 9, **Quiz 3** *Drawing* Paper Pres 4-6
8-Mar	Spring Break (No Class)	
15-Mar	Theory: Particle Transport Applications: Cell Scaffolds & Fuel Cells	Kirby 10, 11, **Quiz 4** Paper Pres 7-8
22-Mar	Theory: Multiphase Flow Applications: Cell Transport & Electrophoresis	Kirby 11, **Quiz 5** Paper Pres 9-10
29-Mar	Scheduled Throughout the Week: **Lithography Lab** **Fabrication Lab**	*Prototype*
5-Apr	**Group Final Presentations** Applications: Multiphase Systems	***Groups 1,2*** Paper Pres 11-12
12-Apr	**Group Final Presentations**	***Groups 3,4***
26-Apr	**Group Final Presentations**	***Groups 5,6***