Fall 2016

MECH 410R - MICROFLUIDICS

Instructor:	Professor Gwynn Elfring		
Lectures:	Tue Thu	9:30-11:00am	MCML 256
Office hours:	*After class*		ICCS 181
Course page:	*Connect*		
Tutorial:	Wed	1:00pm-2:00pm	MCML 254

Academic prerequisites: MECH 380

Synopsis:
The dynamics of fluid flows that are slow, and whose scales are small, are much different than those in flows that we are more familiar with from everyday experience. At smaller scales inertia is much less important because surface forces tend to dominate. Microfluidics is the study of scaling down complex fluid processes — think of scaling a factory or a laboratory down to fit on a small chip — so that we can do things more efficiently. In this class we will learn the fundamentals of slow fluid flows so as to be able to understand the advantages and disadvantages of scaling down fluid processes. For example, without inertia, fluid dynamics are substantially simplified (no turbulence) but this can also make it quite hard to mix fluids. These concepts are particularly important in understanding biological behaviour at the very small scale of cells. In this class we also introduce important small-scale biological fluid dynamics (biological microfluidics) such as the flow of blood and the motility of bacteria.

Course Goals:
To develop a functional understanding of the physics in fluids at small scales which are leveraged by microfluidic technologies and are prevalent in biology.

Textbook: None is required the following are good references

- Kirby Micro- and Nanoscale Fluid Mechanics: Transport in Microfluidic Devices, *Cambridge University Press.*
- Tabeling, Introduction to Microfluidics, *Oxford*.
- Bruus, Theoretical Microfluidics, *Oxford*.
- Probstein, Physicochemical Hydrodynamics. *Wiley-Interscience.*
- de Gennes, Brochard-Wyart and Quere, Capillarity and Wetting Phenomena: Drops, Bubbles, Pearls, Waves, *Springer.*
- Barthès-Biesel, Microhydrodynamics and Complex Fluids, *CRC Press*.
- Guazzeli and Morris, A Physical Introduction to Suspension Dynamics, *Cambridge University Press.*

Course Evaluation (tentative):

1. Midterm Exam (20% of course grade);
2. Final Exam (50% of course grade);
3. Research project (30% of the grade);

The project is to be chosen by the student, in collaboration with the instructor, to reflect the students interests while utilizing subject matter from the course for background. The goal is learn how to scan recent research literature then how to read a technical paper, synthesize the relevant content and finally how to present it to the class at an appropriate level. A 10 page (maximum) report and a 20 min presentation are required deliverables.

Course topics:

[1] Introduction	What is microfluidics? Introduction to physics at small scales.
[2] Fluid Mechanics	Scaling principles and dimensional analysis. Low Reynolds number hydrodynamics. Network flows.
[3] Complex fluids	An introduction to the behaviour of biological fluids.
[4] Capillarity	Boundary conditions on flows with fluid/fluid interfaces. Capillary flow
[5] Scalar Transport	Diffusion, random walks, the advection-diffusion equation; mixing and separation; surfactants.
[6] Electrokinetics	Review of electrostatics; the electric double-layer; electroosmosis and electrophoresis.
[7] Microrheology	An introduction to passive and active microrheology.
[8] Lab on a chip	Experimental techniques, chip fabrication, flow visualization.

Course timeline:

[1] Tuesday, September 6	First day of classes
[2] Tuesday, October 25	Midterm
[3] Thursday, November 24	Research projects due
[4] Tuesday, November 29	Research presentations 1
[5] Thursday, December 1	Research presentations 2, last day of classes

Course policy:

(a) Answer only will not receive full credit. You must justify clearly all requisite steps required to obtain an answer. You should think of it as trying to demonstrate to the marker how you solve the problem.

(b) **All exams are no notes, no books and no calculators**. This may seem bizarre, but you won't need them. The solution to the midterm exams will be posted on the class website, and the graded midterms will be available in class the following week.

(c) **Plagiarism and cheating will not be allowed**. We will follow UBC's policy on academic dishonesty as presented in the UBC catalog. Do not cheat.

(d) **Re-grading of midterm exams**: Graded midterm exams will be available for pickup during instructor office hours. All regrading requests have to be made in writing and attached to the exam. Once you leave with the exam, no regrading will be accepted.