Syllabus

Course Administration

Lecturer	**Graduate Assistant**
Prof. Issam Lakkis	xxx
Office: FEA Bechtel 410 *Tel:* x–3636	
E-mail: `issam.lakkis@aub.edu.lb`	`xxx@aub.edu.lb`

Office hours: MW 3:30 PM – 5:00 PM
Lectures: MW 2:00 – 3:15 PM
Bechtel 537

Catalog Description

Theory and applications of micro flows. The continuum hypothesis and the various flow regimes. Shear and pressure driven micro flows. Electro-kinetically driven liquid micro flows. Compressibility effects of micro flow of gases. Particulate flows in Bio-applications. Modeling techniques. Hybrid continuum-molecular methods. Reduced order modeling of micro flows in multi-physics micro flow applications. Case studies in BioMEMS. 3 credits. Prerequisites: MECH 310, MECH 411, MECH 412.

Educational objectives

The objectives of this course are to

1. expose the student to state of the art engineering applications in micro flows.
2. to provide a thorough understanding of the various effects encountered in micro flow dynamics.
3. to explore efficient modeling techniques of micro flows in multi-disciplinary engineering applications.
4. prepare the student for further studies/research in microfluidics and related areas.

Textbook

The suggested text is *Microflows and Nanoflows: Fundamentals and Simulation* by George Karniadakis, Ali Beskok, and Narayan Aluru. Springer; 1st edition (July 5, 2005).

Problem sets, projects, exams and grading

The final grade in the course will be based upon analytical homework assignments, a midterm, a project, and class performance weighted as follows:

- 15 % Homework assignments: Problem Sets will be assigned at two weeks intervals and collected at the end of the lecture on the due date. Note that some of the problems assigned will be complementary to the material presented in class. The final problem set will not be collected.
- 40 % Project.
- 40 % Midterm: will be given in class.
- 5 % Class performance: The performance will be evaluated according to the individual's contribution to the discussion.

Approach

The course will be presented as a series of lectures accompanied by visual aids (when available). Reading material is assigned when necessary from reference books and/or publications. Each team of students will be asked to give a presentation on their project.

Course outline

1. Continuum Viewpoint and flow regimes in MEMS (1 week)
2. Governing equations and slip models (1 week)
3. Shear-driven and separated micro flows (1 week)
4. Pressure-driven micro flows (2 week)
5. Thermal effects in micro scales (1 week)
6. Navier-Stokes Equation and Viscous Flow (1 week)
7. Micro gas flow applications (1 week)

8. Electrokinetically driven liquid micro flows (1 week)
9. Numerical methods for continuum simulations (1 week)
10. Numerical methods for atomistic simulations (1 week)
11. Micro flow applications in MEMS (3 week)

References

1. *Introduction to Microfluidics* by Patrick Tabeling, Suelin Chen. Oxford University Press, USA (February 2, 2006)
2. *Physicochemical Hydrodynamics* by Probstein, R. F. (1994). Wiley and Sons Inc, New York.
3. *Molecular Modeling and Simulation* by Schlick, T. (2006). Springer.
4. *Fundamentals and Applications of Microfluidics* by Nguyen, N.-T. and Wereley, S. T. (2002). Artech House.
5. *Microhydrodynamics: Principles and Selected Applications* by Sangtae Kim , Seppo J. Karrila. Dover Publications (June 17, 2005)
6. *Handbook of MEMS* Gad-El Haq (editor), M. (2001). CRC Press.
7. *Microsystem Design* by Senturia, S. D. (2001). Kluwer Academic Publishers.