MATH 559: Mathematical Modeling of Complex Fluids

Instructor:

Dr. James J. Feng Office: MATX 1206
Phone: 604-822-4936 Email: james.feng@ubc.ca
(Office hour by appointment; please email.)

Reference books:

- R. G. Larson, The Structure and Rheology of Complex Fluids, Oxford (1999).
- R. B. Bird, R. C. Armstrong, O. Hassager, Dynamics of Polymeric Liquids, Vols. 1 & 2, Wiley and Sons (1987).
- P. G. deGennes and J. Prost, The Physics of Liquid Crystals, Clarendon (1993).
- D. Barthes-Biesel, Microhydrodynamics and Compex Fluids, Taylor & Francis (2012).
- M. Doi and S. F. Edwards, The Theory of Polymer Dynamics, Oxford (1988).

Course outline:

This course will give students an overview of Non-Newtonian Fluid Dynamics, and discuss two approaches to building constitutive models for complex fluids: continuum modeling and kinetic-microstructural modeling. In addition, it will provide an introduction to multiphase complex fluids and to numerical models and algorithms for computing complex fluid flows.

I. Introduction
1. Background and motivation
2. Review of required mathematics

II. Continuum theories
1. Oldroyd's theory for viscoelastic fluids
2. Ericksen-Leslie theory for liquid crystals
3. Viscoplastic theories

III. Kinetic theories
1. Dumbbell theory for polymer solutions
2. Bead-rod-chain theories
3. Doi-Edwards theory for entangled systems
4. Doi theory for liquid crystalline materials

IV. Heterogeneous/multiphase systems
1. Suspension theories (Einstein, Batchelor, Acrivos, etc.)
2. Kinetic theory for emulsions and drop dynamics
3. Energetic formalism for interfacial dynamics
4. Numerical methods for moving boundary problems

V. Applications
1. Polymer processing
2. Sedimentation and fluidization
3. Bio-materials and processes: Pattern formation and self-assembly
4. Others (gels, surfactants, colloids, Marangoni flows, etc.)

Prerequisites:

Undergraduate-level course on Partial Differential Equations (MATH 257 or MATH 400), and graduate-level course on

Fluid Mechanics (one of MATH 519, CHBE 557, MECH 502).

Evaluation:

The instructional format for the course will consist of lectures of 3 hours per week. The final grade is computed as such: 50% from cumulative marks of biweekly homework assignments, and 50% on a final presentation based on a cluster of research papers. There is no final exam.

Homework problems

To be assigned after class begins.