Syllabus for ME512: Physicochemical Hydrodynamics

Fall 2023, Mechanical Science and Engineering, University of Illinois at Urbana-Champaign
Mondays and Wednesdays during 10:00 to 11:50am in Loomis 143

Instructor: Prof. Kyle C. Smith LuMEB 3048 kcsmith@illinois.edu

Prerequisites: Graduate level introductory courses in heat transfer, mass transfer, or fluid mechanics. Students who are interested should contact me if they are unsure of whether they have sufficient background knowledge to take the course. I am happy to talk about the possibilities.

Office Hours: In-person office hours will be held during 3:30 to 4:30 pm Thursdays in LuMEB 3048.

Course Description: This course introduces basic concepts of molecular diffusion in liquids with interactions due to stationary or flowing fluid. Uncharged and charged solutions, dispersions, and suspensions of molecules, macromolecules, and particles are considered in enclosed and porous media flows. Particular emphasis is placed on analysis using the equations that govern velocity, concentration, temperature, and potential fields, flux and flow constitutive relations, driving forces, transport properties and parameters, and the relationships between them that follow from non-equilibrium thermodynamics and Onsager reciprocity. Applications are discussed in energy, environmental, chemical, biological, and electrical systems. In addition, other relevant interdisciplinary applications are covered, based on student interest.

Textbook: Assigned readings listed on the ME512 Course Schedule are primarily drawn from the required textbook for ME512:

- Probstein R.F., *Physicochemical Hydrodynamics: An Introduction*, 2nd Edition, Wiley (2005).

Excerpts from the following texts are also assigned as pre-lecture reading:

- Bird R.B., Stewart W.E., Lightfoot E.N., *Transport Phenomena*, 2nd Edition, Wiley (2006).
- Israelachvili J.N., *Intermolecular and Surface Forces*, 3rd Edition, Academic Press (2011).
- Kaviany M., *Principles of Convective Heat Transfer*, 2nd Edition, Springer (2001).
- Newman J.S., Thomas-Alyea K.E., *Electrochemical Systems*, 3rd Edition, Prentice Hall (1991).

Lectures: This course will meet twice weekly for 1 hour and 50 minutes each. Lecture sessions will be in-person in Loomis Lab 143, unless announced otherwise. Students are expected to attend in-person lectures. I will deliver most lectures in class using electronic notes on a tablet PC. While in many cases I will post those notes on the ME512 Canvas site after lecture under *Lecture Content*, students are encouraged to take notes in-person. Reading the assigned sections from the listed texts is essential preparation for lectures.

Graded Assignments: Student grades will be determined as a weighted average of the assignments listed below.

- **Seven Homeworks** will be assigned to exercise and extend course concepts (30% overall). Assignments will be listed on the ME512 Canvas site under *Homework*.
- **One Take-Home Midterm Exam** will be given to assess depth of knowledge (35% overall). Examination information will be listed on the ME512 Canvas site under *Exam*.
- **One Article Assessment** will be completed on a journal article related to course content selected by the student and approved by myself (15% overall). Students will prepare and present slides in-person on a date to be determined. Literature assessment assignment details will be listed on the ME512 Canvas site under *Article Assessment*.
- **One Course Project** will be completed individually by each student on a research topic relevant to the specific interests of the student in physicochemical hydrodynamics (20% overall). Project topics must be approved by Prof. Smith after presentation to him using a single slide during a one-on-one meeting. Projects will culminate in end-of-semester written reports. Course project details will be listed on the ME512 Canvas site under *Course Project*.