University of Hawaii at Manoa
Department of Mechanical Engineering

ME650 Surface Phenomena (3 Credits) Fall 2010

Instructor

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Course description

A surface or interface is defined as the area where two immiscible phases meet. Such surfaces include air-liquid (drops, bubbles, clouds, foams, hairspray, ice cream), liquid-liquid (emulsions, milk), air-solid (particles, aerosols, smoke), liquid-solid (slurries, sols, butter), and solid-solid (concrete, ceramics) surfaces. Behavior of these surfaces can be further complicated by the presence of surface active molecules, such as surfactants adsorbed at the surfaces. The surfaces possess many interesting characteristics distinct from the bulk phases. These properties become increasingly important as the size of a system continues to shrink, such as in microelectronics, lab-on-a-chip, cellular biomechanics, and nanotechnology. For example, on the microscale and nanoscale, gravity is less important, but van der Waals forces become dominant. The phenomena that take place at the surfaces are collectively called surface phenomena.

This course introduces the fundamental and modern concepts of surface phenomena. The course begins with the introduction of fundamental surface thermodynamics, followed by quantitative studies of capillarity and wetting phenomena, introduction of surface forces, surfactants, and particles. Each concept will be followed by practical examples structured around a series of case studies and modern applications in nanotechnology and biotechnology. By the end of this course, the students are expected to learn fundamental concepts related to colloid and surface science, and should be able to identify and solve real-world and simple research problems related to surface phenomena.

Prerequisites: ME311; Graduate and senior standing or permission of instructor.

Textbooks

- John C. Berg, *An Introduction to Interfaces and Colloids. The Bridge to Nanoscience*, World Scientific, 2010.
- Hans-Jürgen Butt, Karlheinz Graf, and Michael Kappl, *Physics and Chemistry of Interfaces*, 2^{nd} ed, Wiley, 2006.

Supplemental textbooks

- Paul C. Hiemenz, and Raj Rajagopalan, *Principles of Colloid and Surface Chemistry*, 3^{rd} ed, Taylor & Francis, 1997.
- A. Wilhelm Neumann, and Jan K. Spelt (eds) *Applied Surface Thermodynamics*, Marcel Dekker, 1996.
- Pierre-Gilles de Gennes, Francoise Brochard-Wyart, and David Quere, *Capillarity and Wetting Phenomena Drops, Bubbles, Pearls, Waves,* Springer, 2004.

Topics to be covered — **Berg** — **Butt**

- Introduction to colloids and surfaces — Ch. 1 — Ch. 1
- Advanced and surface thermodynamics — Ch. 3 — Ch. 3
    - Thermodynamics for bulk phases
    - Thermodynamics for surface phases: Gibbs adsorption equation
    - Thermodynamics for line phases
    - Simple liquid-fluid systems: Laplace's equation
    - Simple liquid-vapor-solid systems: Young's equation
- Capillarity phenomena — Ch. 2 — Ch. 2
    - Air-liquid and liquid-liquid interfaces
    - Study of menisci: capillary rise, droplet and bubbles
    - Surface tension measurements
    - Modern applications: microfluidics and MEMS
- Wetting phenomena — Ch. 4 — Ch. 7
    - Air-solid and liquid-solid interfaces
    - Contact angle phenomena: wettability, spreading, adhesion and cohesion
    - Contact angle measurements
    - Contact angle interpretation: determination of solid surface tension
    - Modern applications: superhydrophobic surfaces and electrowetting
- Intermolecular and surface forces — Ch. 7 — Ch. 6
    - van der Waals forces
    - Surface forces due to VDW interactions: the Hamaker constant
    - Surface forces other than VDW interactions: DLVO theory
    - Modern applications: atomic force microcopy (AFM), gecko adhesion
- Soluble and insoluble surfactants — Chs 3,9 — Ch. 9,12
    - Surfactant aggregations: micelles, emulsions, foams
    - Surfactant at interfaces
        - Soluble monolayers (Gibbs films)
        - Insoluble monolayers (Langmuir films)
    - Langmuir-Blodgett films
    - Modern applications: lung surfactant
- Particles*
    - Surface energetics of particles
    - Particle engulfment
    - Modern applications: nanoparticles, environmental issues of fine and ultrafine particles, particle-based drug delivery

* Only cover when time permits.

Exams and grading

- Homework and class participation — 30%
- Midterm exam — 30%
- Project with class presentation and written report — 40%