18.357 INTERFACIAL PHENOMENA

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Fall 2010
MW 2-3:30
Room 2-135

GRADING SCHEME

- 50%: 2-3 problem sets (group discussion encouraged)
- 50%: course project on subject of your choosing
  - 30% based on final paper, 20% final presentation

There is no required text for the course, which will be based on the lecture notes; however, the following are recommended supporting material.

SUGGESTED REFERENCES

Capillarity and Wetting Phenomena: Drops, Bubbles, Pearls, Waves

A readable and accessible treatment of a wide range of capillary phenomena.


A DVD with an extensive section devoted to capillary effects.
Relevant videos will be used throughout the course.
TENTATIVE COURSE OUTLINE

Lecture 1. Sept.8. Introduction
• course survey, motivation and philosophy

Lecture 2. Sept.13. Definition of surface tension
• historical development of the concept of surface tension
• molecular origins of surface tension; surface and interfacial energies

Lecture 3: Sept. 15. Theoretical formalism
• review of Navier-Stokes equations
• derivation of interfacial boundary conditions
• the scaling of surface tension: when is it important?

Lecture 4: Sept. 20. Fluid statics
• curvature pressure, minimal surfaces
• static drops and bubbles, static menisci
• Plateau bodies of revolution and rolling drops

Lecture 5: Sept. 22. Drops and bubbles
• shapes and trajectories of drops and bubbles
• impact, coalescence and non-coalescence

Lecture 6: Sept. 27. Marangoni flows I: Thermocapillary effects
• thermal/chemical convection in a fluid layer: Rayleigh-Bénard versus Marangoni
• thermocapillary drop motion

Lecture 7: Sept. 29. Marangoni flows II: Surfactants
• the role and dynamics of surface impurities
• soap films and Marangoni elasticity
Lecture 8: Oct. 4. Wetting

- fluid-solid interactions
- contact lines, contact angles, Young’s equation; contact angle hysteresis
- detergency

Lecture 9: Oct. 6. Spreading

- spreading at the surface: the dynamics of oil spills
- spreading on a solid: contact line dynamics

Columbus Day Holiday Oct. 11. NO CLASS


- Wenzel and Cassie states
- dynamic water-repellency
- water-repellency in biology

Lecture 11: Oct. 18. Capillary rise

- capillary-induced fluid motion along a tube
- wicking in a porous medium

Lecture 12: October 20. Withdrawal

- the Landau-Levich problem
- applications in coating flows

Lecture 13: Oct. 27. Fluid jets

- shapes of falling fluid jets
- the Rayleigh-Plateau instability
Lecture 14: Oct. 27. Fluid sheets
- sheet retraction and the Culick speed
- sheet instability and break up; fluid fishbones
- water bells

Lecture 15: Nov. 1. Capillary waves
- Rayleigh-Taylor instability
- Kelvin-Helmholtz instability

Lecture 16: Nov. 3. Droplet impact
- impact on a fluid surface
- impact on a rigid surface

Lecture 17: Nov. 8. The Faraday instability
- a fluid on a vertically driven oscillating substrate
- the Tibetan singing bowl

Lecture 18: Nov. 10. Microfluidics
- capillary micropumps
- capillary self-assembly

Lecture 19: Nov. 15. Biocapillarity I
- surface tension in biology
- walking on water

Lecture 20: Nov. 17. Biocapillarity II
- drinking strategies in nature
- capillary origami
- swarming patterns in birds and fish

APS Fluids Meeting Nov. 22. NO CLASS
Lecture 21: Nov. 24. Quantum capillarity I

- bouncing droplets and quantum mechanics
- the remarkable experiments of Yves Couder

Lecture 22: Nov. 29. Quantum capillarity II

- the Madelung transformation: from quantum mechanics to fluid mechanics
- towards QM in a petri dish

Lecture 23: Dec. 1. STUDENT PRESENTATIONS

Lecture 24: Dec. 6. STUDENT PRESENTATIONS

Lecture 25: Dec. 8. STUDENT PRESENTATIONS. Course Projects Due