18.357 INTERFACIAL PHENOMENA

Professor John W. M. Bush  
Office: 2-446  
Phone: 253-4387 (office)  
email: bush@math.mit.edu  
Office hours: after class, available upon request

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.*
COURSE OUTLINE

Lecture 1. Feb. 7. Introduction
• course survey, motivation and philosophy

Lecture 2. Feb. 12. Definition of surface tension
• historical development of the concept of surface tension
• molecular origins of surface tension; surface and interfacial energies
• capillary forces and Laplace pressure

• surface energies and spreading parameter
• equilibrium contact angles and Young’s Law

Lecture 4: Feb. 20. Theoretical formalism
• review of Navier-Stokes equations
• derivation of interfacial boundary conditions
• the scaling of surface tension: when is it important?

• curvature pressure, minimal surfaces
• static drops and bubbles, static menisci

• floating bodies: extending Archimedes Principle to small bodies
• Plateau bodies of revolution and rolling drops

Lecture 7: Feb. 28. Capillary rise
• statics and dynamics of capillary-induced fluid motion along a tube
• wicking in a porous medium, Washburn’s law
Lecture 8: Mar. 5. Marangoni flows I: Thermocapillary effects
- thermal/chemical convection in a fluid layer: Rayleigh-Bénard versus Marangoni
- thermocapillary drop motion

Lecture 9: March 7. Marangoni flows II: Surfactants
- the role and dynamics of surface impurities
- soap films and Marangoni elasticity

Lecture 10: March 12. Fluid jets
- shapes of falling fluid jets
- the Rayleigh-Plateau instability

Lecture 11: March 14. Capillary Instabilities
- instabilities on thin films
- Rayleigh-Plateau instabilities on a coated wire

Lecture 12: March 19. Fluid sheets
- sheet retraction and the Culick speed
- sheet instability and break up; fluid fishbones
- water bells

Lecture 13: March 21. Instability of superposed fluids
- the role of surface tension on the Rayleigh-Taylor instability
- the role of surface tension on the Kelvin-Helmholtz instability

SPRING BREAK March 26–30. NO CLASS

Lecture 14: April 2. Wetting of rough solids
- the failure of Young’s Law; contact angle hysteresis
- Wenzel and Cassie states; water-repellency
Lecture 15: April 4. Forced wetting I
  • viscous withdrawal: the Landau-Levich-Derjaguin problem
  • applications in coating flows; e.g. fiber coating
  • displacing an interface in a tube: the Bretherton problem

Lecture 16: April 9. Spreading on a solid
  • contact line dynamics and Tanner’s law

Lecture 17: April 11. Spreading on a surface
  • gravity currents and oil spills

Patriot’s Day HOLIDAY April 16. NO CLASS

Lecture 18: April 18. Drops and bubbles
  • their birth, life and death
  • droplet impact and fracture, dynamics of coalescence
  • the role of surfactants

Lecture 19: April 23. Water waves
  • dispersion relation; group and phase velocity
  • capillary and gravity waves
  • the role of surfactants

Lecture 20: April 25. Biocapillarity I
  • surface tension in biology
  • interfacial locomotion

Lecture 21: April 30. Biocapillarity II
  • water repellency in nature
  • drinking strategies in nature
Lecture 22: May 2. Hydrodynamic quantum analogs I
   - the experiments of Yves Couder
   - the dynamics of droplets bouncing on a vibrating surface

Lecture 23: May 7. Hydrodynamic quantum analogs II
   - pilot-wave hydrodynamic theory
   - connections to realist models of quantum dynamics

Lecture 24: May 9. STUDENT PRESENTATIONS

Lecture 25: May 14. STUDENT PRESENTATIONS

Lecture 26: May 16. STUDENT PRESENTATIONS. Course Projects Due