18.357 INTERFACIAL PHENOMENA

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Spring 2025
MW 3-4:30
Room 2-151

Office hours: after class, available upon request

GRADING SCHEME

- 50%: 2 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

by P.G. de Gennes, F. Brochard-Wyart and D. Quéré. Springer Publishing.

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

Multimedia Fluid Mechanics. Cambridge University Press, Ed. Bud Homsy.

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

COURSE OUTLINE

Lecture 1. Feb.3. Introduction

- course survey, motivation and philosophy

Lecture 2. Feb.5. 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

Lecture 3: Feb.10. Wetting

- surface energies and spreading parameter
- equilibrium contact angles and Young's Law

Lecture 4: Feb.12. Theoretical formalism

- review of Navier-Stokes equations
- derivation of interfacial boundary conditions
- the scaling of surface tension: when is it important?

Lecture 5: Feb.18. Fluid statics I

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

Lecture 6: Feb.19. Fluid statics II

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

Lecture 7: Feb.24. Capillary rise

- statics and dynamics of capillary-induced fluid motion along a tube
- wicking in a porous medium, Washburn's law

Lecture 8: Feb.26. Marangoni flows I: Thermocapillary effects

- thermal/chemical convection in a fluid layer: Rayleigh-Bénard versus Marangoni
- thermocapillary drop motion

Lecture 9: March 3. Marangoni flows II: Surfactants

- the role and dynamics of surface impurities
- soap films and Marangoni elasticity

Lecture 10: March 5. Fluid jets

- shapes of falling fluid jets
- the Rayleigh-Plateau instability

Lecture 11: March 10. Capillary Instabilities

- instabilities on thin films
- Rayleigh-Plateau instabilities on a coated wire

Lecture 12: March 12. Fluid sheets

- sheet retraction and the Culick speed
- sheet instability and break up; fluid fishbones; water bells

Lecture 13: March 17. Instability of superposed fluids

- the role of surface tension on the Rayleigh-Taylor instability
- the role of surface tension on the Kelvin-Helmholtz instability

Lecture 14: March 19. Wetting of rough solids

- the failure of Young's Law; contact angle hysteresis
- Wenzel and Cassie states; water-repellency

SPRING BREAK March 24–28. NO CLASS

Lecture 15: March 31. 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 2. Spreading on a solid

- contact line dynamics and Tanner's law

Lecture 17: April 7. Spreading on a surface

- gravity currents and oil spills

Lecture 18: April 9. Drop dynamics

- their birth, life and death
- droplet impact and fracture, dynamics of coalescence
- the role of surfactants

Lecture 19: April 14. Bubble dynamics

- their birth, life and death
- the role of surfactants

Lecture 20: April 16. Water waves

- dispersion relation; group and phase velocity
- capillary and gravity waves
- the role of surfactants

Lecture 21: April 21.. Respiratory disease transmission

- transport of exhaled pathogen-bearing droplets
- a safety guideline for mitigating indoor COVID-19 transmission

Lecture 22: April 23. Biocapillarity I

- surface tension in biology
- interfacial locomotion

Lecture 23: April 28. Biocapillarity II

- water repellency in nature
- drinking strategies in nature

Lecture 24: April 30. Hydrodynamic quantum analogs I

- pilot-wave hydrodynamics
- the dynamics of droplets bouncing on a vibrating surface
- generalized classical pilot-wave dynamics

Lecture 25: May 5. Interfacial Miscellany

Lecture 26: May 7. STUDENT PRESENTATIONS

Lecture 27: May 12. STUDENT PRESENTATIONS. **Course Projects Due**