18.357 INTERFACIAL PHENOMENA

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Fall 2022
MW 3-4:30

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. Sept. 7 Introduction

- course survey, motivation and philosophy

Lecture 2. Sept. 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

Lecture 3: Sept. 14. Wetting

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

Lecture 4: Sept. 19. Theoretical formalism

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

Lecture 5: Sept. 21. Fluid statics I

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

Lecture 6: Sept. 26. Fluid statics II

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

Lecture 7: Sept. 28. Capillary rise

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

Lecture 8: Oct. 3. Marangoni flows I: Thermocapillary effects

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

Lecture 9: Oct. 5. Marangoni flows II: Surfactants

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

MIT HOLIDAY Oct. 10. NO CLASS

Lecture 10: Oct. 12. Fluid jets

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

Lecture 11: Oct.17. Capillary Instabilities

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

Lecture 12: Oct. 19. Fluid sheets

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

Lecture 13: Oct. 24. 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: Oct. 26. Wetting of rough solids

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

Lecture 15: Oct. 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: Nov. 2. Spreading on a solid

- contact line dynamics and Tanner's law

Lecture 17: Nov. 7. Spreading on a surface

- gravity currents and oil spills

Lecture 18: Nov. 9. Drops and bubbles

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

Lecture 19: Nov. 14. Water waves

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

Lecture 20: Nov. 19. Respiratory disease transmission

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

Lecture 21: Nov. 21 Biocapillarity I

- surface tension in biology
- interfacial locomotion

Lecture 22: Nov. 23. Biocapillarity II

- water repellency in nature
- drinking strategies in nature

Lecture 23: Nov. 28. Hydrodynamic quantum analogs I

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

Lecture 24: Nov.30. Hydrodynamic quantum analogs II

- pilot-wave hydrodynamic theory
- a generalized classical pilot-wave framework

Lecture 25: Dec. 5. Hydrodynamic quantum analogs III

- connections to realist models of quantum dynamics
- attempts to develop a rational theory of quantum dynamics

Lecture 26: Dec.7. STUDENT PRESENTATIONS

Lecture 27: Dec.12. STUDENT PRESENTATIONS

Lecture 28: Dec. 14. STUDENT PRESENTATIONS. **Course Projects Due**