

ME 260A/B
ADVANCED FLUID MECHANICS

by
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2018-2019

COURSE: ME260A

You are expected to be proficient in fundamental thermodynamics and fluid dynamics, such as those topics covered in ME 105 & 106 and with mathematics inasmuch as it is needed for that proficiency. You must understand how a rigid body behaves under external forces before you can even imagine to understand the behavior of fluids. In particular, you are expected to have derived the equations of motion for continuum at least once. Mathematically, you should be comfortable with vector calculus, ordinary and partial differential equations, and be familiar with complex variables and tensor notation. We will cover the following topics at appropriate levels for this course: (260A) the formulation of the fluid flow problem, potential flows, compressible flows, canonical viscous flows; and (260B) boundary layer theory, creeping flows, vortical flows, point vortices, rotating flows, stability, transition, and turbulence. The homework problems are intended for augmenting the lecture material and, therefore, constitute an essential part of the course.

GRADING: ME260A

LETTER GRADE BOUNDARIES

| | | | |
|-------------------------|------|---|-------|
| Homework (~ 4) | 40% | A | 85.0% |
| Midterm exam (Oct 17) | 30% | B | 75.0% |
| Final exam (due Dec 11) | 30% | C | 65.0% |
| TOTAL | 100% | D | 55.0% |

COURSE: ME260B

January 12, 2018

This is an *organic* continuation of ME260A. Alternatively, if you have had an equivalent background, you may benefit from the course. In contrast to ME260A where the flow field descriptions were exact, the flow descriptions in ME260B will be approximate, even empirical. We will cover the following topics at appropriate levels for this course: a review of *instructive* exact solutions, boundary layer theory, creeping flows, lubrication theory, vortical flows, point vortices, rotating flows, stability, transition, and turbulence.

There will be a few homework problems, intended to augment the lecture material. In lieu of a mid-term exam, you will be asked, using a pre-packaged CFD code, such as Ansys, COMSOL, OpenFOAM, SimScale, to reproduce a flow visualization study selected from a list of pictures. Also, in lieu of a final exam, you are required to prepare a term project on a topic of current interest. It can not be a recycled work, a published work of yours, or a topic of your research. You will be judged both on your presentation (peer and instructor) and your report.

GRADING: ME260B

LETTER GRADE BOUNDARIES

| | | | |
|--|------|---|-----|
| Homework | 30% | A | 85% |
| CFD Project | 20% | B | 75% |
| Term Project: Report & Presentation (30+10+10) | 50% | C | 65% |
| TOTAL | 100% | D | 55% |

POLICY

All members of the UC Berkeley community are bound by our honor code: honesty, integrity, and respect for others. All assigned material is to be done independently. Unless you have a good reason, no late assignment will be accepted, no makeup will be given.

REFERENCES

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 32. *Physics of Fluids (Phys. Fluids)*
 33. *Annual Reviews of Fluid Mechanics (Ann. Rev. Fluid Mech.)*
 34. <http://web.mit.edu/fluids/www/Shapiro/ncfmf.html>, National Committee for fluid Mechanics Films
 35. Savaş, Ö. 2017/18 *ME-260A/B Advanced Fluid Mechanics*. Webnotes: bcourses.berkeley.edu

ME 260A
ADVANCED FLUID MECHANICS
Fall 2018

| # | date | Topic |
|-----|--------|--|
| 1. | Aug 23 | Introduction , Homework assignment, Formulation Differentiation Theorems, Continuity |
| 2. | Aug 28 | Momentum equation, Stress at a point, stress tensor |
| 3. | Aug 30 | stress tensor, energy equation, Surface force work, |
| 4. | Sep 4 | differential equations, Motion near a point |
| 5. | Sep 6 | Constitutive relation, Viscosity , derivation concluded, |
| 6. | Sep 11 | Preliminaries to flow theorems: Kelvin, Helmholtz, Crocco, Bernoulli |
| 7. | Sep 13 | Potential Flow Euler's equations |
| 8. | Sep 18 | Bernoulli's, Stream function, Potential flow $\nabla^2\phi = 0$, catalog |
| 9. | Sep 20 | Potential flow catalog |
| 10. | Sep 25 | Catalog continued, water waves |
| 11. | Sep 27 | Water waves – continued |
| 12. | Oct 2 | Compressible Flow Introduction |
| 13. | Oct 4 | Normal shock waves, Isentropic stream tube flow, |
| 14. | Oct 9 | Unsteady shock, reflection |
| 15. | Oct 11 | Riemann Invariants, Centered expansion, shock tube |
| 16. | Oct 16 | MIDTERM EXAM – <i>in class, closed book, personal notes only</i> |
| 17. | Oct 18 | Shock formation |
| 18. | Oct 23 | Acoustics |
| 19. | Oct 25 | Canonical Viscous Flows : Parallel flows, Couette, Poiseuille, |
| 20. | Oct 30 | Circular flows, Jefferey-Hamel flow |
| 21. | Nov 1 | Hiemenz flow, Kármán flow, Bödewadt Flow |
| 22. | Nov 6 | Berker Flow: Corotating eccentric discs |
| 23. | Nov 8 | Landau jet, suddenly accelerated wall, oscillating wall, |
| 24. | Nov 13 | Decaying viscous vortex , starting pipe flow |
| 25. | Nov 15 | Bubble dynamics: Rayleigh - Plesset equation |
| | Nov 20 | APS/DFD Meeting |
| | Nov 22 | THANKSGIVING |
| 26. | Nov 27 | Sextl-Womersley Flow |
| 27. | Nov 29 | Starting viscous jet. <i>Class ends, TAKE HOME EXAM handed out</i> |
| | Nov 30 | <i>Formal classes end</i> |
| | Dec 7 | <i>Last day of instruction</i> |
| | Dec 10 | Monday 17:00 - FINAL EXAM DUE |
| | Dec 14 | Friday: <i>Semester ends</i> |

ME 260B
ADVANCED FLUID MECHANICS
Spring 2019

| # | date | Topic |
|-----|--------|--|
| 1. | Jan 22 | Introduction |
| 2. | Jan 24 | Summary of ME260A |
| 3. | Jan 29 | Boundary layer: general |
| 4. | Jan 31 | Boundary layer: Blasius, FS flows |
| 5. | Feb 5 | Boundary layer: Shear layer, Jets, Wall Jets |
| 6. | Feb 7 | Von Kármán integral formulation, Thwaites method. |
| 7. | Feb 12 | Compressible boundary layer. |
| 8. | Feb 14 | Compressible boundary layer (concluded) |
| 9. | Feb 19 | Creeping Flows Introduction, Hele-Shaw flow, sphere |
| 10. | Feb 21 | Cylinder, Flat plate |
| 11. | Feb 26 | Acoustic streaming |
| 12. | Feb 28 | Reynolds equation, |
| 13. | Mar 5 | Meniscus, film drawing |
| 14. | Mar 7 | Motion of bubble in a tube |
| 15. | Mar 12 | Vortex Motion |
| 16. | Mar 14 | Introduction, Vorticity equation, Helmholtz' laws, Kelvin's circulation theorem, |
| 17. | Mar 19 | Invariants of 2D vortex motion, Point vortices, Row of vortices |
| 18. | Mar 21 | Stability of a row and rows of vortices, Vorticity generation etc. a la Savaş |
| | Mar 25 | <i>Spring Recess</i> |
| 19. | Apr 2 | Stability Introduction, Static stability of atmosphere, Centrifugal stability |
| 20. | Apr 4 | Orr-Sommerfeld equation, Rayleigh's theorem, Squire's theorem |
| 21. | Apr 9 | Fjörtøft's theorem, Howard's semi-circle theorem |
| 22. | Apr 11 | Row of point vortices under stability theory, viscous stability |
| 23. | Apr 16 | Joseph's theorems, Boundary layer, Tollmien-Schlichting waves |
| 24. | Apr 18 | Introduction to Turbulence |
| 25. | Apr 23 | Energy density, Kolmogorov scale, Energy spectrum, Degrees of freedom |
| 26. | Apr 25 | Presentations I |
| 27. | Apr 30 | Presentations II |
| 28. | May 2 | Presentations III |
| | May 3 | <i>Classes end</i> |
| | May 10 | <i>Instruction ends, Reports due</i> |
| | May 17 | <i>Semester ends</i> |
| | May 18 | <i>Commencement</i> |