ME 165/242 Ocean-Environment Fluid Mechanics:
Viscous-Fluid Flow, Boundary-Layer Theory, Surface Waves, Ship Waves, and Applications

Lectures T&Th 11:10-12:30, 3117B Etcheverry
Discussion time and place Th 13:10-14:00, 1109 Etcheverry

Staying healthy: the instruction is in person. However, if you are ill, please stay home and get well before returning. We will not count absences and notes can be had from classmates or instructor.

INSTRUCTOR
Associate Prof. S.A. Mäkiharju, e-mail: makiharju@berkeley.edu website: https://flow.berkeley.edu/
Office hours: Th 1410-1500 in 6119, and by appointment in person or zoom as needed.

GSI
Ph.D. candidate Ozgur Orun, e-mail: ozgur@berkeley.edu
Office hours: T 1715-1815 in Etch 3117B

Description
Ocean environment. Physical properties and characteristics of the oceans. Global conservation laws. Surface-waves generation. Gravity-wave mechanics, kinematics, and dynamics. Design consideration of ocean vehicles and systems. Model-testing techniques. Prediction of resistance and response in waves, physical modeling and computer models.

Prerequisites: ME106 or CEE100 or equivalent fluids/hydro undergraduate class.

TEXTBOOK(S) AND/OR OTHER REQUIRED MATERIAL
Textbooks (available on-line **for free** through OskiCat): All part of the Principles of Naval Architecture Series by The Society of Naval Architects & Marine Engineers.
Book A: Ship Resistance and Flow, L. Larsson & H. Raven.
Book B: Propulsion by J. E. Kerwin & J. A. Hadler.
Book C: The Geometry of Ships by J.S. Letcher.
+Lecture-Notes & Handouts

COURSE OBJECTIVES
To provide training of mechanical engineers to understand the unique characteristics of the ocean environment, local and global scale, and to provide background on engineering and design tools that are commonly used by engineers working with system and component designs of ocean, marine energy, and ship systems.

DESIRED COURSE OUTCOMES
At the end of the course, the students should understand general scientific properties that characterize the main body of the oceans; understand components of drags that contribute to the resistance of a marine vehicle and the associated engineering skills in model-testing that quantify the drag characteristics of a ship hull; comprehend simple harmonic surface-wave theory, with strong realization of the underlying concepts of wave kinematics, wave energy, and group velocity.

TOPICS COVERED
Physical properties of the oceans, overall characteristics, ocean circulation, atmospheric interaction; global heat balance, water balance and salt balance; wind-generated surface-waves; surface-wave dynamics, equations of motion, wave energy; random processes, random wave description, spectral description; design considerations of ocean systems; fluid-dynamic drag; unsteady forces, dimensional analysis; principles of model testing, calm-water performance; linear system theory for motion prediction; response operators; equations of motions for ocean systems; wave excitation; response analysis in frequency domain; nonlinear forces and nonlinear motion dynamics.

CLASS/LABORATORY SCHEDULE
Three hours of lectures and one hour discussion section.
Laboratory experiments during one or two of the weeks at TBD times based on student schedules.

CONTRIBUTION TO THE PROFESSIONAL DEVELOPMENT
Students will be exposed to issues, terminology, and design practice of the sector of maritime affairs and maritime engineering of the US and the rest of the world. Mechanical Engineers often find themselves working on the design of mechanical systems that operate in the ocean environment, which include ship-board machinery, navigation & control systems, underwater robotics, and propulsion devices, to name a few.

RELATIONSHIP OF THE COURSE TO ABET PROGRAM OUTCOMES
An ability to apply knowledge of mathematics, science, and engineering. An ability to design and conduct experiments, as well as to analyze and interpret data. An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability. The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

ASSESSMENT OF STUDENT PROGRESS TOWARD COURSE OBJECTIVES
Five sets of homework problems with two sets involved with design issues of the topics being addressed. Lab 1 (shared with ME165): resistance, laboratory report from each team of four to five students. Lab 2 (report for only ME242): Waves lab or similar, reports in teams of two to three. One midterm exam and a final project.

Difference between room shared ME165 and ME242
- 242 students have one extra lab report to submit.
- Homework sets have additional higher-level question for the graduate students enrolled in 242 (Or, 242 students may be asked to answer same question with more derivation or detail.)
- Final will have one question that is for 165 only, and another higher-level question for 242 only. (Or, 242 students may be asked to answer same question with more derivation or detail.) Additionally, final will have 2-4 shared questions.

GRADING **60% Homework and lab(s), 15% Midterm, and 25% Final project.**

- Late penalty is 10% of total possible points per day (e.g., a homework submission that was two days late and would have received 8 of 10 points based on answers earns 6 points).
- **After 72 hours late - no points** (this is to enable timely return of scores to all students).
    - We will try to return grades within 10d of due date (3d buffer for late submissions, 7d to grade)
- *Extensions can be requested for extenuating circumstances by the instructor.* ***Note on the top of an assignment if an extension has been granted (indicate date granted)***
- *On group assignments everyone gets the same grade, unless they skip contributing to a particular assignment.* ***Not contributing to an assignment result in a zero score. In each group assignment, all team members will summarize succinctly on the 1st page how they contributed to the joint assignment.*** **[To enable trying to resolve problems early, group mate's complete non-participation should be reported to GSI/instructor via email.]**
- *If you have a letter of accommodation from DSP, please inform the instructor via email during the first week of class. We will strive to provide accommodations (extended deadlines) in the most equitable and discrete manner possible.*

BERKELEY HONOR CODE Everyone in this class is expected to adhere to this code: "As a member of the UC Berkeley community, I act with honesty, integrity, and respect for others."

ACADEMIC HONESTY You are encouraged to form study groups and work together to understand course material, but all written work should be your own. You may not copy other students' work, including codes, responses, graphs, data, etc. Academic integrity and ethical conduct are of utmost importance in the College of Engineering at UC Berkeley. Any instances of direct copying are required to be reported. *Please no violations! These cases cause much wasted effort for all parties and can result in an F in the course or suspension from the UC.*

EQUITY AND INCLUSION We are committed to creating a learning environment welcoming of all students that supports a diversity of thought, perspectives and experiences, and respects your identities and backgrounds (including race/ethnicity, nationality, gender identity, socioeconomic class, sexual orientation, language, religion, ability, etc.)

- Teams will be assigned by the instructors: Research indicates stronger, more inclusive teams result from random assignment by instructors.
- Learning to cooperatively work with a diverse group of co-workers is an important skill for your future careers, whether in academy or industry. (You rarely, if ever get to choose your co-workers in industry!)
- We do our best in our imperfect ways. Please be respectful, forgiving & compassionate to all.
- It is expected that you to treat students and course staff with respect within your group, discussion, lecture, etc., any issues should be reported to the instructors *privately* via email ASAP. Group emails should also be reported to instructors in a timely fashion, often disagreements can be resolved if addressed early.

ADDITIONAL STUDENT RESOURCES
https://engineering.berkeley.edu/students/resources/
Academic Accommodations Hub | Executive Vice Chancellor and Provost (berkeley.edu)

Outline and <u>Tentative</u> *Schedule*

Week	Dates (Tu&Th)	Topic	Items due (reading assigned in class)
1	8/29	1. Introduction, Dimensional analysis	
2	9/3 9/5 9/5	2. Dimensional analysis cont. special examples 3. Ship terminology and Geometry of hulls Discussion: dimensional analysis - together	
3	9/10 9/12 9/12	4. Center of buoyancy and ship stability 5. Governing eq.& boundary cond., laminar BL Discussion: Stability & Buoyancy (HW2)	HW 1 due 9/13 11:59pm on bC
4	9/17 9/19 9/19	6. BL on body w/ thickness, turbulent flows intro 7. Turbulent boundary layers & frictional drag Discussion: HW2 related material	
5	9/24 9/26 no OH 9/26	8. TBL & drag cont. with drag reduction slides 9. cont. Discussion: HW 1 answers, current topics	HW 2 due 9/27 11:59pm on bC
6	10/1 10/3 10/3	10. Guest lecture – Alexia Aubault , CTO, Ocergy 11. Resistance, Froude's hypoth.& model-testing Discussion: Review of HW2 answers	
7	10/8 10/10 10/10	12. Instrumentation and resistance testing **Midterm during class time on Thursday** **No discussion (time buffer for Midterm)**	
8	10/15 10/17 10/17	11. Inviscid flow eqn., BCs, Bernoulli, free surf 13. Discussion: Potential flow past 2D object Discussion: HW3 related material	
9	10/22 10/24 10/24	14. Lin. waves over horizontal bottom, Simple harmonic waves, wave properties 15. Particle motions, superposition, group velocity Discussion: Waves, where BC come from	HW 3 due 10/28 23:59 bCourses
10	10/29 10/31 10/31	16. Ocean Wave Energy 17. *Lab 1: Towing resistance lab –RFS Visit* No disc. Group returning from RFS	
11	11/5 11/7 11/7	18. Ship wave resistance, Kelvin wedge intro 19. 2D Lifting flow, Introduction to Cavitation Discussion: Wave energy	HW 4 due 11/8 23:59 bCourses
12	11/12 11/14 11/14	20. Propeller geometry and design 22. Actuator-disk theory Discussion: Lab 2 analysis preparation	Lab 1 due 11/13
13	11/19 11/21 11/21	Lab 2: Wave lab – **ONLY 1st half of the students** Lab 2: Wave lab - **ONLY 2nd half of the students** Discussion: HW5 material	
14		T – APS-DFD, Th– Thanksgiving – NO CLASS	Lab 2 due 11/26
15	12/3 12/4 12/4	23. Special guest lecture via Zoom: CFD for OE 24. Propeller testing & final discussions Discussion: previous HW answers	HW5 due 12/6 23:59 bCourses

16	12/9-13	RRR Week	Report due 12/8, no penalty extension until 12/10
17	12/18	Exam replaced by final project	

**READING ASSINGNED IN CLASS*

If time:

- Oscillatory loads, drag and inertia coefficients
- Frictional drag reduction expanded