Viscous-Fluid Flow, Boundary-Layer Theory
Surface Waves, Ship Waves, and Applications

Lectures T&Th 9:40a-11:00a, 3111 Etcheverry

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.

Homework & lab: (60%), Midterm: (15%), Final (25%)
Note: ME242 has one extra lab report worth 10 points – courses graded separately

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TEXTBOOK(S) AND/OR OTHER REQUIRED MATERIAL
Required skills: Introductory background in Fluid Mechanics.

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: Seakeeping and Maneuvering 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 as needed 1 hour discussion section – no GSI budget for weekly discussion). One week of laboratory experiments totaling about ten hours of work during the week

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 exam.

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.

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

Week	Dates (Tu&Th)	Topic	Reading* & due
1	1/21, 1/23	Introduction, Dimensional analysis; Dimensional analysis cont. special examples	
2	1/28, 1/30	Governing eq. & boundary conditions, laminar BL; BL on body with thickness, turbulent flows intro	
3	2/4, 2/6	Turbulent boundary layers & frictional drag; TBL & drag continued with drag reduction slides	
4	2/11, 2/13	Ship terminology and Geometry of hulls; Center of buoyancy and ship stability	HW 1 due 2/11
5	2/18, 2/20	Resistance, Froude's hypothesis & model-testing Model testing continued;	
6	2/25, 2/27	Instrumentation and resistance testing Potential flow past 2D object;	HW 2 due 2/27
7	3/3, 3/5	*Towing resistance – RFS Lab Experiments* *Towing resistance – RFS Lab Experiments*	
8	3/10, 3/12	**Midterm Quiz in class on Tuesday** Inviscid flow eqn., BCs, Bernoulli, Free surfaces;	midterm
9	3/17, 3/19	Linear waves over horizontal bottom Simple harmonic waves, wave properties	Lab 1 r. due 3/17
10	3/24, 3/26	Spring Recess	
11	3/31, 4/2	Orbital motions, Wave superposition, group velocity **Ocean Wave Energy** & resistance	HW 3 due 4/2
12	4/7, 4/9	2nd lab – all attend, report only from ME242 students 2nd lab – all attend, report only from ME242 students	
13	4/14, 4/16	Flow into propeller; 2D Lifting flow, Introduction to Cavitation	HW 4 due 4/16
14	4/21, 4/23	Actuator-disk theory; Propeller geometry and design	ME242 only - lab 2 report due 4/23
15	4/28, 4/30	Propeller testing Review & discussion of final	HW5 due 5/3 11:59pm
16	5/4-8	RRR Week	
17	5/11-15	Finals Week	

**READING ASSINGNED IN CLASS*

If time:

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