OCE 562 Syllabus
Modeling, Simulation and Control of Marine Vehicles

Instructor: Stephen Licht

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Office Hours: TBD and by appointment.

Class Days/Time: MW12:30-1:45

Classroom: Sheets 112

Prerequisites: EGR 515 or permission of instructor.

Course Description:

This course will cover the design and evaluation of control systems for surface and underwater vehicles (ships, submarines, autonomous and remotely operated robots.) Derivation of the 6-DOF equations of motion with hydrodynamic forcing; development of linear and nonlinear models appropriate for maneuvering, heading, and sea-keeping autopilot design and analysis; actuator and control surface modeling. Stability, observability, and controllability will be explored in the context of marine systems. Students will apply the modeling and control concepts from this course to an independent project, chosen by the student in consultation with the instructor. Projects may be simulation studies, but implementations in hardware available to the students are encouraged .

Course Goal:

Upon successful completion of this course, each student will be able to:

1. Create and use models to simulate ocean going vehicles including surface vessels, submarines, autonomous underwater vehicles, and remotely operated underwater vehicles, using:
    a. drag and maneuvering coefficient estimates based on similitude and slender body theory;
    b. added mass estimation from empirical data and slender body theory;
    c. linear models of control surfaces;
    d. empirical models of propeller performance;
    e. and a complete understanding of model/simulation limitations imposed by implicit and explicit assumptions made during model development.
2. Design and test (in simulation) a linear heading autopilot and waypoint navigation algorithm for a hybrid dynamic positioning/cruising marine surface vehicle (i.e. a ship.)
3. Design and test (in simulation) a linear speed/depth/heading controller for conventionally propelled autonomous underwater vehicle.

Suggested References:

Thor Fossen, *Handbook of Marine Craft Hydrodynamics and Motion Control*, Wiley, 2011.

Thor Fossen, *Marine Control Systems - Guidance, Navigation, and Control of Ships, Rigs and Underwater Vehicles*, www.marinecybernetics.com , 2002.

It is often most effective to see material presented in many diferent ways -- below are resources from MIT OpenCourseWare (OCW) addressing control in three different engineering disciplines. I will provide signposts to particular sections/lectures related to each lecture in this class.

- **Ocean Engineering**: Maneuvering and Control of Surface and Underwater Vehicles (13.49) http://ocw.mit.edu/courses/mechanical-engineering/2-154-maneuvering-and-control-of-surface-and-underwater-vehicles-13-49-fall-2004/lecture-notes/1349_notes.pdf

- **Electrical Engineering**: Dynamic Systems and Control (6.241) http://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-241j-dynamic-systems-and-control-spring-2011/readings/

- **Aeronautics and Astronautics**: Feedback Control Systems (16.30) http://ocw.mit.edu/courses/aeronautics-and-astronautics/16-30-feedback-control-systems-fall-2010/lecture-notes/

Assignments and Grading Policy

Assignment Type	% Weight
Quizzes	35%
Homework	40%
Final Project	25%

- Two in class quizzes (weeks 5 & 10) will cover the derivation of dynamic models including 6-DOF equations of motion for surface and underwater vehicles, linear approximations of hull and control surface hydrodynamic forcing, and state space control concepts.
- Homework assignments will be assigned on a weekly basis through the first 9 weeks of the course.
- The final project grade will be based on a proposal, written report, and oral presentation of results to the entire class. Each aspect of the final project will be graded on technical accuracy, quality of execution, and clarity of communication.

Disabilities:

If you have a documented disability which may require individual accommodations, please make an appointment with Prof. Licht as soon as possible. We will discuss how to meet your individual needs to insure your full participation and fair assessment procedures.