Fundamentals in Underwater Engineering

Syllabus

Fall 2022

Course description: The underwater marine researcher facing the need to specify and design scientific instrumentation or to adapt underwater vehicles and systems to specific scientific missions is confronting significant technological challenges; Hydrostatic pressure, medium dynamics, lack of air, corrosive environment and need for water tightness are only some of the technological challenges in deep sea exploration. As part of the course we will learn how to quantify the significance of these difficulties, learn about ways to handle those and on adequate technological solutions.

Number of credits: 2

Prerequisites by topic:

1. Mechanics, Statics & Dynamics (academic course in Physics or equal)
2. Differential and integral calculus
3. Knowledge with programming in MATLAB

Course objectives: The student will:

1. Review concepts in fluid mechanics – hydrostatics and hydrodynamics relevant to underwater vehicles and equipment.
2. Learn on basic concepts in strength of materials, terms and their meaning, and some insights into the strength aspects of pressure vessels.
3. Learn on materials commonly used for underwater applications and principles of selection and on methods to protect against corrosion.
4. Review methods to seal against water ingress, ensure and test for water tightness

Course schedule: Sundays 11:00 – 13:00, 13 weeks.

Class: Pending COVID-19 situation: Small conference room, Marine Technologies Center, Israel Oceanographic and Limnological Research, Tel-Shikmona, Haifa or remotely via zoom.

Grading: Homework (3 assignments) – 30%
Final exam – 70%.

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Detailed Content: (may be modified during the semester)

Topic 1	Fluid statics: Phases of matter, Fluids vs. Solids, Liquid vs. Gases, definition of a fluid, concept of a continuum, properties of a fluid, hydrostatic forces on submerged surfaces, buoyancy, stability of submerged rigid bodies, stability of floating objects, stability of ships
Topic 2	Fluid dynamics: Lagrangian and Eulerian representation, mass and momentum conservation, Euler's equation, Bernoulli's equation. viscous flow, external flow and drag, lifting surfaces, wings and airfoils.
Topic 3	Water waves: Introduction, basic wave motion, the equation for surface waves, small amplitude waves, the dispersion relation, the velocity field, trajectory of fluid particles, the varying pressure from the waves. Waves load on structures: Morison equation
Topic 4	Marine propulsion: drag and propulsion, drag of underwater vehicles, powering, basic structure of an underwater vehicle thrust unit, buoyancy systems, propellers (principle of action, propeller curves, propeller matching for underwater vehicle, propeller selection), other types of propulsion.
Topic 5	Magnetism and DC motors: DC electric motors fundamentals, magnetism and magnets, motor principles, commutation, motor force and torque, pmdc motors, control of dc motors.
Topic 6	BLDC motors: operation theory structure, hall effect sensors, speed control, modelling.
Topic 7	Introduction to strength of materials: mechanical properties of metals, normal stress, relationship between stress and strain, elastic properties, volume change, Hooke's law, fracture, distortion energy theory
Topic 8	Design for the underwater environment: shell structures, pressure vessels, the concept of collapse and buckling calculations for spherical and cylindrical pressure bodies, sealing methods.
Topic 9	Corrosion in sea environment: types of corrosion, rates of corrosion on bare metals, galvanic corrosion, crevice corrosion, pitting, erosion corrosion, cathodic protection.
Topic 10	Materials for sea application: aluminum alloys, titanium alloys, protective coatings.