13.42: Design Principles for Ocean Vehicles

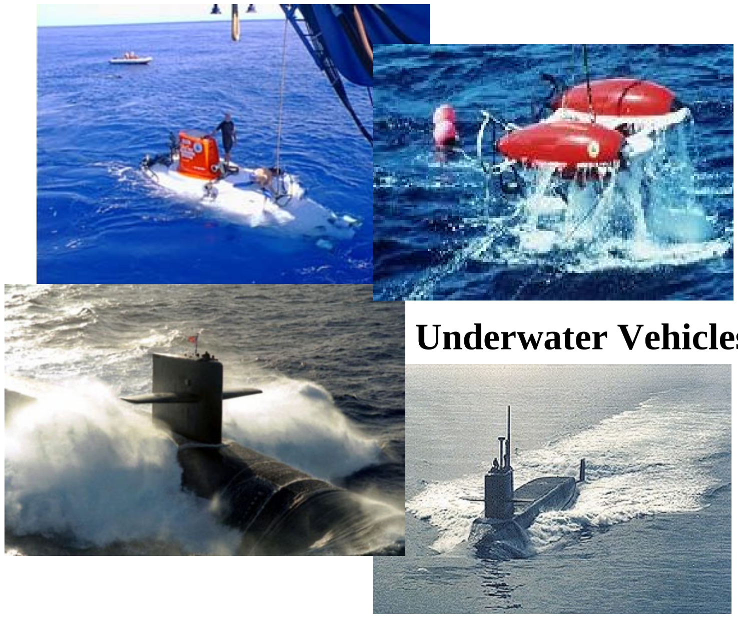
Spring 2005: T/R 9:30-11:00

Prof. Alex Techet

Design Principles for Ocean Vehicles

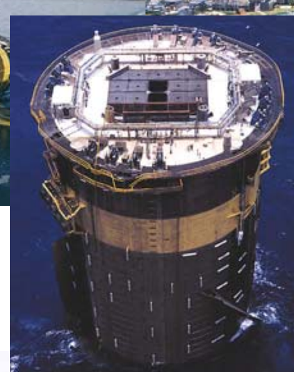
- "Vehicles" – Surface ships, underwater vehicles, and offshore platforms
- "Design Principles" – Tools for analyzing system dynamics

Underwater Vehicles



Surface Vessels

Offshore Platforms



Genesis Spar Platform

Basic "Recipe"

- Fundamental Math & Science
  - Newton's 2nd Law, $\vec{F} = M\vec{a}$
  - Conservation of Angular Momentum
  - Basic Fluid Mechanics
- Idealized System

  Ship Heaving in waves → Mass Spring Dashpot system
- Mathematical Model

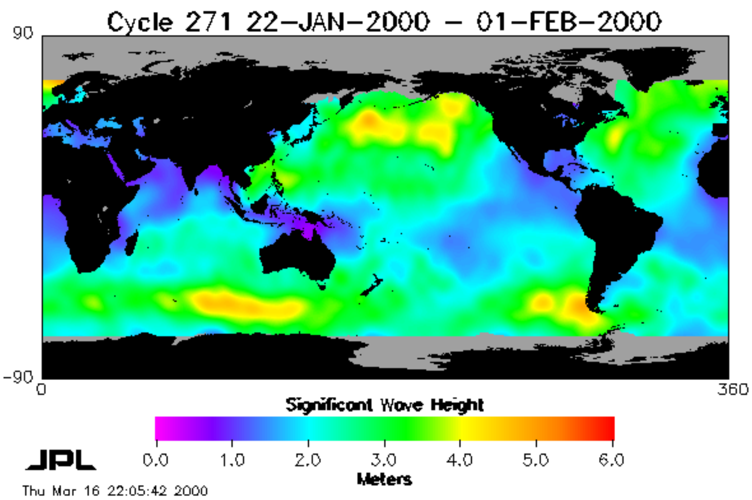
$$M\ddot{x}(t) + B\dot{x}(t) + Cx(t) = F(t)$$

- Behavior Prediction
  - System analysis "tools"

Tools for Design

- Linear systems analysis
- Fourier Transforms, Transfer Function
- Probabilistic forecasting extreme events (such as the 100 year wave and water on deck)
- Wave forces on floating bodies
- Added mass and damping forces
- Equations of motion of a vessel in waves

Wave Statistics



Significant Wave Height

Wave Energy Spectra

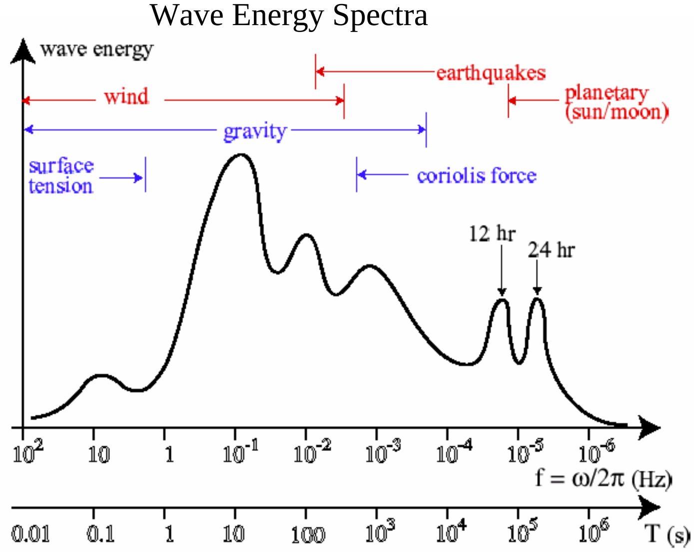


FIGURE 1. Wave energy spectra. Red text indicates wave generation mechanisms and blue text indicates damping/restoring forces.

Hydrodynamic Forces on Vessels

- Linear wave theory
- Strip theory – Added mass!!!
- Wave forces on bodies
- Viscous forces on bodies:
  - Skin Friction Drag
  - Vortex shedding, Vortex induced vibrations
- Viscous damping

Ship Motions

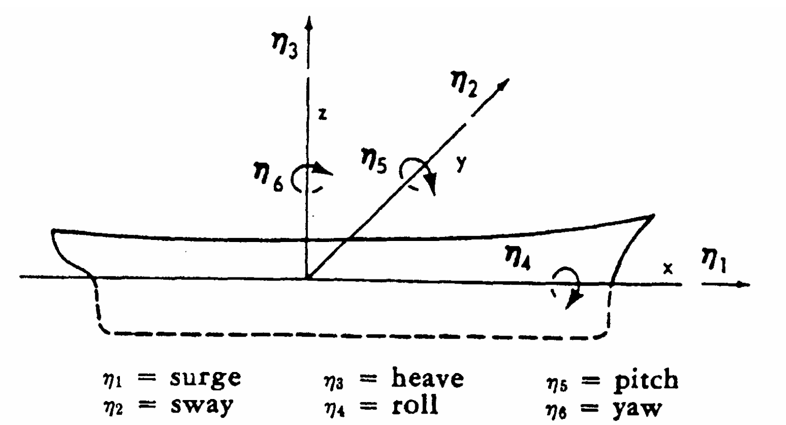


Fig. 37 Sign convention for translatory and angular displacements

13.42 Organization

- Instructor:
  - Professor Alexandra Techet
  - ahtechet@mit.edu
  - Office 5-326c
  - Phone x2-2266
- TA:
  - Cara LaPointe
  - lapointe@mit.edu
  - Office Hours:
    - Mondays 2:30-3:30
    - Room 5-326
- Grading
  - 50% Exams
  - 15% Homework
  - 35% Labs (2) + Project
- Homeworks
  - Due weekly on Thursdays
- Website
  - web.mit.edu/13.42/www

Syllabus