

13.42: Design Principles for Ocean Vehicles

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

Prof. Alex Techet

Image of drilling platform removed for copyright reasons.

Design Principles for Ocean Vehicles

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



Courtesy of U.S. DOE.



Courtesy of NOAA.

Underwater Vehicles

Surface Vessels



Photo courtesy of Steven Jayne.

Offshore Platform



Courtesy of U.S. DOE.

Genesis Spar Platform

Photos of Genesis Spar Oil Platform removed for copyright reasons.
Please See: <http://www.offshore-technology.com/projects/genesis/>.

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

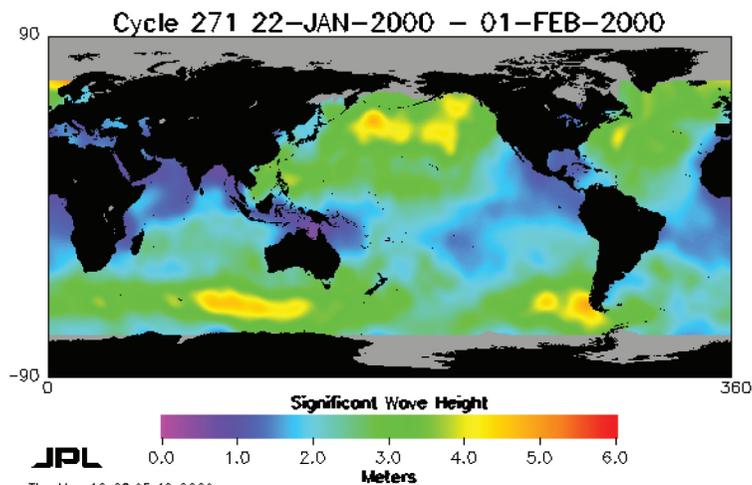
$$M\ddot{x}(t) + B\dot{x}(t) + Cx(t) = F(t)$$

- 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

Courtesy of JPL.

Wave Energy Spectra

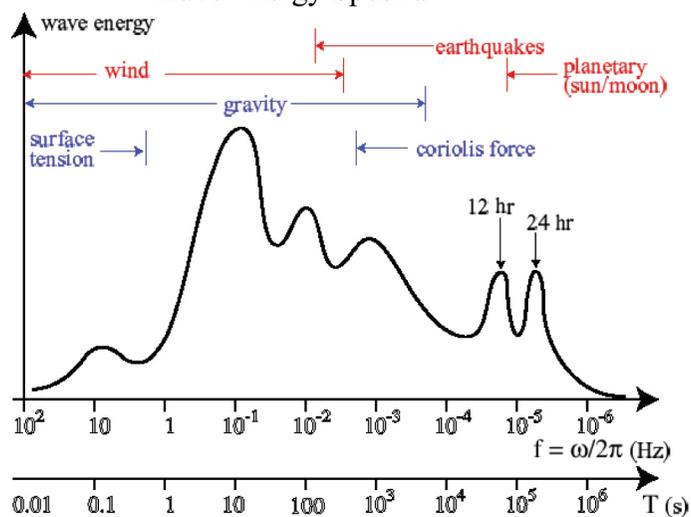
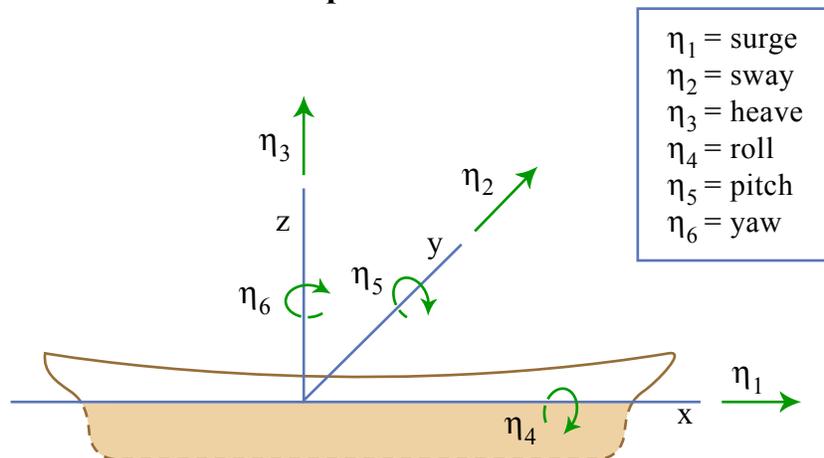


FIGURE 1. Wave energy spectra. Red text indicates wave generation mechanisms and blue text indicates damping/restoring forces.

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



Sign convention for translatory & angular displacements

Figure by MIT OCW.

13.42 Organization

- Instructor:
 - Professor Alexandra Techet
- Grading
 - 50% Exams
 - 15% Homework
 - 35% Labs (2) + Project
- Homeworks
 - Due weekly on Thursdays