13.012 Hydrodynamics for Ocean Engineers
Fall 2004
Prof. A. Techet
HW #7

Out: November 2, 2004
Due: November 16 2004

PLEASE NOTE THAT EXAM #2 IS SCHEDULED FOR NOVEMBER 9th.

THERE IS NO CLASS NOV 11th DUE TO VETERANS DAY.

WE **WILL** HAVE LAB OR RECITATION ON 11/12/04.

1) Problem 1:

a) Relate the Diffraction and Incident potentials through the body boundary condition.

b) Give the boundary conditions for the Radiation potential.

c) Write the expression used for determining the force on a body in waves.

d) For long wavelengths compared to the diameter of a bouy or the beam of a ship what can be said about diffraction?

e) Given a sphere floating on a quiescent free surface, sketch (from the top and side views) what the radiated waves might look like when the sphere is heaving up and down.

2. Consider a slender cylindrical buoy of diameter d and draft T fixed in deep water subject to ambient plane progressive waves of amplitude A and frequency ω (see Figure 2):
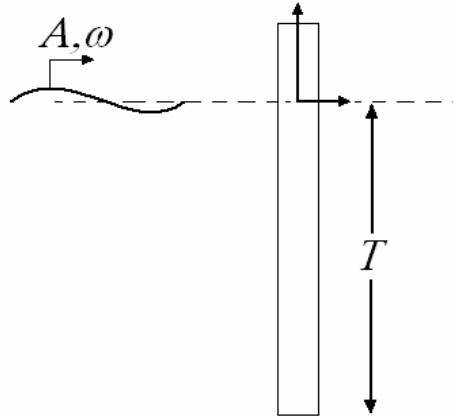

Figure 2 – Cylindrical buoy in waves

a. Assuming that $\lambda \gg d$ and that $A \approx 2d$, write down an expression for the surge excitation force.

b. Derive the Froude-Krylov term in this expression by integrating the pressure about a section of the cylindrical buoy and then applying the long wavelength assumption ($\lambda \gg d$).

c. Explain the significance of the added mass term.

d. Explain why the expression (from part a.) may not be adequate for cases where the wavelength is of the order of the buoy diameter.

3.

Consider a rigid circular cylinder, diameter 1.0m, mounted at an incline angle of 15 degrees from vertical, slanting away from the incoming waves.

a. Determine the sectional lift and drag on the cylinder (force per unit length acting on a small strip of the cylinder) when it is subjected to incoming deepwater waves with amplitude a = 0.9 m, frequency 1.1 rad/s, and wavelength 30m.

(Hint: first determine the tangential and normal component of the forces acting on the cylinder. You can approximate the coefficient of friction as: $Cf \approx 1/100 \ast Cd$.)

b. What implications does this method of force decomposition have on the forces acting on vertical cylinders (angle zero degrees) in waves?

4. A rigid circular cylinder with diameter, d = 1.8 m, is rigidly mounted at the seafloor. The water depth in this region is 50 meters and waves can be considered deep water waves. Monochromatic, linear waves are incident on the cylinder from one direction. The waves have frequency ω= 2.0 rad/s and amplitude a = 1.1 m. There is no current in this location in addition to the waves and we can neglect effects due to the cylinder piercing the free surface.
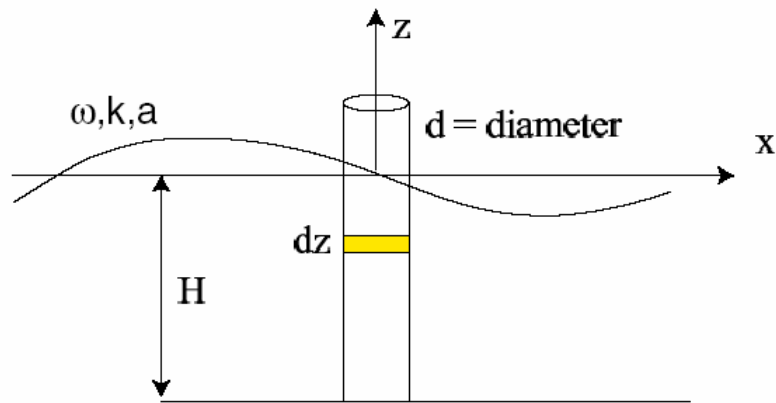

Figure 3 – Rigidly mounted vertical cylindrical in waves

Using the appropriate form of Morrison's Equation:

a. Calculate the MAXIMUM total force acting on the cylinder in the x-direction.

b. Determine the phases (time in the wave cycle) of the incident wave, $\eta(x,t)$, at which the horizontal force acting on the cylinder is MAXIMUM and is MINIMUM. (Consider this relative to the wave elevation at x=0, the centerline of the buoy).

c. Compare the total force over one period to the inertial and drag components of the force over that same time.

d. Calculate the moment acting on the cylinder about the seafloor mount.

e. Find the location of the center of force along the height cylinder (relative to the seafloor).

f. In the early morning the waves have lower amplitude but similar frequency. Repeat parts (a) through (c) for the case where the wave amplitude is 0.25 meters and the frequency is the same as above.