

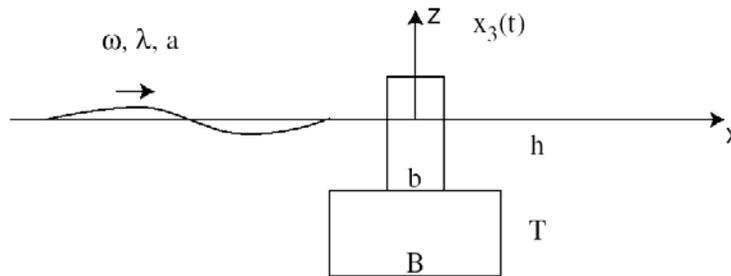
13.42 Design Principles for Ocean Vehicles Homework #8

Out: Tuesday, 13 April 2004

Due: Thursday, 22 April 2004

(Remember there will be no classes Tuesday, 20 April)

- 1.) Floating cylindrical instrumentation buoy is moored in deep water. Given: the wavelength of the incident wave is larger than the dimension, B , and $B > b$; also the wave amplitude is less than h and b .



- a. Determine the heave forces on the buoy due to the incident waves.
- b. Write out the full equation of motion for this buoy if it is allowed to heave freely. You should approximate the added mass and hydrostatic coefficients based on the geometry, but can leave the damping as B_{33} .
- c. Give the natural frequency of the buoy in heave.
- d. Sketch a qualitative plot of the heave amplitude to wave amplitude ratio, $|x_3/a|$, as a function of kT (k = wavenumber and T = height of lower buoy section). Discuss possible ways to use this plot in your design – assuming that your design goal is to minimize heave.
- e. Using the force determined in part a, and hydrodynamic coefficients from part b, the total force on the body can be found by adding in the diffraction force, estimated as follows:

$$F(t) = F_1(t) + F_D(t)$$

$$F_D(t) = m_a \frac{d}{dt} w(x=0, z=-(h + T/2), t)$$

Find the value of b that minimizes the heave motion at frequency $\omega = 0.7 \text{ rad/s}$, given the following buoy geometry:

$$B = 5 \text{ m} \quad T = 10 \text{ m} \quad h = 4 \text{ m} \quad T1 = T + h = 14 \text{ m}$$

The vertical position of the center of gravity is approximately at $z = -(h + T/2)$.

- 2.) Consider the following cylindrical buoy (see Figure 2) in ambient plane progressive waves of amplitude A and frequency ω . Let the mass of the buoy be m and the center of gravity be located at $z = -\frac{3}{4}T$. Assume deep water.

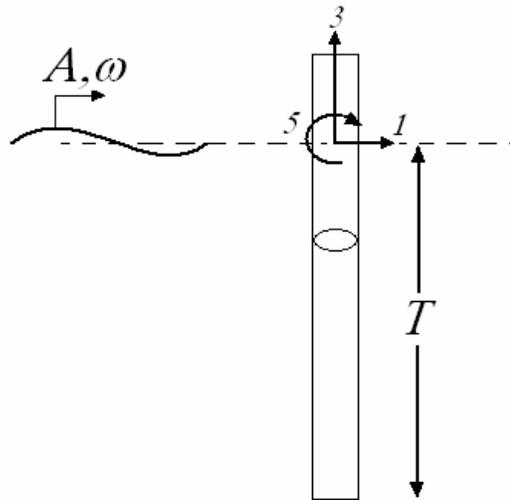


Figure 2 – Cylindrical buoy with circular cross-section

- Given that $\lambda \gg d$ (the diameter of the buoy), find the surge excitation force and the pitch exciting moment, neglecting viscous effects.
- Find the added mass and linear restoring coefficients A_{ij} and $C_{ij} - i, j = 1, 3, 5$.
The heave added mass may be approximated by the added mass of a sphere of equal diameter.
- Determine the natural frequency of the buoy in heave.
- Determine the natural frequency of the buoy in the coupled surge-pitch.
- State the equations of motion for the system.

Now consider the following cylindrical buoy tethered to the sea floor by a cable (Figure 3).

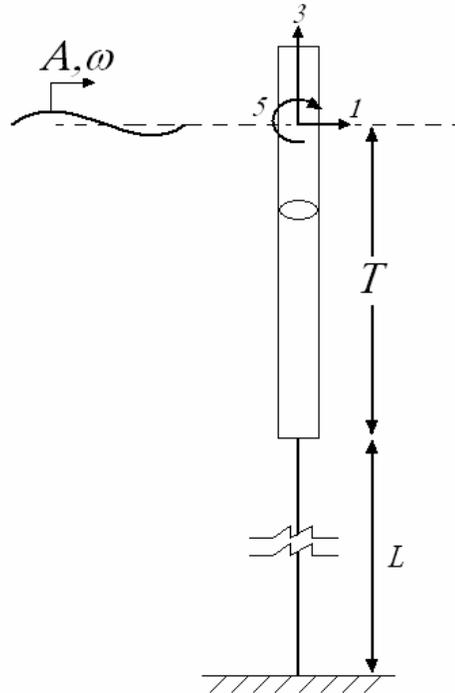


Figure 3 – Cylindrical buoy with circular cross-section tethered to the seafloor.

Assume that the weight of the buoy is less than the buoyant force, and that the cable tension is P . The linear restoring matrix due to the cable is given as:

$$C_{CABLE} = \begin{pmatrix} k_{11} & 0 & k_{15} \\ 0 & k_{33} & 0 \\ k_{51} & 0 & k_{55} \end{pmatrix}$$

- f. Find the added mass and linear restoring coefficients A_{ij} and $C_{ij} - i, j = 1, 3, 5$.
- g. Find k_{11} and the natural frequency of the buoy in surge.