

## 13.42 Homework #9

Spring 2005

Out: Thursday, April 21, 2005

Due: Thursday, April 28, 2005

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Problem 1: From Problem 1 of Homework #8, consider the naval vessel operating in the given ambient wave spectrum. Then consider the following operational limits:

*Point-to-point transit operational limits*

*~ RMS pitch angle = 2.5 degrees*

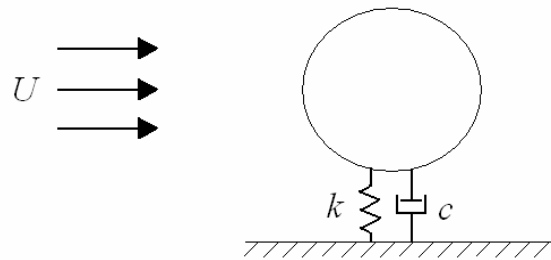
*~ RMS vertical acceleration at the bridge (point B in Figure 1 of HW8) = 0.2g*

*Helicopter flight operations (helo flight ops)*

*~ RMS vertical velocity at the flight deck (point A in Figure 1 of HW8) = 1.0 m/s*

- a) Does the present design satisfy the point-to-point transit operational limits? The x-coordinate of the bridge is  $x_B = 12 \text{ m}$ .
- b) Does the present design satisfy the helo flight ops limit? The x-coordinate of the flight deck is  $x_A = -22 \text{ m}$ .

**Problem 2:** Consider a flexibly-mounted rigid circular cylinder in a steady flow of water (see Figure 1), where the mass per unit depth of the cylinder is  $M$  and its diameter is  $d$ :



**Figure 1 – Flexibly-mounted cylinder in a steady flow**

- Write down an expression for the natural frequency of the system in terms of the given parameters.
- Given that  $U = 5$  m/s and  $d = 0.1$  m, find the frequency of vortex shedding. (Assume that the cylinder has a *smooth* surface and that the distance between the cylinder and the wall is  $\gg d$ .)
- Given that the system is in *lock-in*, what is the frequency of vortex shedding, of the cylinder response, and of the unsteady drag force (in terms of the expression derived in part a.)?

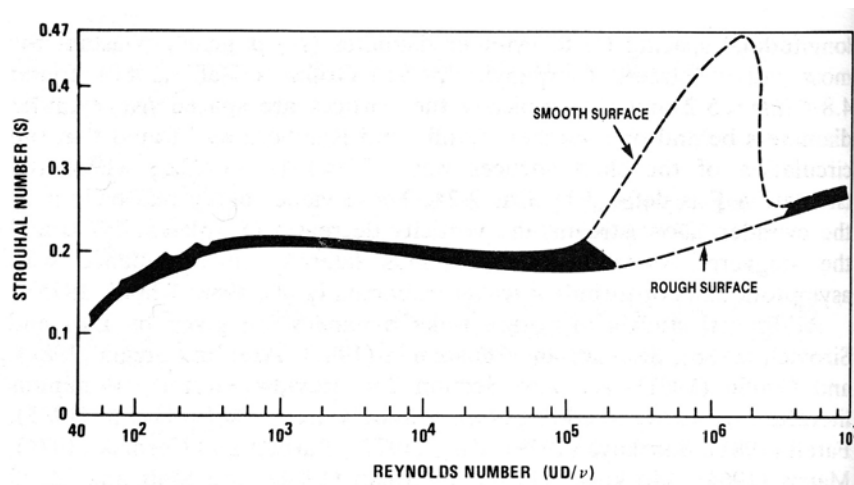
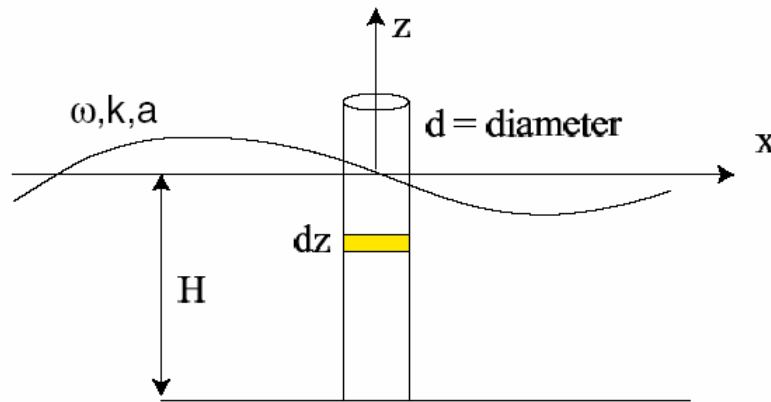


Fig. 2.2 Strouhal number. Reprinted from Fluid Mechanics, 6th Edition, by R. C. Hibbeler, © 2004 John Wiley & Sons, Inc.

**Problem 3:** A rigid circular cylinder with diameter,  $d = 1.8$  m, is rigidly mounted at the seafloor as shown in Figure 2. 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  $\omega = 2.0$  rad/s and amplitude  $a = 1.1$  m. Assume that 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 2 – Rigidly mounted vertical cylindrical in waves**

Using the appropriate form of Morrison's Equation:

- Calculate the MAXIMUM total force acting on the cylinder in the x-direction.
- 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).
- Compare the total force over one period to the inertial and drag components of the force over that same time.
- Calculate the moment acting on the cylinder about the seafloor mount.
- Find the location of the center of force along the height cylinder (relative to the seafloor).