Homework 3: Oscillations and waves

PHY250 - Fall 2021

Deadline: 10/25/2021

Exercise 1[1]

The two pendulums shown in Fig. 1 each consist of a uniform solid ball of mass M supported by a rigid massless rod, but the ball for pendulum A is very tiny while the ball for pendulum B is much larger. Find the period of each pendulum for small displacements. Which ball takes longer to complete a swing?

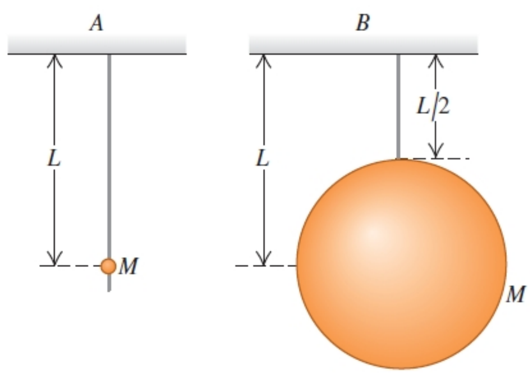

Figure 1: Exercise 1

Exercise 2[2]

An object with height h, mass M, and a uniform cross-sectional area A floats upright in a liquid with density ρ (a) Calculate the vertical distance from the surface of the liquid to the bottom of the floating object at equilibrium. (b) A downward force with magnitude F is applied to the top of the object. At the new equilibrium position, how much farther

[1] 14.57 from Sears and Zemansky
[2] 14.76 from Sears and Zemansky

below the surface of the liquid is the bottom of the object than it was in part (a)? (Assume that some of the object remains above the surface of the liquid.) (c) Your result in part (b) shows that if the force is suddenly removed, the object will oscillate up and down in SHM. Calculate the period of this motion in terms of the density ρ of the liquid, the mass M, and the crosssectional area A of the object. You can ignore the damping due to fluid friction.

Exercise 3[3]

A simple harmonic oscillator at the point $x = 0$ generates a wave on a rope. The oscillator operates at a frequency of 40.0 Hz and with an amplitude of $3.00 cm$. The rope has a linear mass density of 50 g/m and is stretched with a tension of 5.00 N. (a) Determine the speed of the wave. (b) Find the wavelength. (c) Write the wave function $y(x,t)$ for the wave. Assume that the oscillator has its maximum upward displacement at time $t = 0$ (d) Find the maximum transverse acceleration of points on the rope. (e) In the discussion of transverse waves the force of gravity was ignored. Is that a reasonable approximation for this wave? Explain.

Exercise 4[4]

A string that lies along the $+x$-axis has a free end at $x = 0$. (a) Show that an incident traveling wave $y_1(x,t) = Acos(kx + \omega)$ gives rise to a standing wave $y(x,t) = 2Acos(\omega)cos(kx)$ (b) Show that the standing wave has an antinode at its free end (x=0) (c) Find the maximum displacement, maximum speed, and maximum acceleration of the free end of the string. (d) find the resonance frequencies for the system.

[3] 15.21 from Sears and Zemansky

[4] 15.75 from Sears and Zemansky