PART I: Multiple choice questions

Only one of the choices given is the correct answer. No explanation for your choice is required. Each multiple choice problem is worth 5 points.

1. Two coins are placed on opposite sides of a balancing scale. One of them is made of silver, while the other is zinc. The density of silver is greater than zinc, but if the scale is subject to the normal atmosphere near the surface of the earth the scale is exactly balanced. If the scale is submerged in water, will the angle of tilt between the two sides change and if so in which direction?

   (a) The scale will tilt towards the side of the silver coin.

   (b) The scale will tilt towards the side of the zinc coin.

   (c) The angle between the two sides will remain unchanged.

NOTE: If the scale tilts toward the side of the silver coin, then the silver coin will be lower with respect to the zinc coin, etc.

2. Which of the following will decrease the frequency of oscillations of a long cylindrical pendulum of uniform density?

   (a) Increasing the length of the pendulum.

   (b) Increasing the density of the pendulum.

   (c) Decreasing the density of the pendulum.

   (d) Releasing the pendulum from a greater initial angular deflection.

3. If the position of a mass on the end of a spring as a function of time is $x(t) = A\cos\left(\omega t + \frac{1}{2}\pi\right)$, when will the mass have zero acceleration?

   (a) At $t = \pi/(4\omega)$

   (b) At $t = \pi/(2\omega)$

   (c) At $t = \pi/\omega$

   (d) It will never have zero acceleration.

4. A spring can be stretched a distance of 60 cm with an applied force of 1 N. If an identical spring is connected in parallel with the first spring, and both are pulled together, how much force will be required to stretch this parallel combination a distance of 60 cm?

(a) 0.25 N

(b) 0.5 N

(c) 1 N

(d) 2 N

(e) 4 N

5. Assume there is a temperature gradient that causes the density of a particular gas in a closed container to increase linearly with the distance from the bottom of the container. In other words, $\rho = ay$ where ρ is the density, y is the vertical distance measured from the bottom of the container, and a is some constant. If P is the pressure at the bottom of the container and h is the height of the container, what is the pressure of the gas at the top of the container?

(a) $P - agh$

(b) $P + agh$

(c) $P - \frac{1}{2}agh^2$

(d) $P + \frac{1}{2}agh^2$

6. A boat is moored in a fixed location, and waves make it move up and down. If the spacing between wave crests is 20 m and the speed of the waves is 5 m/s, how long does it take the boat to go from the top of a crest to the bottom of the adjacent trough?

(a) 1 second

(b) 2 seconds

(c) 4 seconds

(d) 8 seconds

PART II: Short problems

To earn full credit on the following problems, you must exhibit the steps that lead to your final result (and will depend on the clarity of your method of solution as well as on your final answer). Problems 7 and 8 are worth 20 points each, and problem 9 is worth 30 points.

7. A 6.0-cm-diameter horizontal pipe gradually narrows to 4.5 cm. When water flows through this pipe at a certain rate, the gauge pressure in these two sections is 32.0 kPa and 24.0k Pa, respectively. What is the volume rate of flow?

8. A mass m at the end of a spring oscillates with a frequency of 0.83 Hz. When an additional 60 g mass is added to m, the frequency is 0.60 Hz. What is the value of m?

9. A physical pendulum consists of an 85 cm long, 240 g mass, uniform wooden rod hung from a nail near one end. The motion is damped because of friction in the pivot; the damping force is approximately proportional to $d\theta/dt$ where θ is the angle of displacement from equilibrium. The rod is set in oscillation by displacing it 15° from its equilibrium position and releasing it. After 8.0 s, the amplitude of the oscillation has been reduced to 5.5°. Write the angular displacement (in radians) from the vertical as $\theta = Ae^{-\gamma t}\cos(\omega' t)$.

(a) What is the value of γ? (Indicate both its numerical value and the appropriate units.)

(b) Determine the approximate period of the motion.

(c) How long does it take for the amplitude to be reduced to half of its original value?