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

2. Two glasses of water are sitting on a table. Both have a constant diameter, but one of them is wider than the other. Both glasses contain the same volume of water. Which of the following is true about the force and pressure exerted by the water on the bottom of each glass?

(a) The pressure on the wider glass is greater, but the force is less.

(b) The force on the wider glass is greater, but the pressure is less.

(c) The pressure on both is the same, but the force on the wider glass is greater.

(d) The force on both is the same, but the pressure on the thinner glass is greater.

3. Two pennies are placed on opposite sides of a balancing scale. One of them is made of copper, while the other is zinc coated in copper. Both pennies are the same size and shape. The density of copper is greater than zinc. 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 tip down further towards the side of the copper penny.

(b) The scale will tip up back towards the side of the zinc penny.

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

4. A mass oscillates in simple harmonic motion with amplitude A. If the mass is doubled but the amplitude is not changed, what will happen to the total energy of the system?

(a) The total energy will increase.

(b) The total energy will not change.

(c) The total energy will decrease.

5. 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.

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. Suppose the top of a water tower has a gauge pressure P_1, and that it is connected through pipes to a faucet surrounded by air at atmospheric pressure P_0.

(a) Derive a formula for the speed, v, at which the water flows out of the faucet, if the difference in height between the top of the water tower and the faucet is y. You may assume there is no other pumping mechanism involved besides gravity, and that the rate at which the water level in the tower is dropping is approximately zero.

(b) If $P_1 = 0.85$ atm, P_0 is standard atmospheric pressure, and $y = 2.4$ m, determine v.

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?