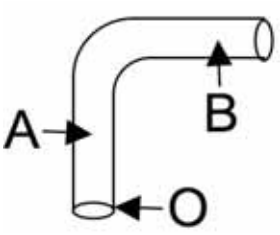
MC (50) = _____ Prob 11 (25) = _____ Prob 12 (25) = _____ Total = _____

Multiple choice, circle the correct answer (5 pts each).

1. The pipe below comes out of the ground and goes up the side of a house before it bends to the right and levels off (becomes horizontal). The pipe is completely filled with water and has a constant cross-sectional area throughout. Water enters the pipe at point O with a speed of 1.3 m/s. Is the water moving faster at point A or B?



   a. The speed of the water is faster at A.
   b. The speed of the water is faster at B.
   c. The speed of the water is the same at both A and B.
   d. It is not possible to determine the relative speeds of the water at the two points without knowing the pressure in the pipe at those points.

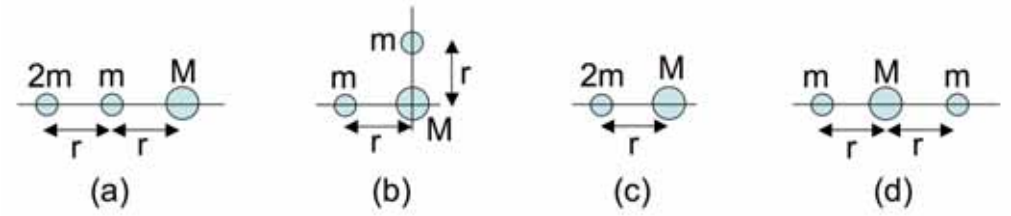
2. A small mass of 0.12 kg is undergoing simple harmonic motion with an amplitude of 0.85 m and an angular frequency of $\omega = 2.1$ rads/s. What is the maximum value of the force acting on the mass?

   a. 0.45 N
   b. 0.10 N
   c. 0.37 N
   d. There is not enough information given to determine this force.
   e. None of the above.

3. A wire, 2.0 m long, with a mass of 40 g, is under tension. A transverse wave propagates down the wire. The wave's frequency is 330 Hz; the wavelength is 0.50 m; and the amplitude is 2.9 mm. The time for a crest of the transverse wave to travel the length of the wire, in milliseconds, is closest to:

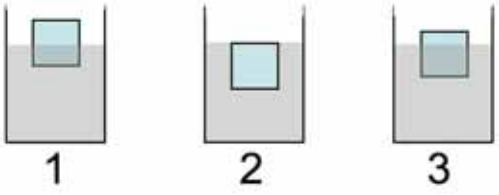
   a. 12
   b. 11
   c. 14
   d. 15
   e. 16

4. For which arrangement of masses below is the net force on mass M the largest?



a. (a)
b. (b)
c. (c)
d. (d)
e. (b), (c), and (d) are all equal and give the largest force on M.
f. Both (b) and (c) are equal and give the largest force on M.

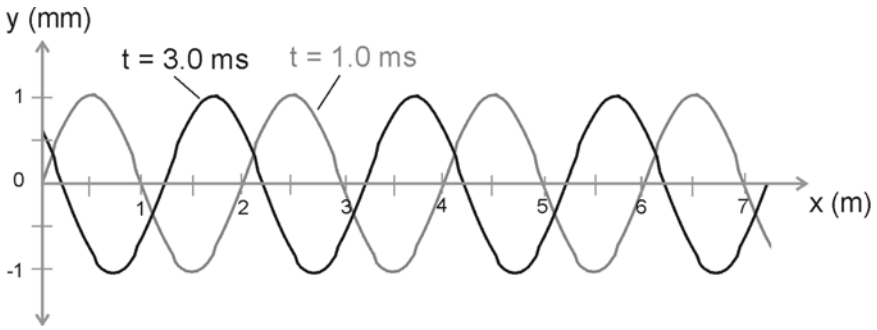
5. An identical mass is floated in three different liquids as shown in the figure below. The masses are all at rest. Which of the following statement(s) are true? *There may be more than one true statement; circle all that are true.*



a. Liquid 2 has the lowest density.
b. Liquid 2 is the same density as the mass.
c. The buoyant force on the mass is the same in all three liquids.
d. Liquid 1 exerts the largest buoyant force on the mass.
e. None of the above statements is true.

6. Graphs of displacement versus position are shown below for a single traveling sinusoidal wave at two different times. If the wave is traveling to the RIGHT (in the +x-direction), what is the smallest possible frequency of this wave?

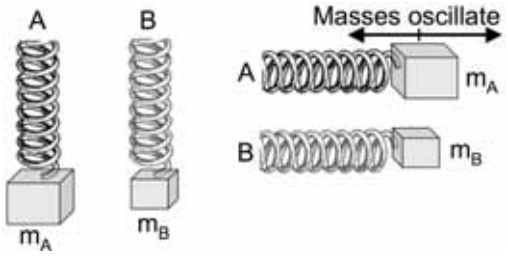
a. 100 Hz
b. 200 Hz
c. 300 Hz
d. 400 Hz
e. 600 Hz



7. The mean distance of the fictional planet Shadow from the Sun is 1.5 times that of the Earth from the Sun. Make the simplifying assumption that the orbits of Shadow and Earth are both circular. Estimate the number of years it takes Shadow to orbit the Sun.

    a. 1.8 yrs
    b. 3.4 yrs
    c. 2.3 yrs
    d. 1.2 yrs

8. When mass m_A is hung from spring A and a smaller mass m_B is hung from spring B, the springs are both stretched by the same distance. If you arrange the same springs and masses horizontally and put each mass into simple harmonic motion with the same amplitude, which system will have more mechanical energy (K + U)?

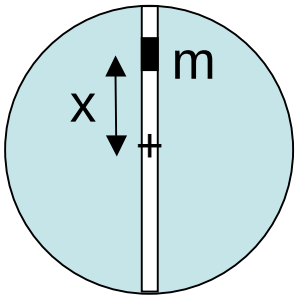


    a. System A (which has the heavier mass)
    b. System B (which has the lighter mass)
    c. They will both have the same energy.
    d. There is not enough information given to tell.

9. Superman's home planet of Krypton had double the mass and half the radius of Earth. The acceleration due to gravity on the surface of Krypton would be how many times greater than that on the surface of the Earth?

    a. 2
    b. 4
    c. 8
    d. 16
    e. The two would be the same.

10. **(25 pts)** An interesting, if somewhat fanciful, example of a Simple Harmonic Oscillator is the "Earth Elevator." A hole is cut through the center of the Earth so that a cylinder can move from one side of the earth to other. (The cylinder is used to carry cargo.) For simplicity, we will ignore the rotation of the earth in working this problem: we will assume the earth is a stationary uniform sphere.



One can show that the force of gravity on the cylinder is always directed towards the center of the earth and is proportional to *x*, the distance the cylinder is from the center of the Earth. Specifically:

$$F = -\frac{GM_e m}{R_e^3} x = m\frac{d^2x}{dt^2} = m\ddot{x} \quad [\text{Note}: \ddot{x} \equiv \frac{d^2x}{dt^2}]$$

Where G is Newton's gravitational constant, M_e and R_e are the mass and radius of the earth, and m is the mass of the cylinder.

a. What is the period of oscillations of the cylinder? I.e., if it starts on one side of the Earth, how long does it take to move to the other side and then come back? Express your answer in seconds.

b. Assuming the cylinder starts at the top of the Earth in the figure, how far is it from the center of the Earth 3600 seconds (one hour) later? Is it above the center of the Earth or below it?

c. What is the speed of the cylinder when it is at the center of the earth?