

Name \_\_\_\_\_

Please work the problems on separate sheets of paper and staple this sheet to the front. Read each problem carefully. *Show your work* and make sure that your answers are *clearly marked*, physically *reasonable*, and expressed with an appropriate number of *sig figs* and proper *units*. I give partial credit, but *only* if I can follow your work, so be as clear as possible about what you are doing.

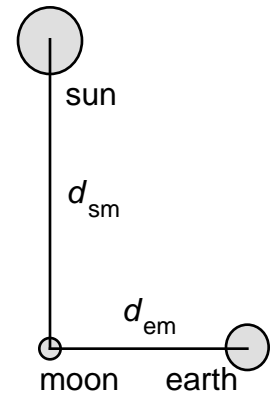
1. a) [17 pts] Find the *acceleration* (magnitude *and* direction) of the moon when it and the sun and the earth are in the positions shown at right. (Note that the drawing is not to scale and ignore any forces on the moon other than those due to the sun and the earth. Make sure that your answer is not ambiguous about the direction of the acceleration.)

Some data:

$$m_{\text{sun}} = 2.0 \times 10^{30} \text{ kg} \quad m_{\text{earth}} = 6.0 \times 10^{24} \text{ kg} \quad m_{\text{moon}} = 7.4 \times 10^{22} \text{ kg}$$

$$d_{\text{sm}} = 1.49 \times 10^8 \text{ km} \quad d_{\text{em}} = 3.8 \times 10^5 \text{ km}$$

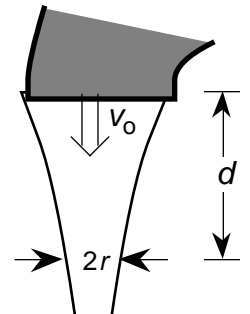
- b) [4 pts] Would you call this a large, moderate, or small acceleration? Compare it with something to support your answer.
- c) [4 pts] How would your answer to part a change if the mass of the moon were just 1 kg? Explain.



2. The highest pitched string (string 1) on a guitar has a fundamental frequency that is four times that of the lowest pitched string (string 6). They are the same length, are made of the same material, and are tightened to the same tension.
- a) [10 pts] What is the ratio  $\mu_1/\mu_6$  of the mass per unit length of string 1 to that of string 6?
- b) [15 pts] If string 1 has a diameter of 0.012 inches, what is the diameter of string 6?

3. The water stream flowing out of a faucet narrows in radius as it falls.

- a) [10 pts] Explain, briefly and clearly, *why*.
- b) [15 pts] Show how you obtain the equation for the radius  $r$  of the stream as a function of the distance  $d$  that it has fallen. (Your equation will also depend on the exit speed of the water from the faucet  $v_0$ , the radius of the faucet  $R$ , and the acceleration due to gravity  $g$ .)



4. A small body of mass  $m$  is attached to two (stretched) springs each with an *unstretched* length  $L$  and a force constant  $k$  as shown at right. Please ignore any effects of gravity in the following.

- a) [4 pts] Find an expression for the net force on the body if it is displaced a distance  $x$  to the right from its equilibrium position.
- b) [2 pts] If you let it go from the position in part a, would the oscillation be simple harmonic? Why or why not?
- c) [3 pts] Determine the angular frequency of the oscillations in part b.
- d) [9 pts] Repeat part a for a displacement by a distance  $y$  above the equilibrium position.
- e) [2 pts] If you let it go from the position in part d, would the oscillation be simple harmonic? Why or why not?
- e) [5 pts] Show that, for small amplitudes (i.e.,  $y_{\text{max}} \ll L$ ), the oscillation in part e *would* be approximately simple harmonic and determine the angular frequency of those oscillations.

