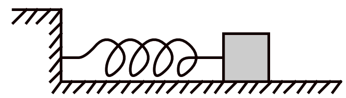
Name ____

PLEASE READ THIS FIRST: Work the problems on separate sheets of paper and staple this sheet to the front. Read each problem carefully. Show your work and/or give brief explanations for *all* answers. (But there is *no* need to be as "wordy" or formal as on the homework.) Make sure that all numerical answers are given with a reasonable number of sig figs and that you have included appropriate units. Check your answers for physical *reasonableness* whenever possible. I give partial credit, but *only* if I can figure out what you are doing, so be as clear as possible.

1. [10 pts] Fill out a simple table showing both the *SI units* and the *dimensions* of the indicated quantities:

   i) pressure, p ii) the force constant of a spring, k iii) the universal gravitation constant, G

2. [10 pts] A periodic wave with a frequency of 30 Hz and a wavelength of 40 cm travels along a string that is 8.0 m long and has a total mass of 200 g. What is the *tension* in the string?



3. [10 pts] A mass is attached to a spring as shown at right. It is then pulled to the right some distance and released at rest. *Just after* being released its acceleration is 60 m/s^2. As it passes the equilibrium position it has a speed of 5.0 m/s. The total energy of oscillation is 16 J. What is the angular frequency of oscillation? (*Big* hint: How are the indicated acceleration and speed related to the angular frequency and amplitude?)

   EXTRA CREDIT [5 pts] Suppose that I use a mass that is *twice* as large, but that I pull it the *same* distance away before releasing it in the *same* way. Now what is the

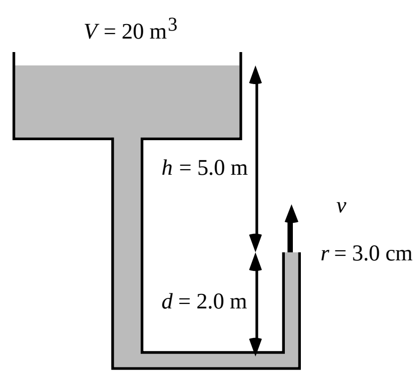
   i) initial acceleration ii) total energy of oscillation iii) speed as it passes the equilibrium position

4. Io is a moon of Jupiter that is approximately the size and mass of Earth's moon and whose nearly circular orbit also has approximately the same radius as that of Earth's moon. To be specific, Io has a mass of 8.9 x 10^{22} kg, an orbital radius of 4.2 x 10^5 km and an orbital period of 1.77 days.

   a) [4 pts] Why does this information tell us that the mass of Jupiter *must* be larger than that of the Earth? (Big hint: Compare the orbital periods and radii of the two bodies!)

   b) [4 pts] What is the orbital *speed* of Io? [Please don't make this complicated. It isn't!]

   c) [12 pts] *Starting with* Newton's second law (write it down!), *applying it* to Io, *using* Newton's law of gravitation, and *assuming* that Io's orbit is circular, obtain an equation and use it to find the *mass* of Jupiter.



5. A large, open air storage tank is filled with 20 m^3 of water. A pipe leads out of the bottom as shown and then turns upward . At its open air outlet, the pipe has a radius of 3.0 cm.

   a) [10 pts] What is the speed of the water as it emerges from the pipe?

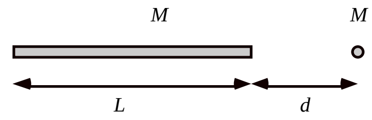
   b) [5 pts] Approximately how long will it take to empty the tank? [Hint: Assume that the speed of the outflowing water doesn't change much.]

   EXTRA CREDIT [5 pts] With the tank full, how high does the water shoot above the end of the pipe AND how would this answer change if you lowered the end of the pipe by 1.0 m?

[OVER for MORE]

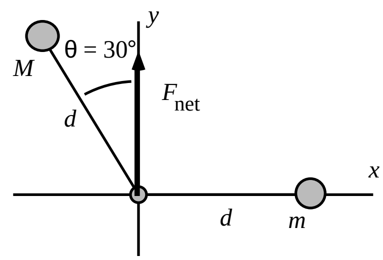
Score ____/100

6. [15 pts] A long thin rod with length L and uniformly distributed mass M gravitationally attracts a small sphere also having mass M that is located a distance d away from one end of the rod as shown. Find the net gravitational force on the small sphere. [Hints: Use a coordinate x that is measured from the right end of the rod. What is the infinitesimal mass of a small piece of the rod in terms of dx?]



EXTRA CREDIT [5 pts] Explain *what* your formula *should* reduce to in the case that $d >> L$ and *then* show that it *does.*

7. Two large bodies exert gravitational forces on a small body located at the origin as shown at right. One of the large bodies has a *given* mass m and the other has an *unknown* mass M. The distances to the centers of the large bodies and the *net* gravitational force on the small body are all indicated in the drawing. We want to find M in terms of m. But first ...



a) [4 pts] Explain *clearly* and in *just a few words* how we know for sure that $M > m$.

b) [4 pts] Draw a reasonably accurate vector diagram showing how the two *individual* forces add up to the indicated *net* force.

c) [10 pts] Use your diagram to find the ratio of the magnitudes of the two forces exerted *on* the small body F_M / F_m .

d) [2 pts]... and, therefore, find M in terms of m.