## **Physics 171** April 3, 2000 Exam # 2

Do the attached problems on the paper provided. Extra paper is available at the front of the room if you need more. Be sure to write your name and the problem number on any extra sheets you use!!

You may use your own pens, pencils, erasers, calculator and <u>one</u>  $8\frac{1}{2}$ " x 11" sheet of paper preprepared with any information you think you might need.

The exam will be graded on the basis of CLARITY of PRESENTATION of your reasoning, as well a correctness of the final answer. You must also show the units on numerical answers to obtain full credit.

Name

- 1. A block of mass m1 = 12.5 kg is sitting on a rough surface. The coefficients of friction between the block and the surface are  $\mu_s = 0.75$ , and  $\mu_k = 0.30$ . A cable is attached to the block and passes over an ideal massless pulley as shown in the drawing. A second mass m2 is suspended from the cable.
- a) Draw and label on the diagram all of the forces acting on each of the masses.
- b) If m2 = 10 kg, the two masses move with uniform acceleration. Find the tension in the cable in this case.
- c) Find the total work done on mass m1 for 1.20 m of displacement during the constant acceleration of part (b).



- 2. A molecule approaching another molecule radially experiences (at small distances) a repulsive force  $F(R) = 12\varepsilon \left(\frac{r_o^{12}}{R^{13}}\right)$ , where  $\varepsilon$  and  $r_o$  are constants.
- a) Find the potential energy corresponding to this force. Specify your choice of the zero of potential energy.
- b) For nitrogen (N<sub>2</sub>, mass =  $4.65 \times 10^{-26}$  kg), the values of the parameters are  $\varepsilon = 1.31 \times 10^{-21}$ J and  $r_0 = 0.415$  nm. If a nitrogen molecule is placed at a distance  $R_1 = 0.6$  nm away from another nitrogen molecule, find the value of its potential energy.
- c) If the molecule is released from rest ( $v_1 = 0$  m/s) at position  $R_1$ , find its speed when it reaches a distance  $R_2 = 5$ nm from the other molecule. (Assume the other molecule is stationary.)

3. Show that the force due to gravity near the surface of the earth is accurately approximated as a constant, F = mg, and derive the value  $g = 9.8 \text{ m/s}^2$ .

The binomial approximation is:  $(1 \pm x)^n \approx 1 \pm nx$  $(1 \pm x)^{-n} \approx 1 \mp nx$ 

- 4. A satellite of mass 2200 kg is in geosynchronous orbit above the earth. This means that it stays above the same place on the earth's surface, so that its period of revolution is T = 24 hours.
- a) Find the radius of the satellite's orbit and its velocity.
- b) If the satellite is to be "boosted" from its orbit so that it escapes entirely from the earth's gravitational pull, how much energy would be needed?
- c) If the energy needed for part b could be provided with direct conversion of mass to energy, how much mass would be needed?