Name _____

You may use two sheets of notes (8-1/2 x 11, both sides) and a standard calculator. No communication or photographic devices. No hats. Work the problems on separate sheets of blank paper and staple *this* sheet to the front.

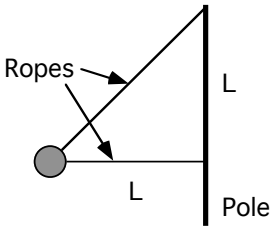
Read each problem *carefully* and be sure to pay attention to any hints that are provided. The credit you receive on each problem will depend at *least* as much on how you get your answer as on what answer you get. There is *no* need to be "wordy" as I ask you to be on homework, but you must show your work or give at least a brief explanation for *every* answer. I give *no* credit for unsupported answers. I give partial credit for partially correct solutions, but *only* when I can figure out what you are doing, so be as clear as possible. Make *certain* that all numerical answers are given with a reasonable number of significant digits (when in doubt, three is usually a good compromise) and that you have included *appropriate* and *simplified* units. Check your answers for physical *reasonableness* whenever possible; I do deduct a small number of points for ridiculous answers that go uncommented upon. In every problem you may use $g = 10.0$ N/kg in order to make the computations simpler.

1. Consider the two vectors $\mathbf{A} = \left(3.0\hat{\mathbf{x}} - 2.0\hat{\mathbf{y}}\right)$ m and $\mathbf{B} = \left(4.0\hat{\mathbf{y}} - 1.0\hat{\mathbf{z}}\right)$ N.
   a) [4 pts] Find their scalar product.
   b) [4 pts] Find their vector product.
   c) [4 pts] Find the angle between them.

2. A 300 gram hockey puck is subject to 75 mN of frictional force as it glides across the ice.
   a) [4 pts] What is the *magnitude of the acceleration* of the hockey puck.

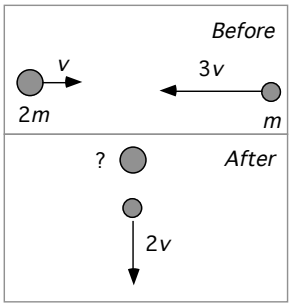
   The puck is given an initial speed of 25 m/s after which it glides the full length of a 50 m rink.
   b) [8 pts] How *fast* is it moving when it reaches the other end of the rink? [Hint: Use the method!]

3. A ball is tethered to a vertical pole by two ropes as shown at right. It moves around the pole at a constant speed constrained by the ropes to move in a circular path. The tension in the shorter (horizontal) rope is equal to the ball's weight.



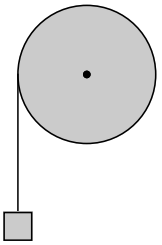
   a) [6 pts] What is the tension in the longer rope? Give your answer in terms of the ball's weight. [Hint: Use the method!]
   b) [9 pts] If the length of the shorter rope is 1.5 m, how long does the ball take to make one revolution? [Hint: Find it's speed and the circumference of its circular path!]

4. Two particles approach each other from opposite directions as shown top right. Their masses and speeds are as shown (in terms of m and v which may be considered to be "given.") They suffer a glancing collision that deflects the lighter particle *counterclockwise through an angle of 90 degrees* and leaves it moving with the speed shown below right.



   a) [10 pts] Find the velocity of the heavier particle after the collision. Give its speed in terms of v and its direction in terms of the angle of deflection from its original direction as I did (above, in italics) for the lighter particle.
   b) [5 pts] Was this an elastic collision? Explain clearly.

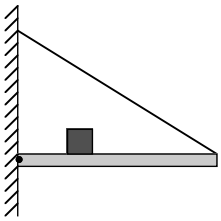
5. [12 pts] A 5.0 kg disk is or radius 15 cm is free to rotate about its axis, which is held fixed and horizontal. A string is wrapped around the perimeter and a 1.0 kg block is attached to its free end. What is the linear acceleration of the block when it is released? [Hint: Consider the forces on the block and the torque on the disk.



   EXTRA CREDIT [5 pts] At any later time, what is the ratio of the kinetic energy of the disk to that of the block?

(over)

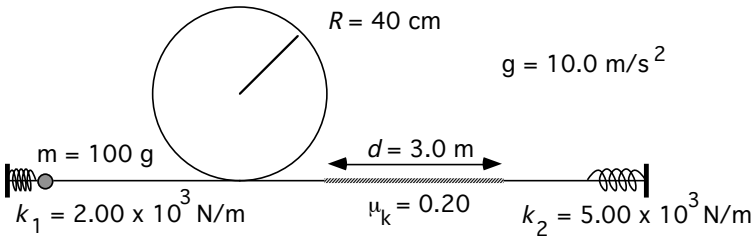
6. [15 pts total] A uniform 200 kg beam with a length of 6.0 m is pinned to the wall at one end and supported in a horizontal position by a cable attached to its other. The cable makes an angle of 30° with the beam and will support a maximum tension of 10.0 kN before breaking. A compact 600 kg load is supported on the beam at a distance x from the wall.



   a) At what minimum value of x will the cable break?

   b) What are the horizontal and vertical components of the force applied to the beam by the pin at the wall when the cable is *just about* to break?

7. A bead slides along a wire in the shape shown at right. The wire passes through a hole in the bead so the bead *cannot* lose contact with the wire. The wire has a circular loop in the middle and springs at each end. The bead moves without friction except on a rough 3.0 m portion of the wire to the right of the loop along which there is a frictional force equal to 0.20 times the weight of the bead. The bead is initially pressed against the spring at the left end of the wire compressing the spring by 5.0 cm and then released.



   a) [5 pts] How much kinetic energy does the bead have just after losing contact with the spring?

   b) [5 pts] How fast is the bead moving the first time it gets to the top of the loop? Please take $g = 10.0$ m/s^2 to make the numbers simpler.

   c) [5 pts] How much mechanical energy does the bead lose as it passes across the rough part of the wire?

   d) [5 pts] How many times total does the bead pass over the top of the loop?

   EXTRA CREDIT [5 pts] Describe *in detail* what the bead does as time goes on.