

Name (Print): \_\_\_\_\_

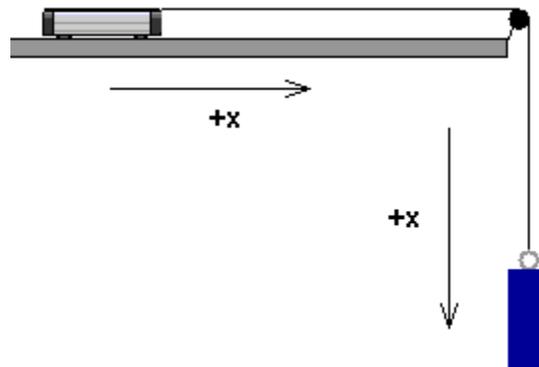
Pledged (Signed): \_\_\_\_\_

This test should be completed during one regular 50 min class period.

Your problem solving approach counts! Be sure and show all work including basic formulas and diagrams.

Do all of the following problems. Start each problem on a fresh page or the back of a page. Clearly label the problem number. Place the answers in order and staple the sheets as you turn in the test. Sign and **pledge** this sheet.

1. (25 pts) A rifle is aimed at a target 50 m away. The bullet leaves the barrel at 400 m/s. If the gun is aimed horizontally directly at the bull's eye, by how many cm will the bullet miss the target? By how many cm will the bullet miss the target if the distance to the target is doubled? Ignore friction.
  
2. (24 pts) A mass  $M_1$  **hangs** over a table pulling a second mass  $M_2$  **along the top** of the table as shown. The mass on the tabletop has a coefficient of static friction of  $\mu_s$  and a coefficient of kinetic friction of  $\mu_k$ . Assume that the string and the pulley are massless and that the pulley is frictionless. Draw free body diagrams where appropriate as you do the following:
  - a. Derive a formula for the smallest coefficient of friction  $\mu_s$  that will cause the system to remain stationary?
  - b. Derive a formula for the acceleration of  $M_1$  if  $\mu_k$  is smaller than the value found in (a)?
  - c. Assume that  $M_1 = 300$  gr,  $M_2 = 200$  gr, and  $\mu_k = 0.5$ . Find the acceleration and the tension in the string.



3. (20 pts) A small coin is placed a distance  $R$  from the center of a rotating turntable.
- Draw a free body diagram.
  - Derive a formula for the maximum frequency of rotation (rotations per second) without the coin slipping.
  - Assume the 10 gram coin is placed 15 cm from the center and that the coefficient of friction between the coin and the turntable is 0.4. At what frequency of rotation will the coin slip off?
4. (15 Points) Two objects A and B fall from rest from different heights to the ground. If object B takes twice as long as A to reach the ground, what is the ratio of the heights from which A and B fell? What is the ratio of their velocities? Neglect air resistance.
5. (16 Points) Two objects A and B start from the same point and travel in different directions. The position of object A is given by  $\mathbf{r}_A = 2 t^2 \mathbf{i} + 3 t \mathbf{j}$  meters where  $\mathbf{i}$  and  $\mathbf{j}$  are unit vectors along the x and y axes. The position of object B is  $\mathbf{r}_B = 6 t \mathbf{i}$  meters.
- What is the displacement of B with respect to A and how far apart are the objects at  $t=2s$ ?
  - What is the relative velocity of object B with respect to object A and the speed of separation at  $t = 2s$ ?
  - What is the relative acceleration of object B with respect to object A at  $t = 2s$ ?
  - Assume you are a physicist riding on object A. Are Newton's laws valid? What if you are riding on object B? Explain.