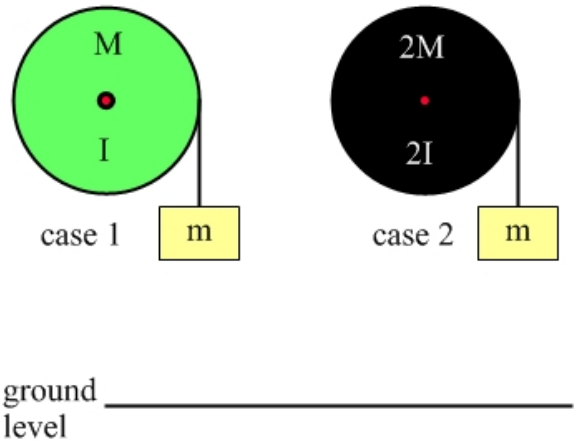
PROBLEM 1 – 15 points



Case 1 and case 2 show two situations of a block hanging from a string wrapped around the outside of a pulley. The blocks are identical, and the pulleys are uniform solid disks of the same radius, but the pulley in case 2 has twice the mass (and therefore twice the moment of inertia) of the pulley in case 1. The systems are released from rest at the same time from the same height above the ground, and in both cases the block accelerates down. Neglect friction.

[3 points] (a) In which case is the acceleration of the block larger?
[ ] case 1 [ ] case 2 [ ] equal in both cases

Briefly justify your answer:

[3 points] (b) In which case is the tension in the string, while the block is falling, larger?
[ ] case 1 [ ] case 2 [ ] equal in both cases

Briefly justify your answer:

[3 points] (c) In which case is the net torque on the pulley, while the block is falling, larger?
[ ] case 1 [ ] case 2 [ ] equal in both cases

Briefly justify your answer:

[3 points] (d) In which case does the block have a higher speed after falling through a distance *h*?
[ ] case 1 [ ] case 2 [ ] equal in both cases

Briefly justify your answer:

[3 points] (e) In which case does the pulley have a larger rotational kinetic energy, measuring the kinetic energy at the instant the block reaches the ground in each case?
[ ] case 1 [ ] case 2 [ ] equal in both cases

Briefly justify your answer:

PROBLEM 2 – 20 points

A uniform solid sphere with a mass of M = 5.0 kg and radius R = 20 cm is rolling without slipping on a horizontal surface at a constant speed of 5.0 m/s. It then encounters a ramp, and proceeds to roll without slipping up the ramp. The goal of this problem is to determine the maximum height reached by the sphere on the ramp before it turns around, and to use conservation of energy to do so. Use g = 10 m/s^2.

[3 points] (a) Sketch this situation, showing the sphere in two positions, one at the bottom of the ramp and the other when the sphere reaches its highest point.

[3 points] (b) Start with the usual conservation of energy equation: $K_i + U_i + W_{nc} = K_f + U_f$. Identify all the terms that are zero in this equation, and explain why they are zero.

[4 points] (c) Write out expressions for the remaining terms. Remember to account for both translational kinetic energy and rotational kinetic energy, if appropriate. Keep everything in terms of variables.

[6 points] (d) How far does the sphere roll up the ramp (measuring the vertical distance)? First find an expression for this distance in terms of variables, simplified as much as possible, and then plug in the appropriate values.

[4 points] (e) If a block slides without friction up the ramp, starting at the bottom with the same initial speed as the sphere, which object travels farther up the ramp?

[ ] the sphere [ ] the block [ ] they travel equal distances

Briefly justify your answer:

PROBLEM 3 – 10 points

A particular horizontal turntable can be modeled as a uniform disk with a mass of 200 g and a radius of 20 cm that rotates without friction about a vertical axis passing through its center. The initial angular speed of the turntable is 2.4 rad/s. A ball of clay, with a mass of 80 g, is dropped from a height of 35 cm above the turntable. It hits the turntable at a distance of 10 cm from the center, and sticks where it hits so that the clay and the turntable rotate together at a new angular speed. Assuming the turntable is firmly supported by its axle so it remains horizontal at all times, find the final angular speed of the turntable-clay system.

Show your work, and explain what you're doing!