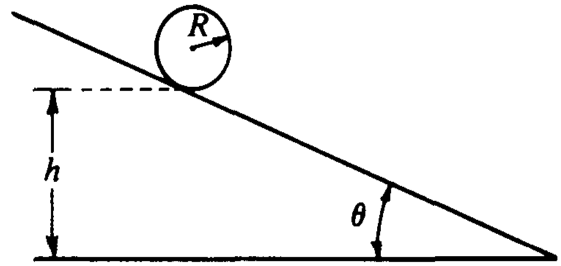
Rotational Dynamics Olympics

1. An inclined plane makes an angle of θ with the horizontal, as shown above. A solid sphere of radius R and mass M is initially at rest in the position shown, such that the lowest point of the sphere is a vertical height *h* above the base of the plane. The sphere is released and rolls down the plane without slipping. The moment of inertia of the sphere about an axis through its center is $2MR^2/5$. Express your answers in terms of M, R. *h,* g, and θ.



a. Determine the following for the sphere when it is at the bottom of the plane:
i. Its translational kinetic energy
ii. Its rotational kinetic energy

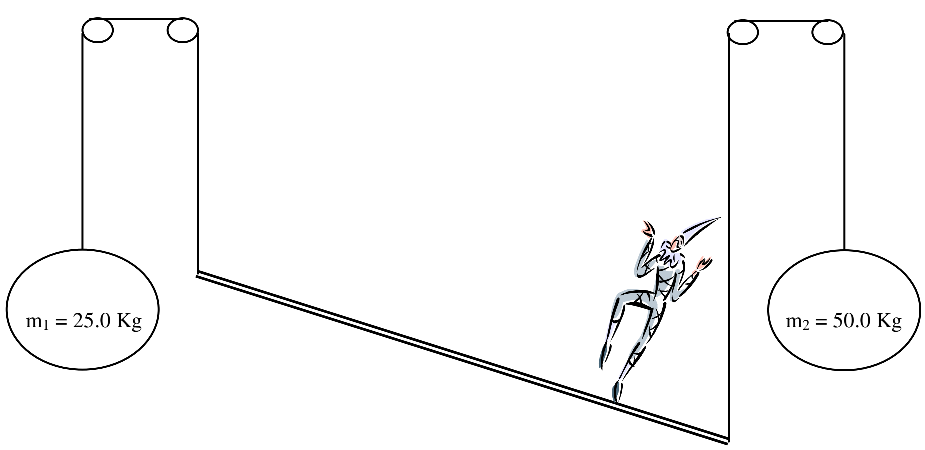
b. Determine the following for the sphere when it is on the plane.
i. Its linear acceleration
ii. The magnitude of the frictional force acting on it

The solid sphere is replaced by a hollow sphere of identical radius R and mass M. The hollow sphere, which is released from the same location as the solid sphere, rolls down the incline without slipping.

c. What is the total kinetic energy of the hollow sphere at the bottom of the plane?

d. State whether the rotational kinetic energy of the hollow sphere is greater than, less than, or equal to that of the solid sphere at the bottom of the plane. Justify your answer.

2. Consider a dancing clown (m_c = 67.0 kg) balancing on a uniform plank (m_P = 8.00 kg, Length = 4.00m.) Measured from plank's edge closest to m_1, where should the clown stand such that the plank is horizontal? Assume the ideal pulleys; massless and frictionless.



3. Consider a tricycle riding clown, initially at rest at the top of a tall hill. Each wheel on the tricycle has a mass of 4.00 kg, a radius of 0.250 m and can be approximated to be solid disks. At the bottom of the hill is a vertical loop with a radius of 4.50 m. Beyond the loop is a linear ramp inclined at $\theta = 32.0°$ ending at a height of 4.50 m. At the top of the ramp, a miracle occurs and the angular speed of the wheels is instantly transferred to the angular speed of the clown as she freefalls towards the ground.

A. Predict and calculate the minimum height the clown must start at to “safely” complete the vertical loop.

B. Predict and calculate the freefall range of the clown.

C. Predict and calculate the number of complete revolutions the clown makes during her freefall.