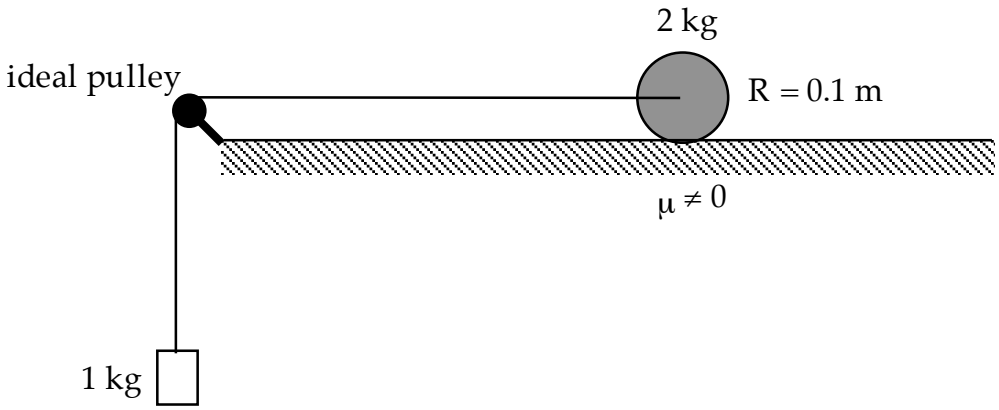
This problem is open book and open notes. You may not consult or confer with anyone *other than Mr. Burns*. Full credit will be awarded for each problem only if the correct answer is accompanied by sufficient work that is presented in such a manner that the logic and mathematical operations are clear and easy to follow. All answers must be boxed, labeled and accompanied by the appropriate units. Do each problem on a separate sheet.

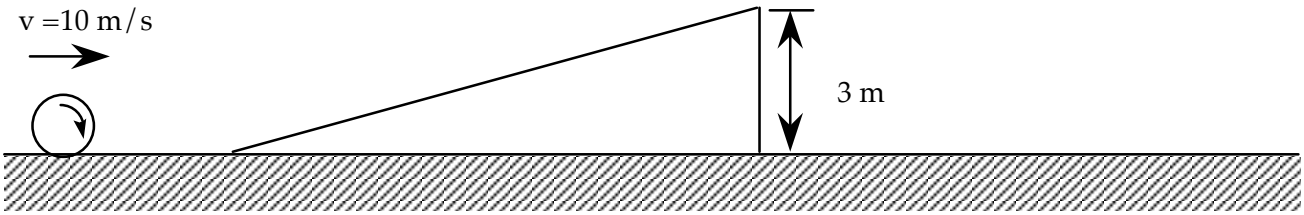
1.



(12) A solid sphere ($I = (^2/_5) MR^2$) with a radius R = 0.10 m is attached to a massless rope by a frictionless axle that passes through the center of the sphere. The rope passes over an ideal pulley and is connected to a 1 kg block. The sphere has a mass of 2 kg. The surface has a $\mu \neq 0$. Assume that the ball always rolls without slipping and that the system is released from rest. Calculate

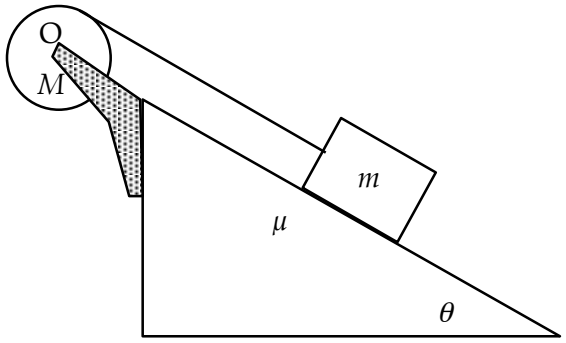
a. the acceleration of the system
b. the tension in the rope
c. the speed of the 1 kg mass, by energy methods, after it has descended 0.25 m.

d. If the ideal pulley is replaced with a real pulley (i.e., a pulley with a finite mass), describe what happens to the acceleration of the system and the tension(s) in the rope. Explain your reasoning in each case.



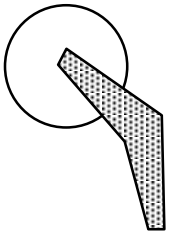
2. (8) A large sphere rolls without slipping across a horizontal surface. The sphere has a constant translational speed of 10 m/s, a mass, M, of 25 kg and a radius, R, of 0.2 m. The moment of inertia of a sphere about its center of mass is $I = (2/5)MR^2$. The sphere approaches a 25° incline of a height of 3 meters as shown above and rolls up the incline without slipping.
   a. Calculate the total kinetic energy of the sphere as it rolls along the horizontal surface.
   b. Calculate the magnitude of the sphere's velocity just as it leaves the top of the incline.
   c. Suppose, instead, that the sphere were to roll toward the incline as stated above, but the incline were frictionless. State whether the speed of the sphere just as it leaves the top of the incline would be less than, equal to, or greater than the speed calculated in (b). Explain briefly. (A derivation does not constitute an explanation.)

3. (10) A block with mass m slides down an inclined surface (at angle θ) as shown in the figure to the right. The coefficient of kinetic friction is μ. A string attached to the block is wrapped around a flywheel on a fixed axis O. The flywheel has a mass M, and an outer radius R, and a moment of inertia βMR^2 with respect to the axis.

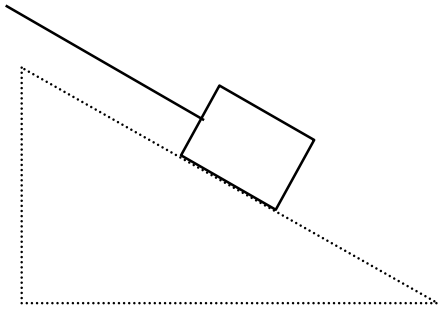


a) Draw and label a complete free-body diagram for the forces acting on

i) the flywheel



ii) the block on the incline



b) Derive, in terms of known quantities m, M, μ, R, g, θ and β **only**, a relationship for the acceleration of the mass down the incline?