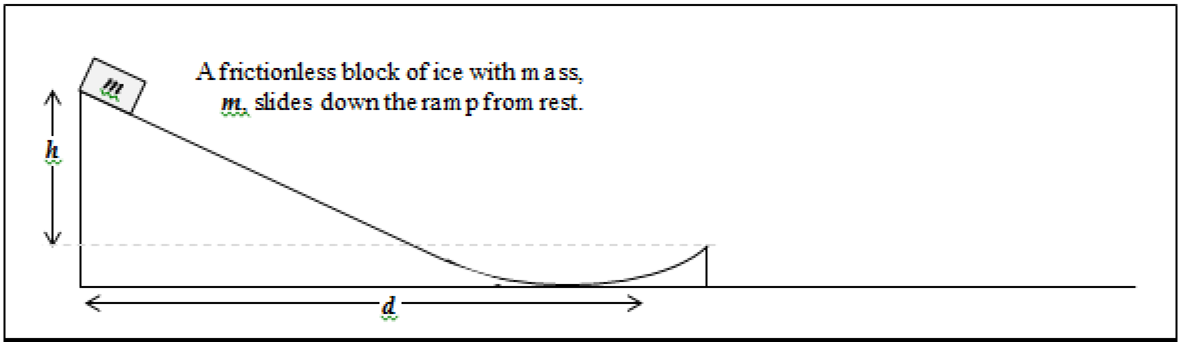
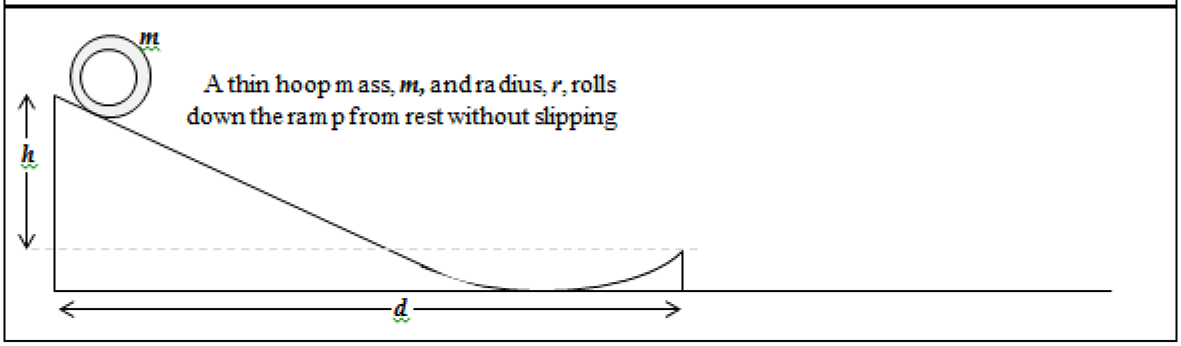


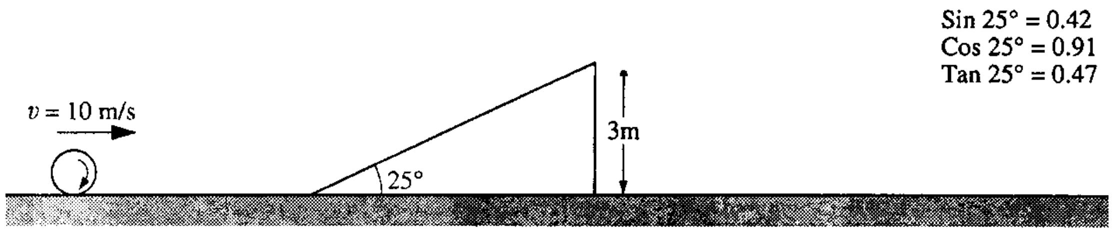


1. Students in a physics class placed two objects on the top of a ramp as shown in the diagrams above. The ramp has a small rise at the end which causes objects to be launched upwards at a small angle. First the students placed a block of ice (which has no friction with the ramp's surface) at the top of the ramp and released it. Next, the students placed a thin hoop at the top of the ramp and released it.

a) Which of the two objects, if either, reaches a greater height after leaving the ramp? Justify your answer qualitatively without any equations.

b) Which, if either, would reach a greater height if the hoop was also made of ice and slid down the ramp without rolling? Justify your answer qualitatively without any equations.

c) Suppose the final angle of the ramp is 30º. How can the maximum height of each be determined?



Note: Diagram not drawn to scale.

2. A large sphere rolls without slipping across a horizontal surface. The sphere has a constant translational speed of 10 meters per second, a mass m of 25 kilograms, and a radius r of 0.2 meter. The moment of inertia of the sphere about its center of mass is $I = 2mr^2/5$. The sphere approaches a 25° incline of height 3 meters as shown above and rolls up the incline without slipping.

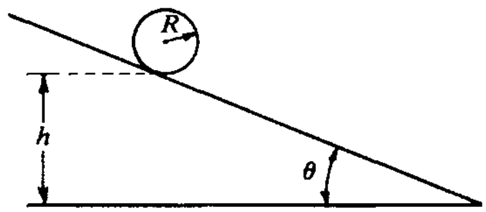
a. Calculate the total kinetic energy of the sphere as it rolls along the horizontal surface.

b. i. Calculate the magnitude of the sphere's velocity just as it leaves the top of the incline.

ii. Specify the direction of the sphere's velocity just as it leaves the top of the incline.

c. Neglecting air resistance, calculate the <u>horizontal</u> distance from the point where the sphere leaves the incline to the point where the sphere strikes the level surface.

d. 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.



3. 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 B.

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.

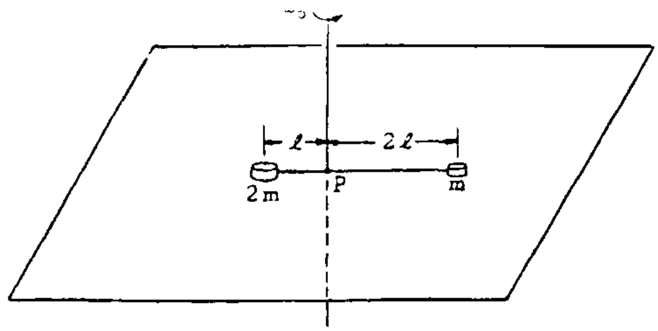
   i. Its linear acceleration

   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. If the rotational inertia of a hollow sphere is $2MR^2/3$, explain why it will reach the bottom of the plane traveling slower than the solid sphere.

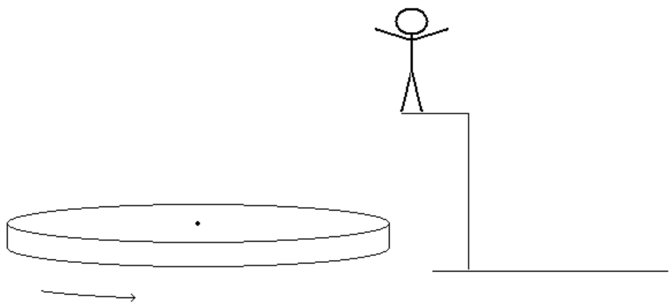


4. A system consists of two small disks, of masses m and 2m, attached to a rod of negligible mass of length $3l$ as shown above. The rod is free to turn about a vertical axis through point P. The two disks rest on a rough horizontal surface; the coefficient of friction between the disks and the surface is μ. At time $t = 0$, the rod has an initial counterclockwise angular velocity ω_o about P. The system is gradually brought to rest by friction. Develop expressions for the following quantities in terms of μ m, l, g, and ω_o

a. The initial angular momentum of the system about the axis through P

b. The frictional torque acting on the system about the axis through P

c. The time t at which the system will come to rest.



5. A solid disk ($I = \frac{1}{2}MR^2$) has a mass of 20M and a radius of 4R. The disk begins spinning at an angular velocity ω_0. An acrobat with a mass of 2M then jumps straight down onto the edge of the disk.

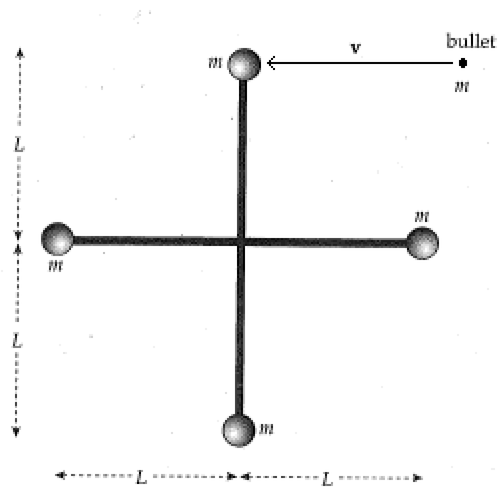
a. What is the angular velocity of the disk after the acrobat has landed?

b. What is the linear velocity of the acrobat?

c. What is the final kinetic energy of the spinning system?

d. How will the following possible modifications change the answer to (a)?

	ω after increases	ω after decreases	ω after is unaffected
Increase the mass of the disk			
Increase the mass of the acrobat			
Increase the initial height of the acrobat			
Have the acrobat land closer to the disk's center			
Have the acrobat land more softly			



6. Two slender uniform bars, each of mass *2m* and length *2L*, meet at right angles at their midpoints to form a rigid assembly that's able to rotate freely about an axis through the intersection point, perpendicular to the page. Attached to each end of each rod is a solid ball of class of mass *m*. A bullet of mass *m* is shot with a velocity *v* as show in the figure (which is a view from above the assembly) and becomes embedded in the targeted clay ball. The rotational inertia of bar around its center is $ML^2/12$.

(a) Determine the angular velocity of the system after the bullet has become lodged in the clay ball.

(b) What is the resulting linear speed of each clay ball?

(c) What is the final kinetic energy of the system?