1. One morning, a skier starts downhill, starting from rest at point A at height $y = h_A = 110. \text{ m}$ and sliding over frictionless snow through valley B ($y_B = 0$) and over hill C ($y = h_C = 55.0 \text{ m}$). Her mass is $m = 55.0 \text{ kg}$.

   a) (6 pts) What is her speed at B?

   b) (7 pts) What is her speed at C?

   c) (7 pts) She returns to the slopes in the afternoon when the snow is getting mushy, so now there is friction between the skis and the snow. If the frictional force is constant for the whole trip covering a distance along the slopes from A to C, $d_{ABC} = d = 1000. \text{ m}$, what is the largest frictional force that still allows her to reach the top of hill C?
2. Two students, each with mass $m = 40.0$ kg, are riding on an amusement park car of mass $M = 20.0$ kg which slides on a frictionless surface. The car and students are initially travelling with a velocity $\vec{V} = 2.00\hat{x}$ m/s. One of the students jumps off the car with velocity (relative to the floor) of $\vec{v}_1 = 1.00\hat{x} + 0.400\hat{y}$ m/s.

a) (7 pts) Find the $x-$component of the velocity, $v_{2x}$, of the car with the remaining student after the first one jumped.

b) (7 pts) Find the $y-$component of the velocity, $v_{2y}$, of the car with the remaining student after the first one jumped.

c) (6 pts) The student who jumped off skids across the floor (no friction) and hits the bumper spring at the edge of the floor and is momentarily brought to rest. The spring constant is $k = 3000$ N/m. What is the compression of the spring?
3. When driving your car, you notice a stop sign at $t = 0$, while traveling at $v_0 = 18.0 \text{ m/s}$. You hit the brakes and decelerate with a constant acceleration to come to rest at the stop sign after 20.0 s. The tires on your car have a radius of 0.75 m. The car rolls without slipping during the deceleration.

a) (5 pts) what is the initial angular velocity of each wheel?

b) (5 pts) What is the angular acceleration of the wheels? (Assume constant angular acceleration.)

c) (5 pts) How many turns did the wheels make during the stopping process?

d) (5 pts) How far did the car travel before coming to a stop?
4. The axle at the center of a uniform cylinder of mass $M = 1.30$ kg and radius $R = 0.50$ m is attached by a massless string that passes over a massless pulley and is tied to a mass $m = 0.400$ kg hanging vertically as shown. The string connects to the axle of the cylinder by means of a small loop around the axle, which has no friction with the axle. The system (cylinder, pulley and mass) starts from rest at $t = 0$. The cylinder rolls on the horizontal surface without slipping, so has both translational and rotational motion. You may take the moment of inertia of the cylinder about its axle to be $I_{\text{axle}} = \frac{1}{2} MR^2$. (You probably won’t need this, but the moment of inertia of the cylinder about the point of contact with the surface is $I_{\text{pt}} = \frac{3}{2} MR^2$.)

a) (7 pts) Using conservation of energy, find the speed of the center of mass of the cylinder (at its axle) when the mass $m$ has dropped a distance $h = 0.600$ m and hits the ground.

b) (6 pts) What is the angular momentum of the cylinder when the mass hits the ground?

c) (7 pts) The force of friction, $F_f$, at the contact point between the cylinder and the surface provides the torque needed to give angular acceleration to the cylinder: $\tau = F_f R = I \alpha$. Draw the force diagrams for the cylinder and hanging mass, and find the acceleration of the cylinder axle.
5. A sign of mass $m = 25.0$ kg hangs from the end of a uniform horizontal bar of mass $M = 15.0$ kg. A wire is attached from the building to the end of the bar with an angle $\theta = 25.0^\circ$ as shown.

a) (8 pts) Find the tension in the wire.

b) (6 pts) Find the horizontal force exerted by the building on the bar at its left end (specify its direction – left or right).

c) (6 pts) Find the vertical force exerted by the building on the bar at its left end (specify its direction – up or down).