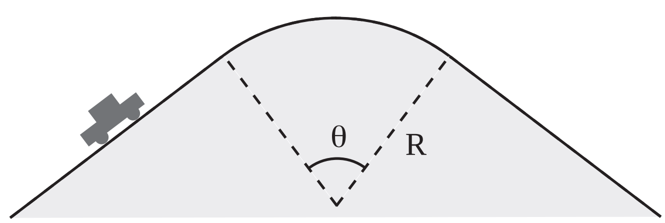
Homework #5

Due Monday, Mar. 7

1. A "barrel of fun" is a ride at an amusement park where the riders stand inside a cylinder of diameter 5 m. The walls of the cylinder are vertical. The cylinder begins to rotate, reaching a speed of 0.90 rotations per second. The floor then drops away, and the riders are "stuck to the wall." Find the minimum coefficient of static friction between the rider and the wall that prevents the rider from slipping down.

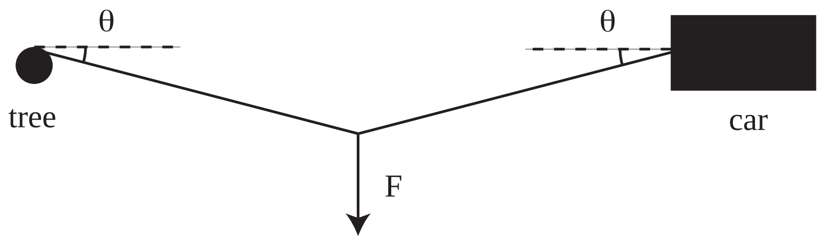
2. A cart of mass 8.0 kg is on horizontal ground, and has a box of mass 15 kg placed on top of it. The coefficients of friction between the cart and the box is $\mu_s = 0.34$ and $\mu_k = 0.21$, while the friction between the cart and the ground is negligible. The cart and the box are set into motion by pushing horizontally on the box. What is the maximum acceleration that the cart can have without the box sliding on the cart?

3. A car goes over a hill with a constant speed v. The shape of the hill is a straight incline with angle θ, followed by a circular portion with radius R, as shown.



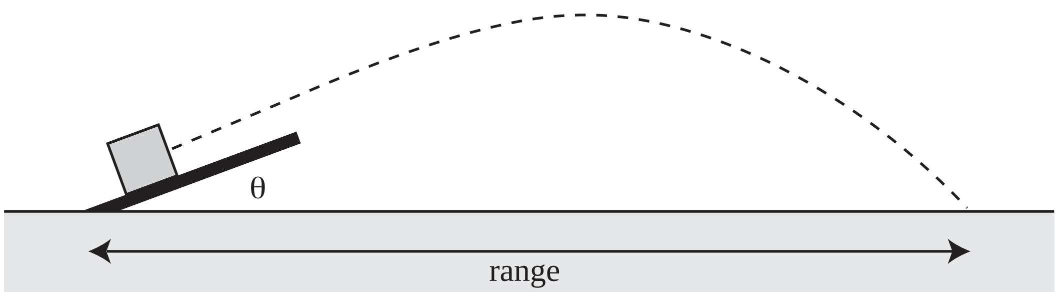
What is the maximum speed that the car can have so that it makes it over the hill without the tires losing contact with the road? If it goes slightly faster than this maximum speed, where does the car leave the road? *Hint:* Be sure to consider both the top of the hill and the point where the hill goes from being straight to being circular.

4. A car is stuck in the mud, and a force of 3000 N is required to move it. The driver has a rope, but he is a physics student who has no time to go to the gym, and so can only exert a force of 1000 N by pulling on the rope. He notices a tree nearby, and ties one end of the rope to the tree and the other to the car. He then takes another length of rope and uses it to pull on the middle of the rope connecting the car and the tree. As the driver pulls on the rope with force F, the rope connecting the car and the tree makes an angle θ relative to the line between the car and the tree, as shown below.



For what angles θ will the car be pulled out of the mud? What happens for very small values of θ?

5. A small block is given an initial velocity 4.5 m/s up a ramp of length 0.15 m that is inclined at an angle of θ above the horizontal. The coefficient of kinetic friction between the block and the surface of the ramp is 0.20.



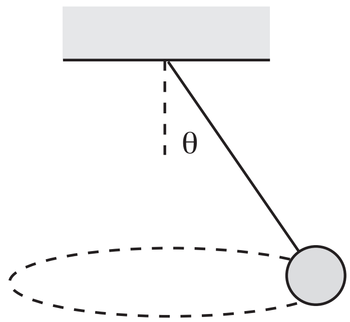
Find the maximum range of the block, defined to be the horizontal distance from where the block starts up the ramp to the place where it hits the ground. Do this by plotting the range as a function of θ and estimating the maximum range from the graph.

6. This problem refers to figure 6-62 in your book. Suppose that the coefficients of friction between the blocks and the surface is $\mu_k = 0.23$ and $\mu_s = 0.33$.

(a) If the system is initially at rest, does it remain at rest?

(b) If the lower block is given an initial velocity 0.40 m/s, what is its subsequent acceleration? Does it slow down or speed up?

7. A ball of mass m is attached to a string of length ℓ, which is attached to the ceiling. The ball is set into motion so that it travels in a horizontal circle, with the string making an angle θ with the vertical, as shown.



Find the time it takes to make a single rotation as a function of m, ℓ, θ, and of course g. Check that your formula makes sense by taking at least two different limits where you know the answer.