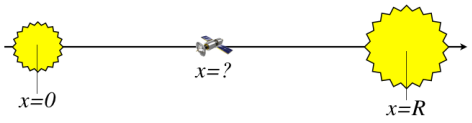
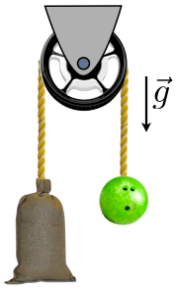
Exam #1 Physics 1501Q, Fall 2013 **BOX AND LABEL YOUR ANSWERS!**

1. A train, starting from rest at position x=0 at time t=0, accelerates to the east with a constant acceleration 0.5 m/s^2. A conductor walks from the front of the train toward the back at a constant speed 0.4 m/s with respect to the train.
(a) Write an equation of motion $x(t)$ for the train using the following conventions: x is measured in meters and increases to the east and time is measured in seconds. Include units.
(b) Using the same conventions, write an equation of motion for the passenger as measured from the ground. Include units.
(c) While continuing to walk at constant speed with respect to the train, the conductor gently lifts his pocket watch so that it hangs motionlessly. Does the hanging watch lean toward the front of the train, toward the back of the train, or does it hang vertically?

2. A binary star system consists of a star α with mass M_α and a star β with a mass M_β=4M_α. If α is at location x=0, and β is at position x=R, at what location is the force of gravity on a satellite zero?

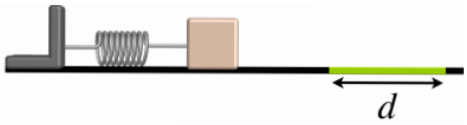


3. A massless pulley hangs from the ceiling, and supports a massless rope. On one end of the rope, a mass M is attached and at the other end a mass 3M is attached. The two masses hang initially at the same elevation and are let go.
(a) What is the magnitude of the sum of all forces on the pulley?
(b) What is the acceleration (direction and magnitude) of the lighter mass?

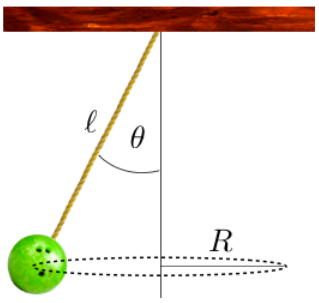


4. As a party trick, you pull a napkin with a uniform acceleration a from under a 0.5 kg glass. The coefficient of static friction between the glass and the napkin is μ_s=0.2.
(a) What is the minimum value a_c such that the glass slides under the napkin?
(b) How does this answer change if the glass is filled with 0.3 kg of marbles?

5. A 1 kg box is launched across a floor, which is frictionless except for a rough patch d=1 m long where the coefficient of friction is μ_k=0.3. The launcher is a spring with constant k=10,000 N/m. How far would you have to compress the spring to successfully launch the box all the way through the rough patch?



6. A ball of mass M = 5 kg is suspended from a long rope whose other end is attached to the ceiling. The ball travels in a horizontal circle of radius R = 1 m at a constant speed of v = 2 m/s.
(a) Draw the free-body diagram for the ball in a vertical plane as shown.
(b) What is the magnitude of the net force on the ball?
(c) If the mass were doubled while keeping the speed constant, how would the angle θ change?
(d) What is the length ℓ of the rope?



7. A 10 g weight is tied to the end of 0.25 m of string extending from a fishing rod tip. After a kick, it swings in a circular path in the vertical plane under the influence of gravity, which is pointed downward. The tension in the string at the bottom of the circular trajectory is twice that at the top ($|T_{bottom}|=2|T_{top}|$). What is the speed v_{bottom} of the weight at the bottom of the orbit? (*Hint: relate tensions to speeds using forces and then use the work-energy theorem to relate speeds*)