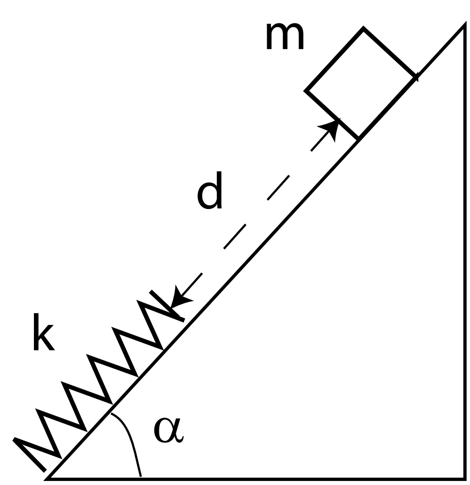
PHY321 Homework Set 2

1. [5 pts] An object is ejected straight up into the air at an initial velocity v_0.
   (a) Determine the time for reaching the maximal elevation when the object is subject to gravity alone.
   (b) Determine the time for reaching the maximal elevation when the object is subject to gravity combined with a retarding force of the form $-kmv$.
   (c) Carefully expand your result from 1b to determine that it agrees with 1a in the limit of $k \to 0$.
   (d) On the basis of the expansion 1c decide whether the retarding force extends or shortens the time to reach the maximal elevation.

2. [5 pts] A ski jumper travels down a slope and leaves the ski track moving in the horizontal direction with a speed of 28 m/s. The landing incline falls off with a slope of 32°.
   (a) How long is the ski jumper air borne? Ignore effects of air resistance.
   (b) How far does the jumper land along the incline?

3. [10 pts] A package of mass $m = 3.0\,\mathrm{kg}$ is released on an incline at an angle of $\alpha = 50°$ from the horizontal. At the moment of release the package is distance $d = 2.5\,\mathrm{m}$ away from a long spring with spring constant $k = 150\,\mathrm{N/m}$ attached at the bottom of the incline. The coefficient of static friction between the package and the incline is $\mu_S = 0.45$ and the coefficient of kinetic friction is $\mu_k = 0.21$. The mass of the spring is negligible.
   (a) What is the speed of the package just before it reaches the spring?
   (b) What is the maximum compression of the spring? Take into account that the package needs to travel the distance by which the spring is compressed.
   (c) Decide whether the package rebounds after the maximal compression of the spring. If it were to rebound, determine how close the package would get to its original position. Describe in words the fate of the package from the release until permanent stop.



4. [5 pts] A woman of mass m sits on a train that coasts along the tracks at a constant speed u. She gets up and begins to walk forward along the car at the speed v relative to the car.

(a) What is the gain in kinetic energy of the woman for a passenger sitting on the train?

(b) What is the gain in kinetic energy of the woman for an observer standing on a station?

(c) How much work has the woman done in order to put herself into motion relative to the car?

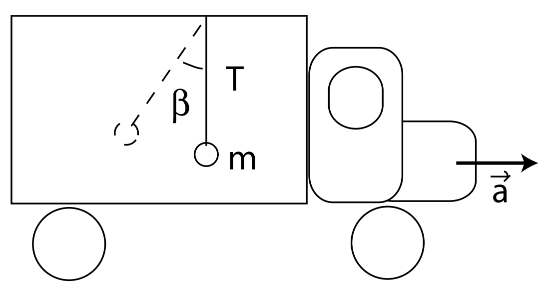
(d) How much additional work was done on the woman by the car while she was putting herself into motion? Hint: To make sure that your answer is correct, take into account the action-reaction law and the impulse-momentum theorem. As the woman pushes with her feet against the floor of the car, the floor acts with a reaction force onto the feet. That force increases the momentum of the woman relative to the car. During the time when the force acts, the woman is displaced relative to an outside observer, because of the motion of the car.

(e) If the woman started walking in a moving lightweight cart, instead of the car of a train, what might be the evidence of the work done by the cart, for an outside observer?

5. [5 pts] Solve this problem by employing the *noninertial* reference frame of the vehicle. A small toy of mass m hangs from a thread inside a vehicle, see the figure.

(a) Find the equilibrium angle β of the thread relative to the vertical when the vehicle is accelerating forward at a constant acceleration a.

(b) At what minimal acceleration a is the thread going to break if the thread can withstand the tensions only up to T_c?



6. [10 pts] A race track has a curve banked at an angle $\theta = 40°$ degrees with respect to the horizontal. The radius of the curve (looking down from directly above) is $R = 50\,\mathrm{m}$.

(a) If the race track is icy so that the tires slide without friction, at what exact speed must the car go around the curve so as not to slide up or down the track? Hint: This problem can be simplified by considering a noninertial frame that is instantaneously comoving and accelerating with the car, though unlike the car with axes that have a fixed orientation in space. (You will learn about reference frames with rotating coordinate axes in CM2.)

(b) On a dry day, the coefficient of friction between the tires and the track is $\mu_s = 0.50$. What are the minimum and maximum speeds at which the car could go around the curve without sliding up or down the track?