Name ________________________________

Section ____________ Date ___________

Physics 211 PreLab #4: Energy

Conserve Your Energy in Lab

In past labs and lectures you studied the dynamics of various physical systems by identifying the forces acting on the systems and then applying Newton's laws. An alternative and in many cases easier approach to studying physical systems is to examine the energy of the system. The relationship between these two approaches can be examined by considering one-dimensional motion of a particle due to the application of a variable force, F(x). In this case, we think of the force as doing *work* on the object, where the work done moving the particle between points x_A and x_B, W_{AB}, is related to the force on the particle, F(x), by the expression:

$$W_{AB} = \int_{x_A}^{x_B} F(x)dx \qquad \text{(Eq. 1)}$$

For certain types of forces, known as *conservative forces*, the work done moving a particle between two points is related to the change in the particle's *potential energy*, U, between these points,

$$W_{AB} = -\Delta U = U_A - U_B \qquad \text{(Eq. 2)}$$

Conservative forces are those which do no net work when moving a particle along any closed path, i.e., $W_{AA} = 0$. Examples of conservative forces include the gravitational force, F = mg, which has an associated potential energy,

$$\Delta U_{grav} = mg(h_B - h_A),$$

where h is the height of the particle at a given point, and the spring force, F = -kx, which has an associated potential energy,

$$\Delta U_{spring} = {}^1/_2 k(x^2_B - x^2_A),$$

where k is the spring constant, and where x_A and X_B are measured relative to the relaxed spring position, i.e., $x_{relaxed} = 0$. Examples of non-conservative forces include time- and velocity-dependent forces, and frictional forces.

In general, the total mechanical energy, E, of a particle under the influence of N conservative forces is given by

$$E = K + U_1 + U_2 + U_3 + ... + U_N \qquad \text{(Eq. 3)}$$

where K is the kinetic energy of the particle,

$$K = {}^1/_2 mv^2 \qquad \text{(Eq. 4)}$$

This leads us to a fact you will use frequency in this course to solve problems: in the presence of only conservative forces doing work on the particle, the total mechanical energy of the particle is conserved,

$$E = K + U_1 + U_2 + U_3 + ... + U_N = \text{constant} \qquad \text{(Eq. 5)}$$

In Investigation 1, you will drop a basketball and study its motion in order to investigate the potential, kinetic, and total energies of an object exhibiting "free fall" motion.

Answer the following question concerning Investigation 1.

Q1 - What is the potential energy of a ball having a mass m that is lifted, and held stationary, at a distance h above the ground? Assume that the total energy of the ball is zero when it is resting on the ground and that positive direction is upward.

Q2 - What is the total energy of the ball in the situation described in question 1?

Q3 - The ball described in question 1 is released. What is the kinetic energy of the ball after it has fallen a distance $\Delta d = d_2 - d_1$ from its initial position?

In Investigation 2 you will study the energetics of a cart sliding down a "frictionless" track inclined at an angle θ (see Figure 1).

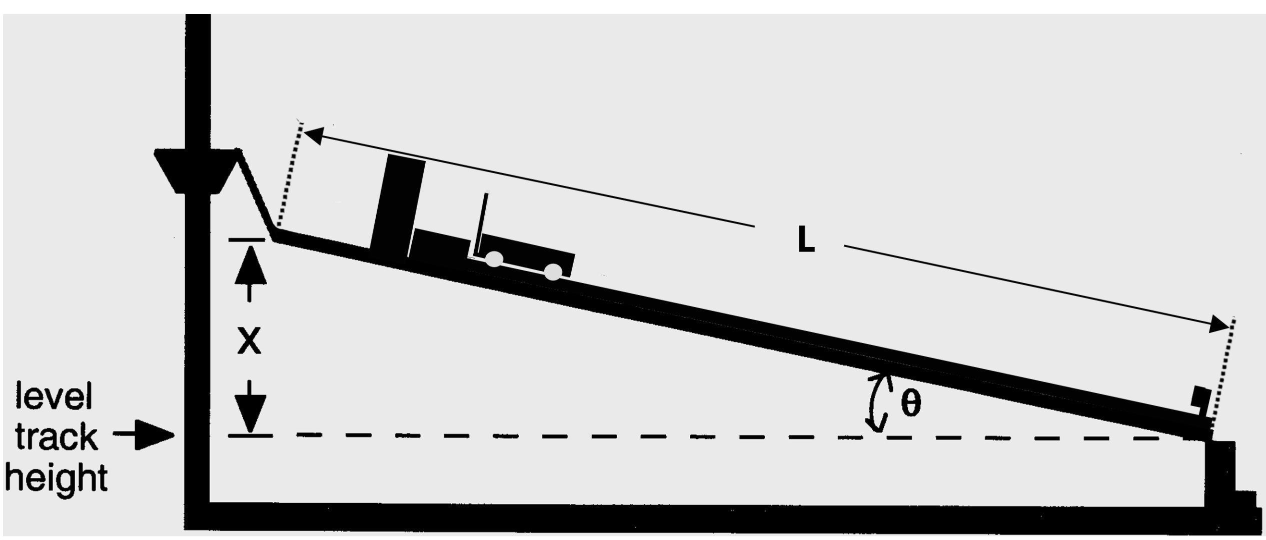

Figure 1. Experimental setup for Investigation 2

Please answer the following questions regarding Investigation 2.

Q4 - Assume that a cart of mass m is initially held at rest a distance d_1 down the incline from the motion detector as shown in Figure 2. If the cart is released, what is the kinetic energy and velocity of the cart when it has rolled a distance Δd (= d_2 - d_1) from its initial position. Neglect friction and assume that the zero of potential energy is at the height of the detector, as shown in Figure 2.

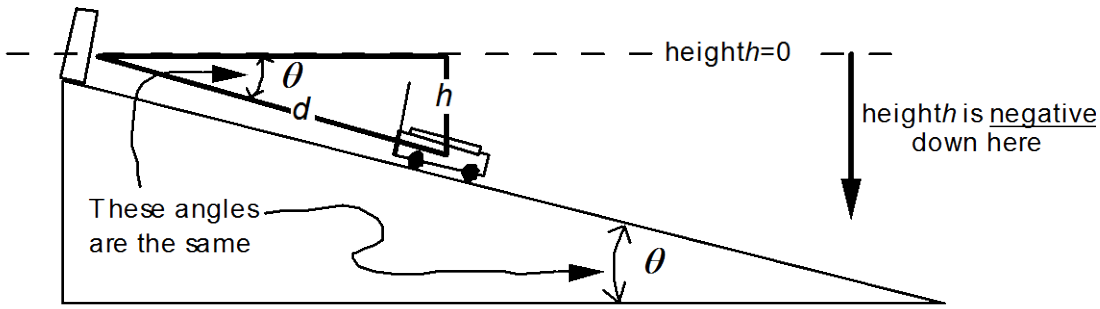

Figure 2. Diagram for determining the relationship between h, Δd, and θ

K. E. = __________ v = ___________

Q5 - Two snow-covered peaks at elevations of 3500 m and 3400 m are separated by a valley. A ski-run having a total length of 3000 m extends from the top of the higher peak to the top of the lower one. A skier starts from rest on the higher peak. With what speed will the skier arrive at the top of the lower peak if she glides down the hill as fast as possible without any initial push? Neglect friction.