TAKE HOME LAB Name: ______________________

Partners: ______________________

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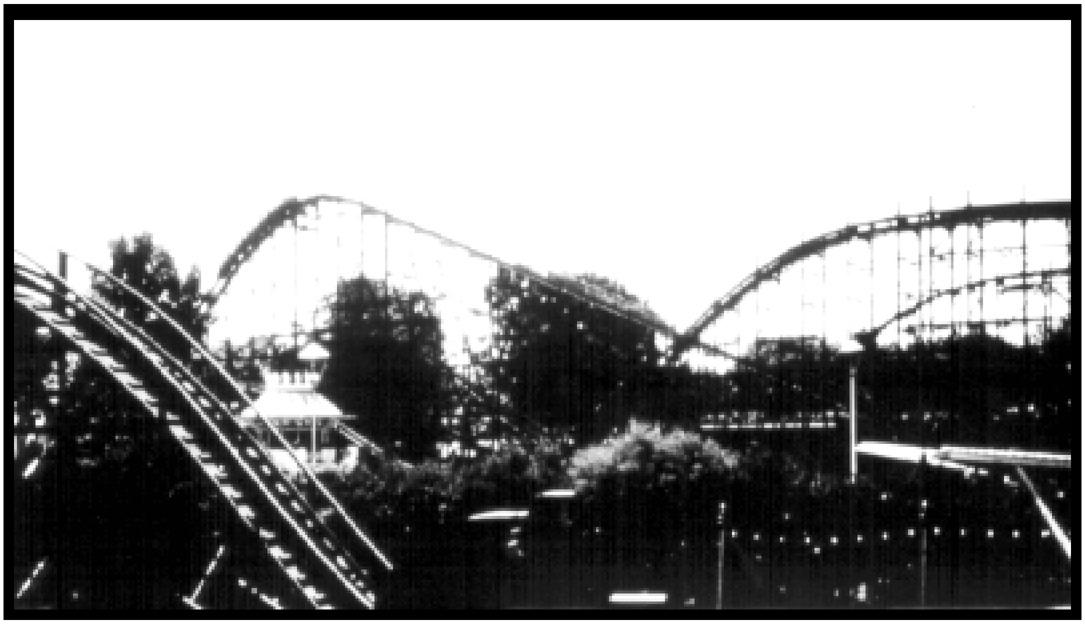
PHYSICS 220 LAB #4: WORK AND ENERGY



A roller coaster presents a special challenge to those trying to use Newton's Second Law to predict the position of the cart as a function of time, because the slope of the track keeps changing. The concepts of work and energy can be used to simplify the analysis of this type of motion.

This time you will re-analyze the scenario of last lab, but from a Work – Energy perspective.

You will collect data (Part One) upon completing Lab 3. You will analyze the data (Part Two) outside of class, prior to the following lab. This is to be handed in when you meet for Lab 5. All questions MUST be attempted before coming to lab (consider this part of the prelab).

OBJECTIVES

1. To get practice calculating work.
2. To understand the concept of kinetic energy and its relationship to the net work (the *Work-Energy Theorem*).

OVERVIEW

You'll consider the *system* of Lab 3: a dropped mass that drags a cart via a rope and pulley. The potential energy of the mass is traded for the kinetic energy of the cart and mass; however, the dissipative frictional interaction will drain energy out of the cart-mass-Earth system.

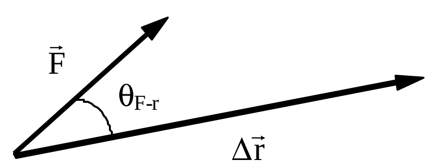
The Work-Energy theorem relates an *external* interaction with a system to a change in its state of being (very much like Newton's 2nd Law does). Specifically, it equates the total work done on a system with the change in the system's total energy.

$$\sum W_{\rightarrow s} = \Delta E_s \qquad (1)$$

Before more explicitly defining Work and Energy, it's important to point out that in order to use this equation correctly, the system must be defined. This specifies which interactions are internal to the system and thus enter the equation as Potential Energy on the right hands side and which interactions happen to the system and thus enter the equation as Work on the left hand side. Here's an example. Say you drop a ball; clearly, it falls because of its interaction with the Earth. If you consider the ball as your system and the Earth an *external* agent, then you say the Earth *does work on your system* (ball). Alternatively, if you consider the ball *plus* the Earth as a single, compound system, then the Earth is an *internal* member, and you account for the Earth – ball interaction as a *change in potential energy of your system* (ball + Earth). Now, if you know how much *work* you'd say is done in the first case (system = ball), then the *change in potential energy* you'd say in the second case (system = ball + Earth) is simply the opposite:

$$DPE = -W \qquad (2)$$

The work done by an external agent on your system depends on how much the interaction's force on your system points in the direction that it moves. For a <u>constant</u> force, the work is related to the size of the force, the length of the displacement, and the angle between the displacement and force vectors by:



$$W = F \cdot \Delta r \cdot \cos q_{F-r}$$

If the force and the displacement are somewhat in the same direction ($q < 90°$), the work will be positive, and if they are somewhat in opposite directions ($q > 90°$), the work is negative.

The kinetic energy of an object is related to its mass and speed (the direction of the motion does not matter):

$$KE = \tfrac{1}{2} m v^2 \qquad \textbf{(3)}$$

PART ONE : Transfer Data from Lab 3

Do the following when you have completed Lab 3's Part Four (Accelerating the Cart with a Hanging Mass) and while you still have the Velocity and Acceleration plots displayed.

1. Transfer the mass values from lab 3.

Cart's (+Force Probe's) mass: m_c=______________

Hanging mass: m_h=_____________

- To acquire the velocity values, click on the velocity plot, and select Examine under the Analyze menu. As you move the cursor across the Velocity plot, velocity and time values will be displayed. Record a velocity and time pair from soon *after* the cart starts moving and record one from a little *before* it peaks.
- Convert the Acceleration plot to a Position one by right-clicking on the vertical axis label and selecting "Position." Then follow the same procedure as for the Velocity. Be sure to collect positions for the *same times* as your velocities.

t_i= s	v_i= m/s	x_i= m
t_f= s	v_f= m/s	x_f= m

PART TWO: Analyze Data

Do this part outside of class, prior to Lab 5.

1. What equation would describe the work done by the Earth in pulling the hanging mass, m_h down by $-Dr$? State it in terms of m_h, g, *and* Dr .

2. Plug your measurements from part 1 into this equation.

W_{grav} = _______________

3. If we define our system as consisting of the cart, the hanging mass, and the earth, is the gravitational interaction internal or external to the system, and therefore, which side of equation (1) does it enter into?

4. What is the change in potential energy of the system due to the mass falling?

DPE_G = ______________________

5. What other type of energy is changing in our system?

6. What is the value of the kinetic energy change in the system?

DKE = ______________________

7. What is the total energy change in this system?

DE = ______________________

8. Are there any forces (besides gravity) acting on the objects in this system?

9. From the work energy theorem, the total energy change is equal to the work done on the system by external forces. Do your answers to questions 7 and 8 agree? Explain.