Work and Energy

Mechanics: work-energy theorem, conservation of energy	GLX setup file: **work energy**

Qty	Equipment and Materials	Part Number
1	PASPORT Xplorer GLX	PS-2002
1	PASPORT Motion Sensor	PS-2103
1	PASPORT Force Sensor	PS-2104
1	1.2 m PASCO Track	
1	GOcar	ME-6951
1	Super Pulley with Clamp	ME-9448A
1	Hooked Mass Set	SE-8759
1	Balance	SE-8723
1 m	Braided Physics String	SE-8050

Purpose

The purpose of this activity is to compare the work done on a cart to the change in kinetic energy of the cart. Determine the relationship of work done to the change in energy.

Background

For an object with mass m that experiences a net force F_{net} over a distance d that is parallel to the net force, the equation shows the work done, W.

$$W = F_{net}d$$

If the work changes the object's vertical position, the object's gravitational potential energy changes. However, if the work changes only the object's speed, the object's kinetic energy, KE, changes as shown in the second equation where W is the work, v_f is the final speed of the object and v_i is the initial speed of the object.

$$W = \Delta KE = KE_f - KE_i = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$$

Safety Precautions

- Follow all directions for using the equipment.

Preview

Use a Force Sensor to measure the force applied to a cart by a string attached to a descending mass. Use the Motion Sensor to measure the motion of the cart as it is pulled by the string. Use the Xplorer GLX to record and display the force and the motion. Determine the work done on the system and the final kinetic energy of the system. Compare the work done to the final kinetic energy.

Prediction

1. As work is done to accelerate a cart, what will happen to its kinetic energy?
2. How would the work done on the cart compare to its final kinetic energy?

Procedure

GLX Setup

1. Turn on the GLX (⏻) and open the GLX setup file labeled **work energy**. (Check the Appendix at the end of this activity.)

- The file is set up to measure force 50 times per second (50 Hz) and to measure motion 20 times per second (20 Hz). The Graph screen opens with a graph of Position (m) and Time (s). The file also has a second graph (Graph 2) of Force (N) versus Position (m).

2. Connect the Motion Sensor to sensor port 1 on the GLX and connect the Force Sensor to sensor port 2.

Equipment Setup

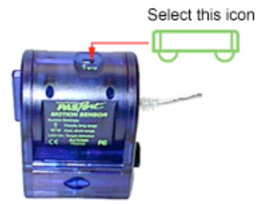


Fig. 1: Select range

1. Set the range selection switch on top of the Motion Sensor to the 'near' (cart) setting.
2. Place the track on a horizontal surface and level the track. If a cart rolls one way or the other on the track, raise or lower one end of the track so the carts does not roll.
3. Attach the Super Pulley with Clamp to one end of the track.
Mount the Motion Sensor at the other end of the track and adjust the sensor so it is aimed at the pulley
4. Mount the Force Sensor on the top of the cart. Add a 200 g (0.2 kg) mass to the cart. Place the cart on the track. Press the ZERO button on the sensor to zero the sensor.
5. Attach a string to the cart and put the string over the pulley. Adjust the length of the string so that when the cart is almost to the pulley, the end of the string almost reaches the floor.
6. Put a 20 g (0.02 kg) mass on the end of the string. Adjust the pulley up or down so the string is parallel to the track.

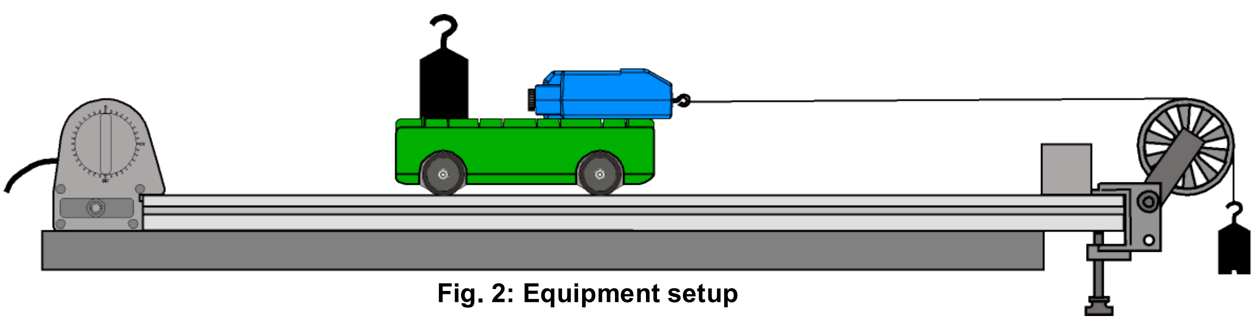


Fig. 2: Equipment setup

7. Put the cart, string, and hanging mass together on a balance and measure and record the *total* mass of the system. (The kinetic energy of the system depends on all the mass that is in motion.) Place the cart, string, and hanging mass back on the track after you record the mass.

Record Data

- NOTE: The procedure is easier if one person handles the cart and a second person handles the Xplorer GLX.

1. Pull the cart away from the pulley until the hanging mass is just below the pulley.
2. Support the Force Sensor's cable so the cart can move freely.
3. Press Start ( ) to start recording data. Release the cart so it moves toward the pulley.
4. Press to stop data recording just before the cart reaches the pulley.

- NOTE: Don't let the cart hit the pulley.

Analysis

Use the Graph screen to examine the Position versus Time and the Velocity versus Time data. Use the second graph (Graph 2) to examine the Force versus Position.

Fig. 3: Select data run

1. To change the Graph screen to show a specific run of data, press to activate the vertical axis menu. Press the arrow keys ( ) to move to 'Run #_' in the upper left hand corner. Press to open the menu, select the data run in the menu, and press to activate your choice.
2. Change the Graph screen to show Velocity versus Time. Press to activate the vertical axis. Press to open the vertical axis menu. Use the arrow keys to select 'Velocity' and press again to activate your choice.

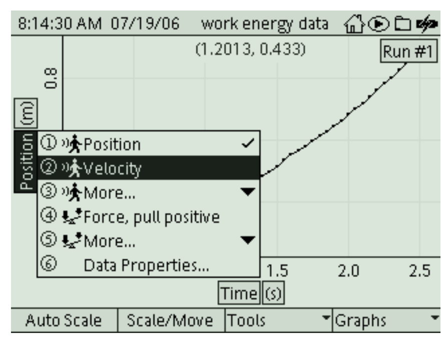
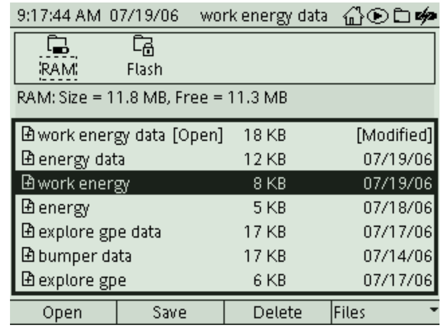


Fig. 4: Select 'Velocity'

3. Move the cursor to the maximum value of velocity and record the value in the Data Table.
4. Switch to Graph 2. Press *F4* ( ) to open the 'Graphs' menu. Select 'Graph 2' and press to activate your choice.
5. Find the area under the curve. Move the cursor to the beginning of the data. Press *F3* ( ) to open the 'Tools' menu. Select 'Area Tool' and press to activate your choice.
6. The area under the curve is shown below the X-axis. Record the value as the work done.
7. Use the maximum velocity and the mass of the system (cart, sensor, string, hanging mass) to calculate the final kinetic energy of the system.

Record your results and answer the questions in the Lab Report section.

Appendix: Opening a GLX File



To open a specific GLX file, go to the Home Screen (⌂). In the Home Screen, select Data Files and press ✓ to activate your choice. In the Data Files screen, use the arrow keys to navigate to the file you want. Press F1 to open the file. Press the Home button to return to the Home Screen. Press F1 to open the Graph.

Lab Report – Activity 19: Work and Energy

Name __________________________________ Date ___________

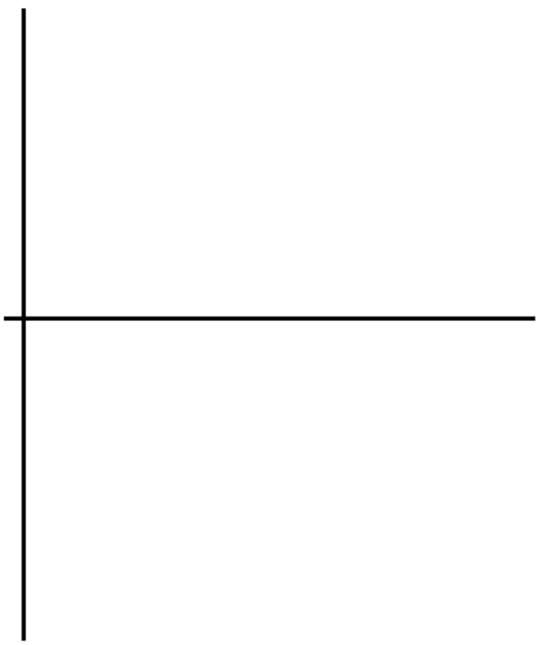
Prediction

1. As work is done to accelerate a cart, what will happen to its kinetic energy?

2. How would the work done on the cart compare to its final kinetic energy?

Data

Sketch a graph of velocity versus time and a graph of force versus position for one run of data. Include units and labels for your axes.



Data Table

Item	Value
Mass of system, total	
Velocity, maximum	
Work done	
Kinetic energy, final	
Percent difference	

Calculations

Use the mass of the system and the final (maximum) velocity to calculate the final kinetic energy of the system. Kinetic energy is $KE = \frac{1}{2}mv^2$ where m is the mass and v is the velocity.

Calculate the percent difference between the work done (area under force-position curve) and the final kinetic energy. $\%diff = \left|\frac{W - KE}{W}\right| \times 100\%$.

Questions

1. What happens to the kinetic energy as work is done on the system?

2. How does the final kinetic energy compare to the work done?

3. The kinetic energy is measured in joules and the work done is measured in newton•meters (N m). What is the relationship between a joule and a newton•meter?

4. Do your results support your predictions?