Lab 6 - Work and Energy Pt.-I.

OBJECTIVES

After successfully completing this laboratory, you should be able to:

- use the concept of energy in describing the interactions of objects in contact with each other,
- identify different types of energy when applying the energy conservation principle to real systems,
- understand work-energy theorem as an example of conservation of mechanical energy principle,
- understand how some kinematic quantities can be calculated using dynamics equations or conservation of energy principle.

Recommended Reading: Giancoli 7.1-7.4, 8.1-8.5. Walker 6.1–6.2, 7.1–7.2.

EQUIPMENT

You will have a 2m track with a low-friction pulley, low-mass string, low-friction cart, scale, a set of free weights, force probe, motion sensor, wooden pads, level.

PROBLEM

You are a volunteer in the citys childrens summer program. In one activity the children build and race model cars along a level surface. To give each car a fair start, another volunteer builds a special launcher with a string attached to the car at one end. The string passes over a pulley and from its other end hangs a weight. The car starts from rest when the weight is allowed to fall. After the weight hits the ground, the car continues along the track. You hope to impress other volunteers by predicting the winner of each race. You decide to calculate how the launch velocity of the car depends on the mass of the car, the mass of the weight, and the distance the weight falls.

WARM-UP

1. Sketch the graph of *velocity vs. time* before the mass hits the floor and after it hits the floor. Explain the shape of the graph.
2. What types of energy are present just before the cart begins its motion? Write down expressions for the magnitudes of each of these types of energy.

3. What is the relationship between the velocity of the cart and the velocity of the falling object? Their acceleration? What happens to the cart when falling object hits the floor?

4. What types of energy will be present just as the falling mass hits the ground? What types of energy will be present then? Write down expressions for the magnitudes of each of these types of energy.

5. Write down an equation relating the energy from question 1 to the energy from question 3.

6. Solve your equation from previous question to find the final velocity of the cart. Check your result applying the the formulae you derived for the acceleration of your cart in Lab 5.

7. What are the forces acting on the cart? Falling object? Are these forces doing work? If so what is the result of these forces doing work on the objects? How is the motion of the cart and the weight related to the work done on them? Is there enough information in the problem to solve for the magnitude of all the forces in the system?

PREDICTIONS

For a (frictionless) cart being pulled along the track by a mass over the pulley predict the value of the speed (velocity) of the cart right before the falling mass hits the floor. Prediction should be done using **both**: kinematics/dynamics and conservation of energy. Assume that the initial distance to the floor and masses of all objects are known to you.

Predict the shape of the kinetic, potential and total energy of your system (whichever way you define it) as a function of time.

If the parameters of the launcher are the same for all competitors, but the parameters of the carts may vary, predict quantitatively and qualitatively the winner of the race.

EXPLORATION

Your experimental set-up should be very familiar to you from previous labs. Explore various possibilities for the weight of the falling mass, mass of the cart, the length of the string etc. Settle on the set of values that would yield the most favorable measuring conditions.

To produce the plot of the kinetic, potential, and total mechanical energy you will need to use a calculator feature of your Capstone software. The quality of the graphs may depend strongly on the motion sensor sampling rate (explain why). Adjust the sampling rates of your sensors if necessary to obtain the best data.

Come up with a measurement plan and discuss it with your instructor.

MEASUREMENT

Conduct the measurement according to your measurement plan. Make sure that you use most favorable conditions for your measurement.

What are the uncertainties in your experiment?

ANALYSIS AND RESULTS

Extract the target quantities of your experiment. Estimate the error in your measurement.

CONCLUSION

Compare your predictions and your experimental result. How do they compare? What are the errors in your predictions and your experimental result? What are the limitations on the accuracy of your measurements and analysis?

Were you able to predict the velocity of the cart reliably? Is it beneficial to use a heavier cart and/or heavier falling mass to achieve the highest velocity? Explain.

What can you tell about the total mechanical energy of your system? Individual components of the system? Does the total energy graph explain any disagreement between the measurement and your prediction? Explain.

Please clean up your lab area.