PHYS 1405 – Conceptual Physics I
Laboratory # 9
Energy

Investigation #1: Is total energy conserved for a falling object?

What to measure: Height, mass, time to fall.

Measuring devices: Meter stick, Drop timer

Calculations: Final velocity, Potential energy, Kinetic energy

Investigation #2: Is total energy conserved for an object sliding down an incline?

What to measure: Height, mass, velocity.

Measuring devices: Meter stick, Air track, Photogates

Calculations: Potential energy, Kinetic energy

INTRODUCTION

In this experiment we shall investigate the nature of energy. Energy is defined as the ability to do work – the ability to apply a force across a distance. Energy comes in many forms, but there are two primary forms which will concern us here:

Kinetic Energy is the energy possessed by a moving object. The kinetic energy of an object depends on its mass and its velocity. An object that is not moving has no kinetic energy. Velocity is a little bit more important than mass in determining kinetic energy. We write the formula for kinetic energy like so:

$$KE = (1/2)mv^2$$

Potential Energy is the energy that something has from its position. **Gravitational Potential Energy** is the energy that something has due to its height above a surface. The greater the height, the greater the gravitational potential energy. Gravitational potential energy also depends on mass, the more the better. The formula for gravitational potential energy is

$$PE = mgh$$

Although there are other kinds of energy, these two will be most important to us. The **Total Energy** of an object can therefore be expressed as the sum of the kinetic and potential energies:

$$TE = KE + PE$$

In this lab we shall study the energy of two different objects in motion, using two different methods. Write down your predictions and turn them in before you take any numbers!

<u>Predictions</u>

Part 1:

1. As a ball falls straight down, what happens to its **Gravitational Potential Energy**? Explain.

2. As the ball falls down, what happens to its **Kinetic Energy**? Explain.

3. As the ball falls, what happens to its **Total Energy**? Explain.

4. What will happen to the ball's **Gravitational Potential Energy** if you drop it from a greater height? Explain.

5. What will happen to the ball's final **Kinetic Energy** (the energy it has just before it hits the ground) if you drop it from a greater height? Explain.

Part 2:

6. What will happen to the **Gravitational Potential Energy** of a cart as it slides down an inclined "frictionless" air track? Explain.

7. What will happen to the **Kinetic Energy** of the cart as it slides down the track? Explain.

8. What will happen to the **Total Energy** of the cart as it slides down the track? Explain.

9. If you were to increase the angle of the track, what would happen to the values for:

    - PE at the start
    - KE at the end
    - TE for the whole experiment.

    Explain your answers

Part 1: The Energy of a Falling Object

In Lab 3, we used the drop timers to measure the time it takes for a ball to fall. Remember that we can calculate the velocity of the ball just before it hits the table using the time to fall and the formula

$$v = gt$$

We can then use that velocity to calculate the kinetic energy of the small ball just before it hits the table.

Question 1: What else do we have to measure about the small ball before we can calculate its kinetic energy?

If we know the height of the ball, we can calculate its potential energy just before it drops. Calculate the potential energy the small ball should have at heights of 20 cm, 30 cm, 40 cm, 50 cm, 60 cm, 70 cm, and 80 cm.

Question 2: What units do mass and height have to be in to calculate potential energy?

Drop the ball from a height of 20 cm five times. Calculate the average time it takes the ball to fall, and then use that average time to find the speed it has just before it hits the table. Use that speed to calculate the ball's kinetic energy just before it hits. Use a value of 9.8 m/s/s for g.

Repeat your measurements and calculations for heights of 20 cm, 30 cm, 40 cm, 50 cm, 60 cm, 70 cm, and 80 cm. Record the following in the data table for each height:

Height (m)	Potential Energy (J)	Average Time (sec)	Final Speed (m/s)	Kinetic Energy (J)

Question 3: How does the potential energy of the ball before you drop it compare to the kinetic energy it has just before it hits the table? Back up your answer with data.

Question 4: Based on your answer to Question 3, how important do you think air resistance is to the falling ball's motion? Explain.

Repeat all your measurements and calculations with the larger ball. Create another data table for the larger ball.

Question 5: Is changing the mass of the ball going to change the final velocity for a given height? What about the values of the initial potential and final kinetic energies? Justify your responses with data.

<u>Part 2: The Energy of a Sliding Object</u>

In this part of the experiment, we shall study the energy of a cart as it slides down a track. We will use the air tracks to get a surface as low in friction as possible. We will use the photogates to determine how fast the cart is traveling at various points along the track, and calculate the values for KE, PE and TE at every point

Begin with the air track tilted. Use the wooden block to prop up one end of the track as you did in a previous lab. Place the cart at the top of the track. Measure straight down to see how far a point on the cart is from the table surface. Any point on the cart will do, as long as you are consistent. This is the initial height of the cart, h_0. Use the formula for gravitational potential energy to calculate a value of PE for this height.

Question 6: What is the kinetic energy of the cart at the top of the incline? Explain.

Question 7: What additional piece of information do you need to measure to calculate the potential energy of the cart? What is the value of that measurement?

Using the measuring scale along the track, place one photogate at 20 centimeters from the top along the track, and another at 120 centimeters. Move the cart into each photogate and hold it there, halfway through. Measure the height of your special point on the cart at each gate and record it. Return the cart to the top of the incline, and turn on the air. Hit the “Collect” button on the computer screen and release the cart. Record the velocities of the cart as it goes through the photogates. Make sure you know which gate gives which velocity!

Move the photogates to positions at 30 and 130 centimeters and repeat the whole process. Keep repeating measurements, moving each gate 10 centimeters, and making sure that the gates remain 1 meter apart. Stop when you have measured the velocities and heights at 70 and 170 centimeters.

Create a data table with one row for each measurement of velocity that you took. Put the following in the columns:

Height (m)	Potential Energy (J)	Velocity (m/s)	Kinetic Energy (J)	Total Energy (J)

Question 8: Which, if any, of your first three "predictions" for the track were mistaken? What do you think was the source of the mistake(s)?

Question 9: What is happening to the gravitational potential energy of the cart as it slides down? Explain why this happens in terms of the formula for potential energy.

Question 10: What is happening to the kinetic energy of the cart as it slides down? How does this relate to the change in potential energy that you described in Question 9?

Question 11: What is happening to the total energy of the cart as it slides down? Explain why in terms of kinetic and potential energy.

Question 12: How would your answer to Question 11 be different if the air track were not "frictionless?" Why?

Part 3: Increasing the Incline

Prop up the air track so that the incline is greater. Repeat your velocity and height measurements from Part 2 for this new incline. As before, create a data table for this incline with one row for each measurement of velocity that you took. Create a table with columns as in

Question 13: Go back and look at your predictions of what would happen with the increased incline. Either prove or disprove these predictions using your numbers.

Materials List

Drop timer
Metal ball and plastic ball
Meterstick
Scale
Airtrack with 1 cart
2 photogates
Wooden block to prop up track