Kuwait University	Course 125 Phys. Lab. I
Physics Department	Experiment 6: Elastic-Kinetic Energy

Objectives

- To study the work required to compress or stretch a spring.
- To study thge relation between the energy stored in a spring and the kinetic energy it can impart to an object.

Equipment to be used

- Experimental setup: 2 m air track with glider, pulley, mass pieces with weight hanger(Figure 1)
- Spring with low spring constant
- Measuring devices:

  meter scale (on the airtrack, for measuring position and displacement)

  photogate timer with memory (for measuring time intervals)

References :

Douglas C. Giancoli, Physics Principles with applications, Thrid Edition, Chapter 6.

Theory

In this experiment you will prove the law of conservation of energy as you investigate the equivalenc between the $work$ stored in a stretched spring and the $KineticEnergy$ it can impart to an object. Suppose a spring has a natural (Unstretched) length L_o. If this spring is stretched or compressed to a new length $L = L_o \pm \Delta x$ then the force exerted by this sprins is given by the expression:

$$F = -k\,\Delta x \qquad \textbf{(Hook's Law)} \tag{1}$$

where the term Δx represent the change in position from x_i to x_f. The constant k is called the **Spring constant** (or **force constant**) and it is a measure of the strechness of the spring. The work done by the spring force on any object that is attached to the spring is given by:

$$W_{spring} = \int_{x_i}^{x_f} F \, dx = -k \int_{x_i}^{x_f} dx = \frac{1}{2} \, k \, (x_i^2 - x_f^2) \qquad (2)$$

and therefor the corresponding change in the **Elastic potential Energy** of the spring-object system is found to be:

$$\Delta U = -W_{spring} = \frac{1}{2} \, k \, (x_f^2 - x_i^2) = \frac{1}{2} k \, (\text{¢} x)^2 \qquad (3)$$

ΔU represent the amount of energy that is being stored in the spring as it stretchs or compresses. If this stored energy is then used to accelerate the object that is attached to the spring, it then will give that object a **Kinetic Energy** equals to :

$$KE = \frac{1}{2} m v^2 \qquad (4)$$

where m is the mass of the object and v is the velocity with which the object will be moving. In the first part of the experiment you will calculate the spring constant k used and in the second part you will analyse the relation between the spring stretch and the glider velocity and prove the law of conservation of energy.

Procedure

Part A: Determining the Spring Constant:

A1. Set up the Air track as shown in (Figure 1). **Level** the air track very carefully by adjusting the *air track levelling feet*. A glider should sit on the air track without accelerating in either direction.

A2. Make a platform for the spring so that it will be supported horizontally and will not sag. **Attach** the platform firmly to the end of the air track.

A3. Connect the spring to the glider by a thread so that the glider is about the middle of the air track with the spring unstretched.

A4. Connect the gider to the mass hanger by another piece of thread that runs through the pulley at the end of the air track.

A5. Hang masses on the hanger and **determine** how far the spring streches.

A6. Record the masses added and the glider position in (Table 1).

A7. Calculate the average value of the spring constant k from (Table 1).

A8. Plot the graph of stretch of the spring versus the amount of force applied to it by the hanging masses.

Part B: Spring Stretch and Glider Velocities:

B1. Remove the hanger, the pulley, and the thread used in part (A) of the experiment and keep the rest of the experimental setup the same. See (Figure 1).

B2. Measure and Record the mass of the glider m and the length of the glider Δd. Record your data in (Table 2).

B3. Position the glider so that the spring exerts No force on the glider, but the thread does not sag. **Record** this position as x_1 in (Table 2). **Position** the photogate timer between the glider and the spring.

B4. Pull the glider approximately 10 cm farther away from the spring. **Measure** the distance between this glider position and x_1, and **record** this distance as the Spring Stretch in (Table 2).

B5. Set the photogate timer to "**GATE**" mode and press the "**RESET**" button.

B6. Hold the glider steady as you turn the air blower on. **Release** the glider but catch it befor it craches into the spring platform. **Record** the measured time as t_1 in (Table 2).

B7. Repeat steps B4-B6 four more times. **Record** your times as t_2 through t_5 in (Table 2). **Determine** the average of these five times and **record** this value as t_{ave}.

B8. Repeat steps B4-B7 for different distances of stretch of the spring up to 20 cm. Also **vary** the mass of the glider by adding masses to it. **Record** the new masses in (Table 2).

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Laboratory Assignment

1. Explain the concept of conservation of energy on the bases of the results of this experiment.

2. What is the spring constant k of a spring that needs (15 J) of work to stretch it a distance of (3.5 cm)?

3. What is the Kinetic Energy of an object of mass (250 g) moving with a speed of (15 m/s)?

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Worksheet for Experiment 6

A. Determining the Spring Constant

Table 1:

Added Mass (m)	Glider Position (x)	Applied Force ($F = mg$)	Spring Stretch (Δx)	Spring Constant (k)

The average value k (from table) =....................................

The value of k (from the graph) = ...

Comments:

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Worksheet for Experiment 6

B. Spring Stretch and Glider Velocities

Table 2:

x_1 = ... Glider length Δd = ...

Mass (gram)	Spring Stretch (x)	t_1	t_2	t_3	t_4	t_5	$\bar{t}$	$v = (\frac{\Delta d}{t})$	PE ($\frac{1}{2}kx^2$)	KE ($\frac{1}{2}mv^2$)	%difference ($\frac{PE-KE}{PE}$100)
180	10 cm										
180	15 cm										
180	20 cm										
280	10 cm										
280	15 cm										
280	20 cm										
380	10 cm										
380	15 cm										
380	20 cm										

Discussion:

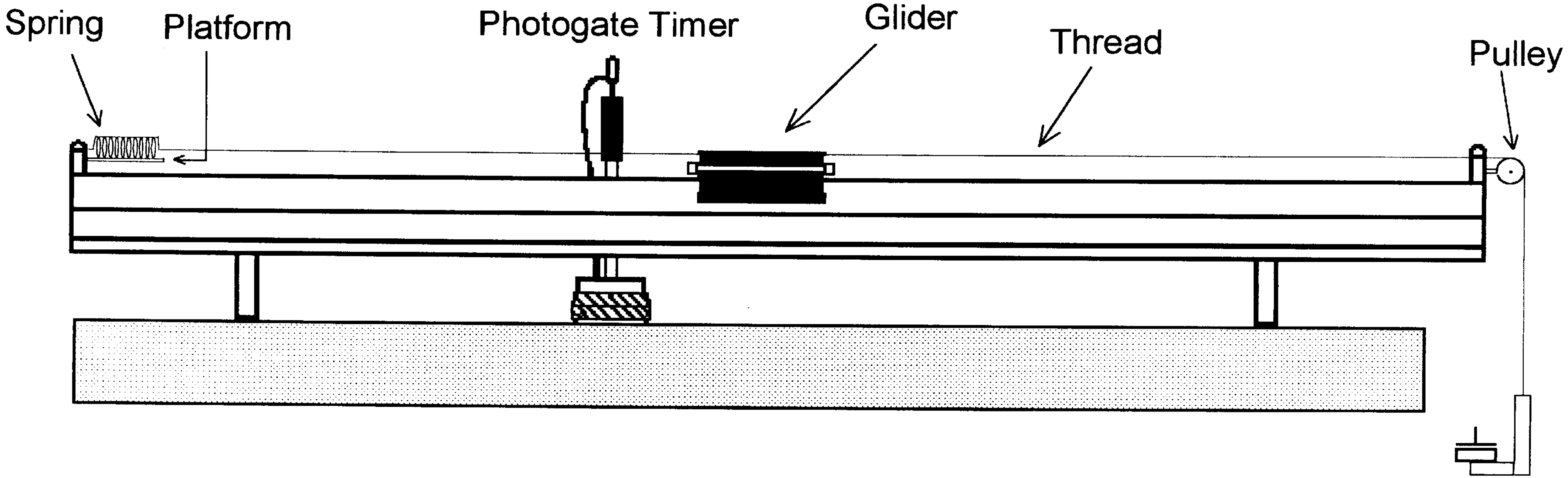

Figure 6.1 : Experimental Setup of the Air Track.