ÇANAKKALE ONSEKIZ MART UNIVERSITY

DEPARTMENT OF PHYSICS

GENERAL PHYSICS LABORATORY MANUAL AND WORKBOOK

EXPERIMENT 4
SIMPLE PENDULUM

PURPOSE

The main purpose of this experiment is to study kinetic and potential energy changes and the conservation of the energy of the simple pendulum on a tilted frictionless air table.

THEORY

A simple pendulum is a weight (body) suspended from a string with negligible mass. While the motion is happening on a vertical plane due to gravity, the string end is fixed, As seen in Fig. 4.1. All figures (a to e) of Fig. 4.1 define complete motion or one period of the pendulum. The system tries to keep the equilibrium position. So if the body moves from the equilibrium position and releases, the gravity will accelerate the body through the equilibrium position. This makes an oscillation around the equilibrium position.

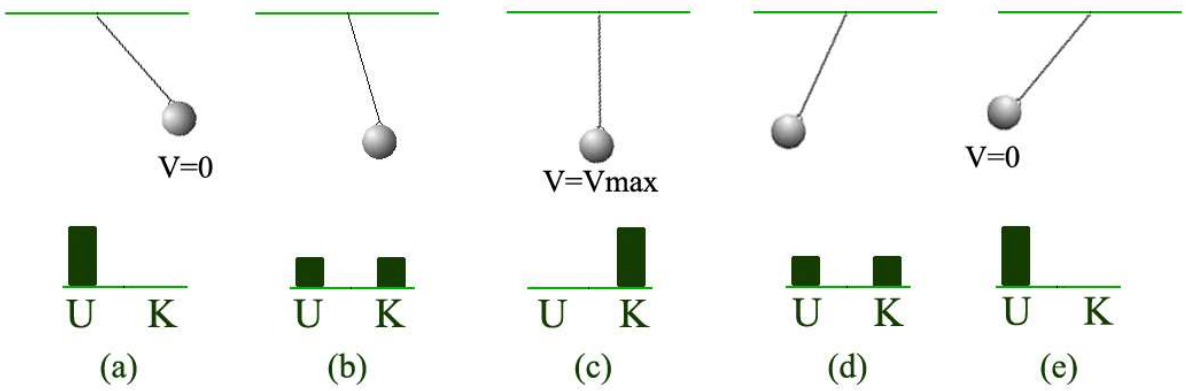

FIGURE 4.1. A period of the simple pendulum

The total energy is conserved in an isolated system.

$$U + K = E \tag{4.1}$$

The potential and kinetic energy changes over time (Figure 4.1, from a to e), because the body will have variable velocity and height. While the body is at the bottom; consider the potential energy is zero. In Figure 4.1, the velocity is maximum at (c) position and the kinetic energy is maximum too.

At (a) and (e) positions, the body is at maximum height; so the potential energy is maximum. At these positions, the velocity of the body is zero; so the kinetic energy is zero.

While the simple pendulum is placed on the air table tilted at an angle, φ; the force vector will shift (Figure 4.2).

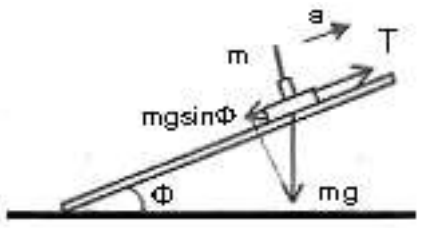

FIGURE 4.2. The forces on a body on the tilted plane.

Let say, *h* for the height of the body on a tilted plane and calculate potential energy:

$$\Delta U = U(y) - U(y_0) \tag{4.2}$$

$$U(y) = U(y_0) - \int_{y_0}^{y} F(y)dy = 0 - \int_{0}^{y} (-mg\sin\phi)dy \tag{4.3}$$

$$U(y) = mgy\sin\phi \tag{4.4}$$

Equation (4.4) defines the potential energy of a body with a mass, *m* on the tilted plane. Please pay attention to the potential energy here that is calculated, does not give the potential energy of the tilted plane (airtable) itself. We won't count for the height of the tilted plane.

The kinetic energy of the body is

$$K = \frac{1}{2}mv^2 \tag{4.5}$$

Let's substitute the equations (4.4) and (4.5) into the equation (4.1). Here, we define conservation of energy for the simple pendulum:

$$E = mgy\,sin\,\varphi + \frac{1}{2}mv^2 \tag{4.6}$$

EQUIPMENT

Airtable, wooden block, puck, string.

PROCEDURE

1. Take the wooden block and give elevation to the table at a tilted angle, ϕ. Place first the carbon paper on the airtable, then place the data paper.
2. We will use only one puck for this experiment; so place one of the pucks to the corner of the table. Tie a puck with a proper length of a string and fix the end of the string to the upper side of the airtable.
3. Move the puck to a new position beside the equilibrium position by keeping the string strained. Release the puck and watch its movement without pressing the air pedal.
4. Set the frequency of the spark table.
5. Press the air and the spark pedal simultaneously until the puck stops. Turn the back of your data paper. Draw motion axis for data points.
6. Mark the first point of the motion as zero point. Write numbers down in order for all points by starting from the first point of the motion. Write the time and distances to the motion axis of each point in Table 4.1.
7. Calculate the slope of the airtable and get ϕ angle.

ENGINEERING FACULTY
DEPARTMENT OF ENVIRONMENTAL ENGINEERING
Year: 2021-2022 Semester: Fall

Course Name: ENV-1021 – **General Physics Laboratory**

EXPERIMENT 4: SIMPLE PENDULUM EXPERIMENT REPORT

INSTRUCTOR'S NAME & TITLE:						SIGNATURE:		EXAM DATE:
STUDENT'S NAME/SURNAME: STUDENT ID #:						SIGNATURE:		EXAM DURATION:
Question								TOTAL POINT:
Point								
Prog. Outcomes	**PO1,2**							

Group:

RESULTS AND DISCUSSION

1. Calculate velocities (v), heights (y), potential energy (U), kinetic energy (K) and total energy (E) of the puck at each point. Write the results in Table 4.1. **Explain all your calculations** in your report.

$$v_{xi} = \frac{\Delta x_i}{\Delta t_i} \text{ and } v_{yi} = \frac{\Delta y_i}{\Delta t_i} \quad \text{Here, } v = \sqrt{v_x^2 + v_y{}^2}, \text{ U= mghsin}\phi, \text{ K} = \frac{1}{2}mv^2$$

TABLE 4.1

	t (s)	x (m)	y (m)	*h* (m)	v_x (m/s)	v_y (m/s)	v (m/s)	U (J)	K (J)	E (J)
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
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NAME SURNAME:
STUDENT ID #:
Signature:

2. Plot the potential and kinetic energy versus time graph on the same graph paper and explain the variations. What do hills and valleys of the plot point out? Explain.

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3. Plot total energy versus time graph to a new graph paper. Is total energy conserved? Explain by using the graph.

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4. Write down any comments related to the experiment, and/or elaborate on and discuss any points.

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Laboratory and Examination Rules:

1- The most important thing in the laboratory is your safety. The dangers mostly result from a lack of knowledge of the equipment and procedures.
2- Personal safety rules must be obeyed with extreme discipline.
3- When you enter the laboratory never play with the equipment until it has been explained and the instructor has given permission.
4- Keep your experimental equipment and tabletop clean.
5- Report any accident to your instructor immediately.
6- Most of the equipment used in the laboratory is expensive and some of them are delicate. Even after you are familiar with the equipment, always have your experimental setup checked and approved by the instructor before putting it into operation.
7- If any of the equipment is broken or does not function properly, report it to the instructor.
8- Read and study the experiments before you come to the laboratory.
9- It is forbidden to share the questions and answers of this assignment on the internet or in another environment.
10- Students must answer the assignment by themselves. It is forbidden to do the assignment with others or to get help from others.
11- **Write your name and surname and student number and sign your signature on the top right of each answer page.**