



# ACTIVITY

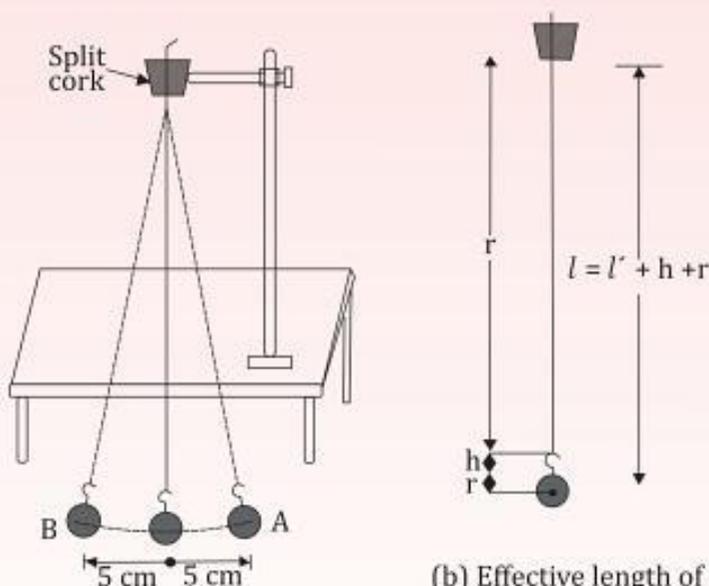
## AIM

To study dissipation of energy of a simple pendulum by plotting a graph between square of amplitude and time.

## MATERIAL REQUIRED

A pendulum bob, a meter scale, fine thread of nearly 160 cm long, a split cork, a clamp stand, a stopwatch and a chalk piece.

## DIAGRAM



(a) Set-up of Dissipation of energy of an Oscillating simple pendulum

(b) Effective length of a simple pendulum

## THEORY

For a freely oscillating mass, total energy is partly kinetic and partly potential. At any displacement,  $x$  = Total energy

$E$  = kinetic energy  $E_k$  + potential energy  $E_p$

$$E = \frac{1}{2} m \omega^2 (A^2 - x^2) + \frac{1}{2} m \omega^2 x^2$$

$$E = \frac{1}{2} m \omega^2 A^2 = \frac{1}{2} k A^2 \quad (k \text{ is the force constant, } m \omega^2 = k)$$

Total energy,  $E$  is constant and  $E \propto A^2$ . But when the pendulum oscillates in a viscous medium the amplitude decreases which is due to energy dissipation by Stoke's viscous force. This force is proportional to velocity i.e.,  $F \propto v$  Therefore, energy decays exponentially which can be given by,



$$E = E_0 e^{-\lambda t}$$

Where,  $\lambda$  is decay constant.

Therefore,

$$A^2 = A_0^2 e^{-\lambda t}$$

Hence, a graph plotted between square of the amplitude ( $A^2$ ) and time ( $t$ ) will be an exponential curve.

### PROCEDURE

1. Take a thread about 160 cm long and tie one end to the hook of the bob.
2. Pass the other end of the thread through the split cork such that length of the pendulum is 150 cm.
3. Fix the cork in the clamp stand firmly.
4. Place the iron stand on the table such that bob hangs below the table without touching its edge and remains about 2 cm above the floor of the laboratory.
5. When the bob is in its mean position place a meter scale just below the bob such that its complete number, e.g., 50 cm etc. lies below the centre of the bob.
6. Take a stopwatch, find its least count and hold it in your left hand.
7. Displace the bob with your right hand along the scale away from the mean position and release it gently so that it starts oscillations about the mean position.
8. After passing a few oscillations mark its extreme position on the meter scale and start the stopwatch and record the time as zero.
9. Then after every third oscillation observe the extreme position of the bob and record time simultaneously till the amplitude decays to about 1 cm.
10. Take at least ten observations.

### OBSERVATIONS

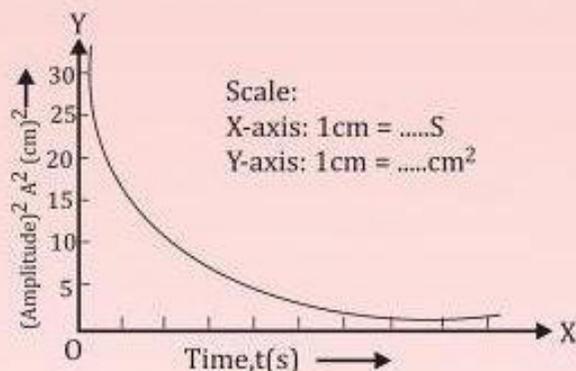
1. Mass of given bob,  $m =$  \_\_\_\_\_ g.
2. Least count of the stopwatch = \_\_\_\_\_ s.
3. Length of the pendulum,  $l =$  \_\_\_\_\_ cm.
4. Force constant,  $k = \frac{mg}{l} =$  \_\_\_\_\_ N/m.

S. No	Amplitude A		$A^2$		Time, t (sec)	$E = \frac{1}{2} kA^2 = E_0$ (joule)	Energy dissipation $E = (E_0 - E)$ joule
	(cm)	(m)	(cm <sup>2</sup> )	(m <sup>2</sup> )			
1.							
2.							
3.							
4.							
5.							
6.							
7.							
8.							
9.							
10.							

### GRAPH

Draw a graph taking time,  $t$  along X-axis and square of the amplitude,  $A^2$  along Y-axis.





## RESULT

Graph plotted of square of amplitude,  $A^2$  against time,  $t$  for a simple pendulum indicates that energy of oscillations of a simple pendulum decreases exponentially with time which reflects that energy initially dissipates rapidly and then dissipates slowly.

## PRECAUTIONS

1. The oscillations should be of smaller amplitude.
2. The oscillations of the pendulum should be in the same vertical plane.
3. As far as possible, amplitude and time should be noted simultaneously, quickly, and carefully.

## SOURCES OF ERROR

1. The support used for suspending the bob may not be perfectly rigid.
2. The string may not be inextensible.
3. There may be up and down or conical motion of the bob.
4. In marking the extreme positions of the oscillations and in noting of time there may be some personal error.

## VIVA VOCE

**Q1. Tell me the object of the given activity.**

**Ans.** To study dissipation of energy of a simple pendulum.

**Q2. How will you study the dissipation of energy?**

**Ans.** By plotting a graph between square of amplitude and time.

**Q3. How does the energy of a simple pendulum depend on amplitude?**

**Ans.** Energy of a simple pendulum is directly proportional to square of its amplitude ( $E \propto A^2$ ).

**Q4. If a body oscillates in a viscous medium, what will be the nature of decay of energy?**

**Ans.** Energy decay is exponential.

**Q5. Can you give other examples of exponential decay?**

**Ans.** Discharging of a capacitor and Radioactive decay.

**Q6. Why do the oscillations of a pendulum die after a certain time?**

**Ans.** Energy of an oscillating pendulum decreases gradually due to air friction. Therefore, oscillations of the pendulum ceases after a certain time.

**Q7. What do you mean by damping?**

**Ans.** Damping is the gradual decrease in the amplitude of oscillation of a pendulum.

**Q8. At what point during the oscillation of a simple pendulum kinetic energy is maximum?**

**Ans.** It is maximum at the mean position.

**Q9. When is the potential energy maximum?**

**Ans.** Potential energy is maximum at the extreme positions of oscillation.

**Q10. Why the kinetic energy is zero at the extreme positions?**

**Ans.** At extreme positions, the bob of a simple pendulum is momentarily at rest. Therefore, the kinetic energy of the bob is zero.

