To Study Variation of Time Period of a Simple Pendulum of a Given Length by Taking Bobs of Same Size but Different Masses and Interpret the Result

Aim

To study variation of time period of a simple pendulum of a given length by taking bobs of same size but different masses and interpret the result.

Apparatus

A clamp with stand, a split cork, thread, vernier callipers, stop clock/stopwatch, metre scale and pendulum bobs of different masses.

Theory

1. Simple Pendulum: See Experiment 7.
2. Length of Simple Pendulum: See Experiment 7
3. The time period is given by the formula,

$$T = 2\pi\sqrt{\frac{l}{g}} \quad \text{or} \quad T^2 = \frac{4\pi^2 l}{g}$$

For the given value of length of simple pendulum (as explained above) and gravitational acceleration at the place of experiment, the time period of the simple pendulum can be calculated by the above formula.

4. Time period of simple pendulum is independent of its mass. The time period of simple pendulum is given by the above formula. It clearly indicates that $T \propto \sqrt{l}$ and $T \propto \frac{1}{\sqrt{g}}$ but it is independent of mass of the simple pendulum i.e., for the same value of l and g, the time period for two bobs of different masses will be same.

Procedure

To check the effect of bobs of different masses on time period

(i) Choose any three bobs of known masses and determine their radii as in Experiment 1A

(ii) Now, arrange the experiment set up for first bob (say mass m_1) with any effective length of simple pendulum (say 100.00 cm) as explained in Experiment 7

(iii) Obtain the average time taken for 20 oscillations by the simple pendulum by performing the steps 12 to 18 as explained in Experiment 7

(iv) Repeat the steps (ii) and (iii) for second bob (say mass m_2) with the same effective length 100.00 cm [Note: Here you should adjust the length of the thread to set effective length 100.00 cm because of change in radius of the new bob as compared to the first bob].

(v) Now, finally repeat the steps (ii) and (iii) for third bob (say mas m_3) with the same

effective length 100.00 cm.
(vi) Calculate the time periods for each bob and mention them in the table given below.

Observations

1. For vernier callipers: See Experiment 7
2. For stop clock/stop watch: See Experiment 7
3. Table to check the effect of bobs of different masses on time period

S. No.	Bob No.	Radius of bob	Effective length of simple pendulum $l = (i + h + r)$ cm	Time taken for 20 oscillation, t(s)				Period of oscillation $T = t/20$ (in second)
				t_1 (second)	t_2 (second)	t_3 (second)	Average t (second)	
1	First bob with mass $m_1 = \ldots$ gram	$r_1 = \ldots$ cm	100.00*	39.7	40.5	39.8	40.0	2.00
2	Second bob with mass $m_2 = \ldots$ gram	$r_2 = \ldots$ cm		40.4	40.2	39.4	40.0	2.00
3	Third bob with mass $m_3 = \ldots$ gram	$r_3 = \ldots$ cm		39.6	40.4	40.0	40.0	2.00

* The effective length of the simple pendulum will be kept same in each case.

Calculations

Average time for 20 vibrations may be calculated as:

$$t = \frac{t_1 + t_2 + t_3}{3}$$

Then calculate the time period T = t/20 second and finally write in the table.

Graph

See Experiment 7.

Result

It is clear from the table, for the same effective length of simple pendulum, the time period is same for bobs of different masses i.e., the time period is independent of mass of the bob.

Precautions

Same as in Experiment 7.

Sources of error

Same as in Experiment 7.

Viva Voce

Question. 1. What is a simple pendulum ?
Answer. An ideal simple pendulum consists of a heavy point mass (called bob) tied to one end of a perfectly in extensible, flexible and weightless string. It is suspended from a rigid support.

Question. 2. Do we really use an ideal simple pendulum ?
Answer. No. The bob has some size. The string is also extensible. The friction cannot be removed completely.

Question. 3. Define length of a simple pendulum.
Answer. It is the distance between the point of suspension and the C.G. of the pendulum which is C.G. of bob itself.

Question. 4. What is the relation between time period and length of the simple pendulum ?
Answer.

The relation is, $T = 2\pi \sqrt{l / g}$.

Question. 5. Does a wall clock run slow or fast in winter ?
Answer. A wall clock runs fast in winter, because decrease of length of pendulum decreases its time period.

Question. 6. Does a wall clock gain or lose time in summer ?
Answer. A wall clock loses time in summer, because its time period increases due to increase of length of the pendulum.

Question. 7. What is damping ?
Answer. It is opposition to free vibrations of bob of a simple pendulum due to presence of air around it.

Question. 8. How does damping affect the amplitude ?
Answer. The damping decreases exponentially the amplitude after each vibration.

Question. 9. What is seconds pendulum ?
Answer. A simple pendulum whose time period is two seconds, is called a seconds pendulum.

Question. 10. What is the length of a seconds pendulum ?
Answer. The length of a seconds pendulum is about 99.4 cm.

Question. 11. What is a ticker-tape timer ?
Answer. It is a time measuring device. In it a vibrating strip makes dots on a moving paper tape at constant interval. [Ans. 4.04(3)]

Question. 12. How is time period of a simple pendulum effected with change in value of 'g' ?
Answer.

From Q. 4, $T \propto \frac{1}{\sqrt{g}}$. As '$g$' decreases at height and depth, T increases. g becomes zero in free fall or in a satellite. In that case, T becomes infinite.

Question. 13. Which pendulum is not effected with change in value of g ?
Answer. A spring pendulum, working on inertia and elasticity has no effect on its time period due to change in value of g.

Energy

Energy of a body is defined as its capacity of doing work. In other words, the amount of work done by a body is a measure of the energy possessed by the body.
It is measured in joule (J). It is a scalar quantity.

Law of conservation of energy

All different forms of energy are inter convertible. The sum total of different forms of energy in the universe is constant (conserved). Whenever an energy of one type is produced, an equal amount of energy or energies of other types are consumed. The energy can neither be created (produced out of nothing) nor destroyed (made to disappear completely).

Kinetic energy

(a) Definition. The energy of a body, due to its motion, is called kinetic energy of the body. It is represented by the symbol K.
(b) Explanation. Motion gives energy (capacity of doing work) to a body. Water in motion can produce hydroelectricity. Hammer in motion can fix a nail.
(c) Expression. Kinetic energy of a body in motion, can be calculated by calculating the work done to bring it into motion from rest.
Let a body of mass m be at rest. Let a force F acting on the body, displace it by a

distance S and give it a velocity v and uniform acceleration a.

Then, work done (on the body to move it)

$$W = F \,.\, S = (ma)\, S = m(aS)$$

From equation of motion,

$$v^2 = u^2 + 2aS$$

$$v^2 = 2aS \qquad (\because \quad u = 0)$$

or $$aS = \frac{v^2}{2}$$

Putting above $$W = \frac{mv^2}{2}$$

Hence, kinetic energy, $K = \frac{1}{2}mv^2$.

Potential energy

(a) Definition. The energy of a body, due to its position or change in configuration, is called potential energy of the body. It is represented by the symbol U.
(b) Explanation. Position gives energy to a body. Water falling from more height can produce more electricity. Hammer falling from more height can fix a nail deeper. Change in configuration also gives energy to a body. Coiled spring of a watch can make the watch run for hours. More pulled string of a bow can send an arrow with more velocity to more distance.
(c) Expression. The potential energy of a body in any position can be calculated by calculating the work done in bringing it to that position from position of zero potential energy.
Let a body of mass m lie on ground (at position of zero potential energy).
Let it be raised (lifted) to a height h against force mg due to gravity.
Then, work done = mg x h = mgh
Hence, potential energy, U = mgh.

Motion with inclined projection

When a body is projected at an angle 0 with horizontal with a velocity U from a point, its velocity has two components. Horizontal component U cos 0 remains constant because g = 0 but vertical component U sin 0 varies due to downward acceleration of gravity. The body goes along a path bent downward. At A, vertical velocity of the body becomes zero and the body does not go further high. A becomes the highest point reached by the body. Vertical height AD is called the maximum height attained by the body and is represented by the symbol H.
As body goes further ahead, due to horizontal velocity U cos 0, body develops a

vertically downward velocity which now increases. Path of body is again bent and it goes along AB. The body returns to point B at same horizontal level as O (called point of projection) with same velocity and same angle but with negative values. B is called point of return of the body. The distance OB is called horizontal range or simply range of the body and is represented by the symbol R.

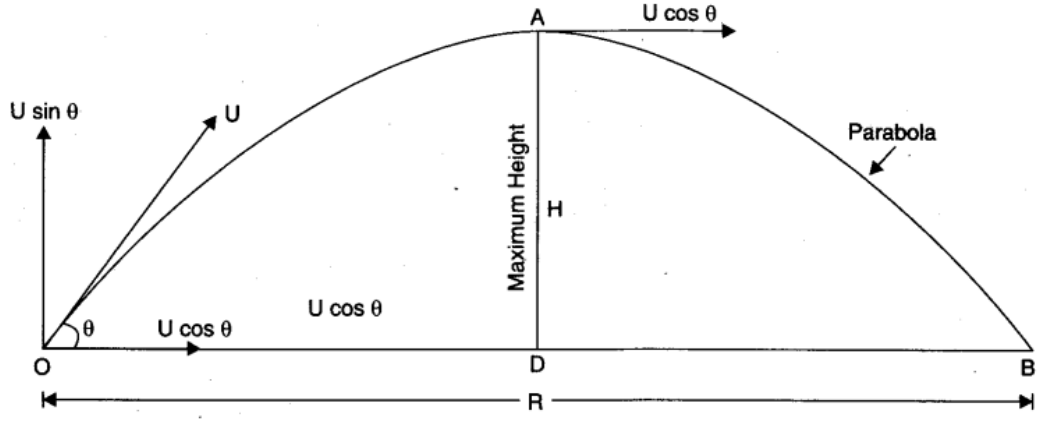

Fig. 6.01. Motion with inclined projection along a parabola.

The time for which body remains in motion (from O to B), is called **time of flight** of the body and is represented by the symbol **T.**

The projected body is called **projectile** and the path is called its **trajectory.**

Calculation shows that

(*i*) Equation of trajectory is

$$y = x \tan \theta - \frac{g}{2U^2 \cos^2 \theta} x^2$$ which represents a parabola.

(*ii*) Maximum height attained,

$$H = \frac{U^2 \sin^2 \theta}{2g}$$

(*iii*) Horizontal range or Range,

$$R = \frac{U^2 \sin 2\theta}{g}$$

Range is maximum for $\theta = 45°$ and its value is

$$R_{max.} = \frac{U^2}{g}$$

(*iv*) Time of flight, $T = \frac{2U \sin \theta}{g}$.

Viva Voce

Question. 1. What is a projectile ?
Answer. Projectile is the name given to a body moving in space by itself, without being propelled by any agent. The only force which affects its motion is force of gravity.

Question. 2. What is a trajectory ?
Answer. The path followed by a projectile, is called its trajectory.

Question. 3. What is a projectile motion ?
Answer. The motion of a projectile is called projectile motion.

Question. 4. What is the shape of trajectory of a projectile ?
Answer. It is a parabola.

Question. 5. Define time of flight.
Answer. The time for which a body remains in motion (from point of projection to point of return), is called time of flight of the body. It is represented by the symbol T.

Question. 6. Give expression for time of flight.
Answer.

The expression is, $$T = \frac{2U \sin \theta}{g}.$$

Question. 7. Define horizontal range.
Answer. The horizontal distance between point of projection and point of return, covered by a body during its flight, is called horizontal range of the body. It is represented by the symbol R.

Question. 8. Give expression for horizontal range.
Answer.

The expression is, $$R = \frac{U^2 \sin 2\theta}{g}.$$

Question. 9. For what angle of projection, the range is maximum ?
Answer. The range is maximum for angle of projection of 45°.

Question. 10. How are the two angles of projection for same range, related with each other ?
Answer. The angles are complementary, i.e., their sum is 90°.