Exercise 1(C) — Very Short Answer Type

Question 1

Define 'amplitude of oscillation'.

Answer : The maximum displacement of the bob from its mean position on either side is called the amplitude of oscillation.

Question 2

Define the terms: (i) oscillation (ii) amplitude (iii) frequency, and (iv) time period as related to a simple pendulum

Answer : (i) Oscillation – One complete to and fro motion of the bob of pendulum is called one oscillation.

(ii) Amplitude – The maximum displacement of the bob from its mean position on either side, is called the amplitude of oscillation. It is denoted by the letter a or A and is measured in metre(m).

(iii) Frequency – The number of oscillations made in one second is called the frequency. It is denoted by f or n. Its unit is per second (s-1) or hertz (Hz).

(iv) Time period – The time taken to complete one oscillation is the time period. It is denoted by the symbol T. Its unit is in second (s).

Question 3

Name two factors on which the time period of a simple pendulum does not depend.

Answer : The time period of a simple pendulum does not depend on —

The mass or material of the body suspended (i.e., the bob).

The extent of swing on either side (i.e. on amplitude), provided the swing is not too large.

Question 4

How is the time period of a simple pendulum affected, if at all, in the following situations:

(a) The length is made four times,

(b) The acceleration due to gravity is reduced to one-fourth.

Answer : As we know that,

$T=2\pi\sqrt{l}\div g$

where,

T = Time period

l = effective length of the pendulum

g = acceleration due to gravity.

(a) In the case when length is made four times, let time period be T1, we see that —

$T_1 = 2\pi\sqrt{4l \div g}$

$T_1 = 2 \times 2\pi\sqrt{l \div g}$

$T_1 = 2 \times T$

Hence, we can say that when the length is made four times, time period of a simple pendulum is doubled.

(b) In the case, when acceleration due to gravity is reduced to one fourth, let time period be T1, we see that —

$T_1 = 2\pi\sqrt{l \div g \div 4}$

$T_1 = 2\pi\sqrt{4l \div g}$

$T_1 = 2 \times 2\pi\sqrt{l \div g}$

$T_1 = 2 \times T$

Hence, we can say that when acceleration due to gravity is reduced to one fourth, time period of a simple pendulum is doubled.

Question 5

How are the time period T and frequency f of an oscillation of a simple pendulum related?

Answer

The time period (T) and frequency (f) of oscillation of a simple pendulum are related as stated below —

$f = 1 \div T$

Question 6

Two simple pendulum A and B have equal lengths, but heir bobs weigh 50 gf and 100 gf respectively. What would be the ratio of their time periods? Give reason for your answer.

Answer

As we know that,

$T=2\pi\sqrt{l \div g}$

where,

T = Time period

l = effective length of the pendulum

g = acceleration due to gravity.

So we see that, time period does not depend on the weight of the bob.

As, lengths are equal so,

$T_1 : T_2 = 1 : 1$

Question 7

What is a seconds' pendulum?

Answer

A pendulum with a time period of oscillation equal to two seconds is known as the seconds pendulum. Its effective length, at a place, where $g = 9.8\ ms^{-2}$ is nearly 1 meter.

Question 8

State the numerical value of the frequency of oscillation of a seconds' pendulum. Does it depend on the amplitude of oscillation ?

Answer

As we know that,

$f=1 \div T$

and T for a seconds' pendulum = 2s.

So, substituting the value of T in equation above we get,

$f=1 \div 2$

$\Rightarrow f=0.5$

Hence, the numerical value of the frequency of oscillation of a seconds' pendulum is $0.5\ s^{-1}$.

No, it does not depend on the amplitude of oscillation.

Exercise 1(C) — Short Answer Type

Question 1

What is a simple pendulum? Is the pendulum used in a pendulum clock simple pendulum? Give reason to your answer.

Answer : A simple pendulum is a heavy point mass (known as bob) suspended from a rigid support by a massless and inextensible string.

No, the pendulum used in the pendulum clock is not a simple pendulum, but it is a compound pendulum.(i.e., a body capable of oscillating about a horizontal axis passing through it.)

Question 2

Draw a neat diagram of a simple pendulum. Show on it the effective length of the pendulum and its one oscillation.

Answer : Below diagram shows the effective length and one oscillation of a simple pendulum:

Question 3

Name two factors on which the time period of a simple pendulum depends. Write the relation for the time period in terms of the above named factors.

Answer : Factors affecting the time period of a simple pendulum are —

Effective length of the pendulum — the time period of oscillation is directly proportional to the square root of its effective length.

i.e., $T \propto l$

Acceleration due to gravity — the time period of oscillations is inversely proportional to the square root of acceleration due to gravity

i.e., $T \propto 1 \div \sqrt{g}$

Relation between time period, effective length and acceleration due to gravity is as follows —

$T = 2\pi\sqrt{l} \div g$

where,

T = Time period

l = effective length of the pendulum

g = acceleration due to gravity.

Question 4

How do you measure the time period of a given pendulum? Why do you note the time for more than one oscillation ?

Answer

To measure the time period of a given pendulum, we record the time for 20 or more oscillations and then divide the recorded time with the number of oscillations. Hence, we get the time period for one oscillation.

The time for more than one oscillation is noted, as the least count of stop watch is either 1s or 0.5s. It cannot record the time period in fraction such as 1.2s or 1.4s and so on.

Hence, it is made possible by noting the time t for 20 oscillations or more and then dividing it by the number of oscillations.

Question 5

Two simple pendulums A and B have lengths 1.0 m and 4.0 m respectively at a certain place. Which pendulum will make more oscillations in 1 minute? Explain your answer.

Answer

Given,

lA = 1.0m

lB = 4.0m

Since,

$T \propto \sqrt{l}$

$\therefore, T_A \div T_B = l_A \div l_B$

Substituting the values of l in the formula above we get,

So, $T_A \div T_B = 14$

$\Rightarrow T_A \div T_B = 1 \div 2$

i.e., T1 : T2 = 1 : 2

∴, time period of B is more (twice) than that of A. Hence, A will make more oscillations (twice) in a given time than B.

Question 6

State how does the time period of a simple pendulum depend on —

(a) length of pendulum,

(b) mass of bob,

(c) amplitude of oscillation and

(d) acceleration due to gravity.

Answer

The time period of a simple pendulum varies as follows —

(a) Length of pendulum (l) — Time period of a simple pendulum is directly proportional to the square root of the length of the pendulum.

$T \propto \sqrt{l}$

(b) Mass of bob — Time period of a simple pendulum is independent of the mass of the bob.

(c) Amplitude of oscillation — Time period of a simple pendulum is independent of the amplitude of oscillation

(d) Acceleration due to gravity (g) — Time period of a simple pendulum is inversely proportional to the the square root of acceleration due to gravity .

$T \propto \sqrt{1 \div g}$

Exercise 1(C) — Long Answer Type

Question 1

How does the time period (T) of a simple pendulum depend on its length (l) ? Draw a graph showing the variation of T2 with l. How will you use this graph to determine the value of g (acceleration due to gravity)?

Answer

Time period of a simple pendulum is directly proportional to the square root of its effective length.

i.e., $T \propto \sqrt{l}$

Graph showing the variation of T2 with l is given below: refer text book

In order to find the acceleration due to gravity with the help of the above graph, we follow the following steps —

The slope of the straight line obtained in the T^2 vs l graph, as shown in fig, can be obtained by taking two points P and Q on the straight line and drawing normals from these points on the X and Y axes. Then, note the value of T^2, say T_1^2 and T_2^2 at a and b respectively, and also the value of l say l_1 and l_2 respectively at c and d.

Then,

Slope =PR÷QR =ab÷cd =$T_1^2 - T_2^2 \div l_1 - l_2$

This slope is found to be a constant at a place and,

Slope = $4\pi^2 \div g$

where, g = acceleration due to gravity at that place.

Thus, g can be determined at a place from the graph using the following relation,

g =$4\pi^2$ ÷ Slope of T2 vs l graph

Exercise 1(C) — Numericals

Question 1

A simple pendulum completes 40 oscillations in one minute.

Find its —

(a) frequency,

(b) time period.

Answer

(a) Given,

40 oscillations in one minute, so

frequency per second =40÷60

= 2÷3

=0.67s

Hence, frequency of oscillation = 0.67 s-1.

(b) As we know that,

T=1÷f

So, substituting the value of f = 0.67 s-1, in equation above we get,

$T = 1 \div 0.67$

$\Rightarrow T = 1.49253 s \approx 1.5 s$

Hence, time period of the simple pendulum is 1.5 s.

Question 2

The time period of a simple pendulum is 2s. What is its frequency? What name is given to such a pendulum?

Answer

As we know that,

$f = 1 \div T$

Given,

T = 2s

So, substituting the value of T in equation above we get,

$f = 1 \div 2$

$\Rightarrow f = 0.5$

Hence, the frequency of oscillation of the simple pendulum is 0.5 s^{-1}.

The name given to such a pendulum is seconds' pendulum.

Question 3

A seconds' pendulum is taken to a place where acceleration due to gravity falls to one forth. How is the time period of the pendulum affected, if at all? Give reason. What will be its new time period?

Answer

As we know,

$T = 2\pi\sqrt{l \div g}$

We observe that time period is inversely proportional to the square root of acceleration due to gravity.

Hence, when 'g' falls to one-fourth, time period increases.

When acceleration due to gravity is reduced to one fourth, we see that —

$T = 2\pi\sqrt{l \div g \div 4}$

$T = 2\pi\sqrt{4l \div g}$

$T = 2 \times 2\pi\sqrt{l \div g}$

Hence, we can say that when acceleration due to gravity is reduced to one fourth, time period of a simple pendulum doubles.

As, the given pendulum is a seconds' pendulum so T = 2s

∴ New T = 2 x 2 = 4s

Question 4

Find the length of a seconds' pendulum at a place where g = 10 ms-2 (Take π = 3.14).

Answer

As we know,

$T = 2\pi\sqrt{l \div g}$

Given,

$g = 10\ ms^{-2}$

$\pi = 3.14$

T = 2 s

Substituting the values in the formula above we get,

$2 = 2 \times 3.14\sqrt{l \div 10}$

$\Rightarrow (2 \div 2 \times 3.14) = \sqrt{l \div 10}$

$\Rightarrow (2 \div 2 \times 3.14)^2 = l \div 10$

$\Rightarrow (1 \div 3.14)^2 = l \div 10$

$\Rightarrow (0.3184)^2 = l \div 10$

$\Rightarrow 0.10142 = l \div 10$

$\Rightarrow l = 1.0142m$

Hence, length of a seconds' pendulum = 1.0142 m

Question 5

Compare the time periods of two pendulums of length 1m and 9m.

Answer

As we know that,

$T=2\pi\sqrt{l}\div g$

Time period is directly proportional to the square root of the length of the pendulum.

In the case when length is 1m,

$T_1=2\pi\sqrt{1}\div g$

and

In the case when length is 9m,

$T_2=2\pi\sqrt{9}\div g$

So, comparison of T1 and T2 gives —

$T_1:T_2=2\pi\sqrt{1}\div g :2\pi\sqrt{9}\div g$

$T_1:T_2=\sqrt{1}\div 9$

$\Rightarrow T_1:T_2=1\div 3$

Hence, T1 : T2 = 1 : 3

Question 6

A pendulum completes 2 oscillations in 5s.

(a) What is its time period?

(b) If g = 9.8 ms-2, find its length.

Answer

Given,

2 oscillations in 5 seconds, so

frequency per second =2÷5

$\Rightarrow$frequency per second=0.4 hertz

Hence, frequency of oscillation = 0.4 hertz.

As we know that,

$T = 1 \div f$

So, substituting the value of f = 0.4 hertz, in equation above we get,

$T = 1 \div 0.4$

$\Rightarrow T = 2.5s$

Hence, time period of pendulum is 2.5 s

(b) As we know,

$T = 2\pi\sqrt{l \div g}$

Given,

$g = 9.8\ ms^{-2}$

and we know,

$\pi = 3.14$

T = 2.5 s

Substituting the values in the formula above we get,

$2.5 = 2 \times 3.14\sqrt{l \div 9.8}$

$\Rightarrow (2.5 \div 2 \times 3.14) = l \div 9.8$

$\Rightarrow (2.5 \div 2 \times 3.14)^2 = l \div 9.8$

$\Rightarrow (2.5 \div 6.28)^2 = l \div 9.8$

$\Rightarrow (0.398)^2 = l \div 9.8$

$\Rightarrow 0.158 = l \div 9.8$

$\Rightarrow l = 9.8 \times 0.158$

$\Rightarrow l = 1.55$

Hence, length of a seconds' pendulum = 1.55 m

Question 7

The time periods of two simple pendulums at a place are in the ratio 2:1. What will be the ratio of their lengths ?

Answer

As we know that,

$T=2\pi\sqrt{l}\div g$

Time period is directly proportional to the square root of the length of the pendulum.

In the case when,

$T_1 : T_2 = 2 : 1$ [Equation 1]

we know that,

$T_1 : T_2 = \sqrt{l_1} : \sqrt{l_2}$ [Equation 2]

So we get,

$\sqrt{l_1} : \sqrt{l_2} = 2:1$

$\Rightarrow \sqrt{l1} \div \sqrt{l2} = 2 \div 1$

Squaring both sides we get,

$l_1 \div l_2 = 2^2 \div 1^2$

$\Rightarrow l_1 \div l_2 = 4 \div 1$

$\Rightarrow l_1 : l_2 = 4:1$

Hence, ratio of lengths = 4 : 1

Question 8

It takes 0.2s for a pendulum bob to move from mean position to one end. What is the time period of pendulum?

Answer

As we know that,

.Time period = 4 x (time a pendulum bob takes to move from mean position to one end).

Given,

Time a pendulum bob takes to move from mean position to one end = 0.2s

Substituting the value in the equation above we get,

Time taken to complete one oscillation(T) —

$=(4 \times 0.2)s$

$=0.8s$

Hence, time period of the pendulum = 0.8s

Question 9

How much time does the bob of a seconds' pendulum take to move from one extreme of its oscillation to the other extreme?

Answer

As we know that, the time period of a seconds' pendulum is 2s.

So, time taken for a seconds' pendulum to move from one extreme to other is equal to the half of time period.

$T_{half}=T_2$

$\Rightarrow T_{half}=2 \div 2=1s$

Hence, time taken for a seconds' pendulum to move from one extreme to other extreme = 1s