UNIT 10

SIMPLE HARMONIC MOTION AND WAVES

(PB) Including (PC) (PD) (PE) (PF) (PG) (PH)

Define the conditions necessary for an object to undergo simple harmonic motion.

- The force or acceleration is directed toward a fixed point.
- The force or acceleration is proportional to the displacement from the fixed point.
- Acceleration and the corresponding displacement always have opposite signs.
- The magnitude of the corresponding acceleration depends on the magnitude of the displacement.

Answer

Simple harmonic motion

Definition

Simple harmonic motion is a type of periodic motion in which an object moves in accordance with the following conditions:

- It is subjected to a force or acceleration that is directed toward a fixed point.
- The magnitude of the force or acceleration is always directly proportional to the displacement from the fixed point. The force or acceleration increases as the object moves farther away from the fixed point.
- The force or acceleration and the displacement always have opposite signs.

(b) Find the maximum speed of mass attached to a spring in SHM?

Answer

Where, ω is the angular frequency of the mass-spring system.

$\omega = \sqrt{\frac{k}{m}}$ and $\omega = 2\pi f$ and $\omega = \frac{2\pi}{T}$

The radius of ω is known as the reference of the spring. All the angular frequency of the mass-spring system is the same as the angular frequency of the reference.

The negative sign in equation 1 means that the force acting on the mass is always in the opposite direction of the displacement of the mass. Because the spring always tries to return the mass to its equilibrium position, it is known as the restoring force.

Acceleration is found substituting force.

Maximum force

Maximum force occurs when the mass is at its maximum displacement. It occurs when $x = A$.

$$F_{max} = -kA$$

Maximum acceleration

Maximum acceleration occurs when the mass is at its maximum displacement. It occurs when $x = A$.

$$a_{max} = -\frac{kA}{m}$$

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Since the mass is subject to the restoring force, the mass will be pulled back toward the equilibrium position. Because the mass is pulled back to the equilibrium position, it will be accelerated toward the equilibrium position. Because the mass is accelerated toward the equilibrium position, it will be subjected to the restoring force. Because the mass is subjected

MULTIPLE CHOICE QUESTIONS

Choose the correct answer from the following choices:

i) Which of the following is an example of simple harmonic motion?

a) Motion of a simple pendulum **b)** The motion of ceiling fan
c) The spinning of the Earth on its axis **d)** A bouncing ball on a floor

ii) If the mass of the bob of a pendulum is increased by a factor of 3, the period of the pendulum's motion will:

a) be increased by a factor of 2 **b)** remain the same
c) be decreased by a factor of 7 **d)** be decreased by a factor of 4

iii) Which of the following devices can be used to produce both a transverse and longitudinal wave?

a) a string **b)** a ripple tank
c) a helical spring (slinky) **d)** a tuning fork

iv) Waves transfer:

a) Energy **b)** frequency
c) wavelength **d)** velocity

v) Which of the following is a method of energy transfer?

a) Conduction **b)** Radiation
c) Wave motion **d)** All of these

vi) In a vacuum all electromagnetic waves have the same:

a) Speed **b)** frequency
c) amplitude **d)** wavelength

vii) A large ripple tank with a vibrator working at a frequency of 30 Hz produces 25 complete waves in a distance of 50cm. The velocity of the wave is:

a) 53 cms^{-1} **b)** 60 cms^{-1}
c) 750 cms^{-1} **d)** 1500 cms^{-1}

viii) Which of the following characteristics of a wave is independent of the others:

a) speed **b)** frequency
c) amplitude **d)** wavelength

ix) The relation between v, f and A of a wave is:

a) $vf = \lambda$ **b)** $f\lambda = v$
c) $v\lambda = f$ **d)** $v = \frac{\lambda}{f}$

Answers

(i) a **(ii)** b **(iii)** c **(iv)** a **(v)** d **(vi)** a
(vii) b **(viii)** a **(ix)** b

Conceptual Questions

10. 1 If the length of a simple pendulum is doubled what will be the change in its time period?

Answer

Let the initial length of simple pendulum is ' l ', and after making it double, it becomes

' l ', i.e. $L' = 2l$.

Time period of simple pendulum is given by,

$$T = 2\pi\sqrt{\frac{l}{g}} \text{ ------(1)}$$

And $$T' = 2\pi\sqrt{\frac{l'}{g}}$$

Or $$T' = 2\pi\sqrt{\frac{2l}{g}}$$

$$T' = \sqrt{2}\left[2\pi\sqrt{\frac{l}{g}}\right]$$

Where, $$2\pi\sqrt{\frac{l}{g}} = T$$

So, $$T' = \sqrt{2}T$$

$$T' = 1.41T$$

It shows that the time period of simple pendulum will increase by 1.41 times by making the length double.

10. 2 A ball is dropped from a certain height onto the floor and keeps bouncing. Is the motion or the ball simple harmonic? Explain.

Answer

No, in case of a bouncing ball, when it hits the floor then there will be no restoring force or acceleration opposite to the downward displacement. So, it does not fulfil the condition of simple harmonic motion. Secondly, in case of bouncing ball, the acceleration due to gravity remains the same, while for SHM the acceleration should vary at different points during the motion of the body.

10. 3 A student performed two experiments with a simple pendulum. He/She used two bobs of different masses by keeping other parameters constant. To his/her astonishment the time period of the pendulum did not change! Why?

Answer

Time period of simple pendulum only depends upon the length of simple pendulum as given in its formula, i.e.

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

The value of 'g' will remain constant up to a certain height. So, by changing mass of the bob or amplitude, there will be no effect on the time period, of simple pendulum.

10. 4 What type at waves do not require any material medium for their propagation?

Answer

Mechanical waves: like sound waves, water waves, waves produced in strings or springs etc.

10. 5 Plane waves in the ripple tank undergo refraction when they move from deep to shallow water. What change occurs in the speed of the waves?

Answer

In case of plane waves in the ripple tank when refraction takes place while moving from deep to shallow water. The speed of the wave is decreased due to decrease in wave length while frequency remains the same, as given by wave equation below.

$$v = f\lambda$$

Review Questions

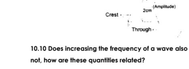
10. 2 Think of several examples in our daily life of motion that are simple harmonic?

Answer

1. Pendulum used in a clock.
2. A boy swinging on a swing.
3. See-saw: when his moved up & down.
4. Human ear drum oscillating back & forth.

10. 6 Draw a transverse wave with an amplitude of 2cm and a wavelength of 4cm. Label a crest and trough on the wave.

Answer



10.10 Does increasing the frequency of a wave also increase its wave length? If not, how are these quantities related?

Answer

No, by increasing frequency, the wave length decreases as given by the following relation,

$$v = f\lambda$$

Or $$f = \frac{v}{\lambda}$$

Or $$f \propto \frac{1}{\lambda}$$ (for constant value of velocity)

[Note: The answer of the remaining questions is given in the topics.]

OBJECTIVE TYPE QUESTIONS & ANSWERS

Q1. Slow shot tremors

1. Wind is caused

Answer

Horizontal movement of thickening/rarefying mass from place/time to another.

2. Differentiate between free period and frequency.

Answer

Time period

Time taken for one complete cycle. To complete one vibration is called as time period.

It is measured in second. Denoted by T.

Frequency

It is measured by no. of cycles in a cycle per sec or in Hertz (Hz).

3. Core zone importance of waves.

Answer

Source of earthquakes of waves is

- Sudden release of energy in a position of breaking.
- Sand and gravel are in the focus.
- Minerals big of rocks and fabrication congloblitate in a ray in the form of a cone.

- Velar of cones are called the radius in the focus rocks.

4. Find the time period of one metre length of simple pendulum on the surface of earth?

Answer

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

$$T = 2\pi\sqrt{\frac{1}{9.8}}$$

$$T = 2\pi\sqrt{\frac{1}{10}}$$

5. Find the time period of one metre length of simple pendulum on the surface of moon.

Answer

$$T = 2\pi\sqrt{\frac{l}{g_m}}$$

$$T = 2\pi\sqrt{\frac{1}{1.6}}$$

$$T = 2\pi\sqrt{\frac{1}{10}}$$

6. Frame a relationship between T and mass spring system?

Answer

Relationship between time period and mass is depicted through a graph/equation. They are inversely or linear type.

$$T \propto \frac{1}{m}$$

$$T \propto \frac{1}{\sqrt{m}}$$

Where T is spring constant?

7. Give relation between the frequency and time period.

Answer

Frequency is inverse of time period.

$$f = \frac{1}{T}$$

Where T is time period?

8. Give relation between the frequency and time period.

Answer

Frequency is inverse of time period.

$$f = \frac{1}{T}$$

So, find the period for one oscillation ?

$$T = \frac{t}{n}$$

So find the time for one oscillation is called time period. For oscillating T is called time period.

9. Define Amplitude

Answer

It is called the maximum displacement from the mean position.

10. Define Frequency

Answer

Frequency is the number of oscillations per second.

$$f = \frac{n}{t}$$

11. Which factors are acting on the pendulum when it is the extreme position?

Answer

When the pendulum is at the extreme position, the forces are acting on it

- The weight of bob of the bob force acting vertically downwards.
- The tension of the string.

12. What is simple pendulum?

Answer

A simple pendulum is consist of a large and heavy bob suspended from a light and inelastic string of fixed length.

13. What are factors upon which the time period of simple pendulum depends?

Answer

The factors on the period of simple pendulum is given by

- The length of the string.

The acceleration due to gravity.

14. What are factors upon which the time period of simple pendulum is independent?

Answer

The period of simple pendulum is independent of the mass of the bob.

15. Time for the period depends on the amplitude of the pendulum?

Answer

The relation for the period of simple pendulum is given by

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

The relation shows that the period of simple pendulum is independent of the amplitude of the pendulum.

16. What is type of force under this as an important role in simple pendulum?

Answer

Under a force of tension exists in the pendulum. Many forces come into play.

- Weight of the bob.
- Tension in the string.

17. Give some example of vehicle that does SHM in nature.

Answer

- Motion of the bob of a simple pendulum.
- Motion of blind folded swing which is pushed from its lowest position.
- Vibration of atoms and molecules about their mean position.

18. Why does a pendulum lose from a corner and gets first to center?

Answer

Answer

The acceleration due to gravity is given by

$$g = \frac{GM}{R^2}$$

The relation shows that the time period of simple pendulum is directly proportional to the square root of the length.

The time period of simple pendulum is directly proportional to the square root of the reciprocal of the acceleration due to gravity.

A simple mass is expressed in length. At time period decreases and mass is given.

19. What happens to the frequency of pendulum, so its oscillations die down in a short time?

Answer

At the functions of time period.

The time period of simple pendulum is given by

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$$f = \frac{1}{2\pi\sqrt{\frac{l}{g}}}$$

$$f = \frac{1}{2\pi}\sqrt{\frac{g}{l}}$$

20. How will the time of simple pendulum be affected?

Answer

If a pendulum clock goes to the mountain top and it takes one second to complete one oscillation. Then what will happen to the time period of the pendulum?

When the clock is set on, clock comes accelerated.

21. Force that the product of time period and frequency is unity.

Answer

As the length of the simple pendulum is fixed that mean that time period remains the same and they changes that light.

22. Can SHM take place in simple pendulum the circular motion?

Answer

Pendulum oscillates only the vertical force of tension and weight of the bob. Therefore, the motion of the pendulum is not circular. It is a vertical motion. When the pendulum is set on, circular motion accelerated.

23. Force that the product of time period and frequency is unity.

Answer

As the length of the simple pendulum is fixed that mean that time period remains the same and they changes that light.

24. Why does the simple pendulum stop?

Answer

Because the time period of simple pendulum is

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

Where T is time period of simple pendulum.

25. Why the amplitude of simple pendulum is small?

Answer

Because the time period of simple pendulum is

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Answer

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40. Give some example of vehicle that does SHM in nature.

Answer

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Answer

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44. Force that the product of time period and frequency is unity.

Answer

As the length of the simple pendulum is fixed that mean that time period remains the same and they changes that light.

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As the time period of simple pendulum is T. Therefore, its frequency will be

$$f = \frac{1}{T}$$

$$f = \frac{1}{2\pi\sqrt{\frac{l}{g}}}$$

$$f = \frac{1}{2\pi}\sqrt{\frac{g}{l}}$$

94. How will the time of simple pendulum be affected?

Answer

If a pendulum clock goes to the mountain top and it takes one second to complete one oscillation. Then what will happen to the time period of the pendulum?

When the clock is set on, clock comes accelerated.

95. Force that the product of time period and frequency is unity.

Answer

As the length of the simple pendulum is fixed that mean that time period remains the same and they changes that light.

96. Can SHM take place in simple pendulum the circular motion?

Answer

Pendulum oscillates only the vertical force of tension and weight of the bob. Therefore, the motion of the pendulum is not circular. It is a vertical motion. When the pendulum is set on, circular motion accelerated.

97. Force that the product of time period and frequency is unity.

Answer

As the length of the simple pendulum is fixed that mean that time period remains the same and they changes that light.

98. Why the amplitude of simple pendulum is small?

Answer

Because the time period of simple pendulum is

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

Where T is time period of simple pendulum.

99. Why does the simple pendulum stop?

Answer

Because the time period of simple pendulum is

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100. Why the time period of simple pendulum is independent of the mass of the bob?

Answer

The length of the simple pendulum is fixed that mean that time period remains the same and they changes that light.

101. Why the time period of simple pendulum is independent of the amplitude?

Answer

Because the time period of simple pendulum is

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

Where T is time period of simple pendulum.

102. Why does the time period of simple pendulum increases?

Answer

Because the time period of simple pendulum is

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

Where T is time period of simple pendulum.

103. What is simple pendulum?

Answer

A simple pendulum is consist of a large and heavy bob suspended from a light and inelastic string of fixed length.

104. What are factors upon which the time period of simple pendulum depends?

Answer

The factors on the period of simple pendulum is given by

- The length of the string.

The acceleration due to gravity.

105. What are factors upon which the time period of simple pendulum is independent?

Answer

The period of simple pendulum is independent of the mass of the bob.

106. Time for the period depends on the amplitude of the pendulum?

Answer

The relation for the period of simple pendulum is given by

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

The relation shows that the period of simple pendulum is independent of the amplitude of the pendulum.

107. What is type of force under this as an important role in simple pendulum?

Answer

Under a force of tension exists in the pendulum. Many forces come into play.

- Weight of the bob.
- Tension in the string.

108. Give some example of vehicle that does SHM in nature.

Answer

- Motion of the bob of a simple pendulum.
- Motion of blind folded swing which is pushed from its lowest position.
- Vibration of atoms and molecules about their mean position.

109. Why does a pendulum lose from a corner and gets first to center?

Answer

The acceleration due to gravity is given by

$$g = \frac{GM}{R^2}$$

The relation shows that the time period of simple pendulum is directly proportional to the square root of the length.

The time period of simple pendulum is directly proportional to the square root of the reciprocal of the acceleration due to gravity.

A simple mass is expressed in length. At time period decreases and mass is given.

110. What happens to the frequency of pendulum, so its oscillations die down in a short time?

Answer

At the functions of time period.

The time period of simple pendulum is given by

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134. Why the time period of simple pendulum is independent of the mass of the bob?

Answer

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**135. Why the time period of simple pendulum is independent of the amplitude?

OBJECTIVE TYPE QUESTIONS & ANSWERS

Q1. Each question is followed by four options encircle the correct option.

1) The maximum potential energy of a vibrating mass attached to a spring is at:
a. Equilibrium position b. Extreme position
c. Between equilibrium and extreme position d. All of them

2) The product of frequency ' and time period is equal to:
a. 1/π b. 1
c. 0 d. 1/0

3) If the mass of bob of a simple pendulum is doubled, its period:
a. is doubled b. becomes four times
c. remains the same d. none of the above

4) If the length of a simple pendulum is halved its time period 1 will become:
a) T/2 b) T/√2
c) √2T d) $T^{2/2}$

5) In terms of wave length (λ), the distance between two neighboring nodes or antinodes is:
a) λ b) λ /2
c) λ/4 d) 2 λ

6) Which of the following waves is not electromagnetic?
a. X-rays b. radio waves
c. light waves d. water waves

7) Which is the correct formula to find the frequency?
a. f=1 b. f=1/π
c. $f=2\pi\sqrt{L/f}$ d. $f=2\pi\sqrt{\sqrt{L}/f}$

8) Hertz is the unit of:
a. frequency b. wavelength
c. mass d. acceleration

9) Which is not the characteristic of simple harmonic motion of a body?
a. It always vibrates about its position of equilibrium
b. Its acceleration is always directed towards its mean position
c. Its velocity is minimum at mean position
d. Its velocity IS maximum at Its mean position

10) The Waves in which the particles of the medium vibrate perpendicular to the direction of motion of waves are called:
a. electromagnetic waves b. transverse waves
c. compressional waves d. longitudinal waves

11) Energy can be transferred from one place to another:
a. through matter b. through waves
c. both of them d. none of these

12) The apparatus used to study the properties of waves is:
a. ripple tank b. water tank
c. electric bulb d. galvanometer

13) Which is concerned with bending of waves around corners?
a. reflection b. refraction
c. diffraction d. none of above

14) The up and down motion of hand produces waves in string known as:
a. Longitudinal waves b. compressional waves
c. transverse waves d. stationary waves

15) Which is not correct:
a. the number of loops on string depends upon the frequency of up and down motion of hand.
b. string makes single loop at the lowest frequency
c. the fundamental frequency is called second harmonics
d. the fundamental frequency is called first harmonics

16) Which is not the true statement?
a. water waves exhibit phenomenon of refraction
b. speed of water waves depends on the depth of water
c. speed of light is more in air than in glass
d. bending of waves from their incident path is called amplitude

17) Which is not a correct equation
a. λ=V/T b. V= λ /T
c. T= λ /V d. V= λ T

18) Find the equation in which spr...g constant has been used:
a. $k=F_s/x$ b. $a=f.m$
c. $T=2\pi\sqrt{L/g}$ d. $f=1/T$

19) When where will the bob have maximum kinetic energy?
a. at its mean position b. at its extreme position
c. when the bob is stationary d. none of the above

20) .The sound waves in air are:
a. longitudinal b. radio
c. stationary d. none of the above

21) The B.I. unit of spring constants K is:
a. Nm^{-2} b. Nm^{-2}
c. Nm^{-1} d.Nm

22) In S.E.M. the acceleration of the vibrating body is directly proportional to the:
a. distance b. displacement
c. amplitude d. velocity

23) The motion which repeats itself in equal intervals of time is called:
a. rotatory motion b. circular motion
c. angular motion d. vibratory motion

24) A force of 20N, produces an extension of 10 cm in an elastic spring. Then the value of spring constant is:
a. 200 Nm^{-1} b. $20Nm^{-2}$
c. 20 Nm^{-1} a. none of these

25) The number of vibrations completed in one second is called:
a. time period b. frequency
c. amplitude d. wavelength

26) One complete round trip of an object about mean position is called:
a. amplitude b. frequency
c. Vibration d. time period

27) In an elastic spring, SHM is produced due to:
a. K.E of spring b. weight of spring
c. mass of spring d. restoring force

28) The time period of the simple pendulum does not depend upon:
a. mass of object b. length of string
c. value of g d. tension in string

29) The time period of the spring depends upon:
a. length of spring b. mass of object
c. value of g d. none of these

30). At which place, the motion of simple pendulum becomes faster?
a. Lahore b. Quetta
c. Murree d. Karachi

31) How many times the' value of "g" on 'moon surface is less than the value of g on earth's surface?
a. 1/6 b. 2
c.4 d. 6

32) The waves which do not require a medium for their propagation are known as:
a. mechanical waves b. electromagnetic waves
c. matter waves d. transverse, waves

33) Which of the following is not electromagnetic wave?
a. ultraviolet b. Microwave
c. water wave d. radio wave

34) The speed of electromagnetic wave is:
a. $3.0 \times 10^8 ms^{-1}$ b. $332 ms^{-1}$
c. 600 m/s d. zero

35) The acceleration of a vibrating body is maximum at:
a. when v is maximum b. mean position
c. extreme position d. both a and b

36) At mean position, a vibrating object has maximum:
a. acceleration b. velocity
c. time period d. displacement

37) The time period of a spring executing S.H.M. is equal 'a:
a. $2\pi\sqrt{\frac{m}{k}}$ b. $2\pi\sqrt{\frac{k}{m}}$ c. $\frac{1}{2\pi}\sqrt{\frac{k}{m}}$ d. $2\pi\sqrt{\frac{m}{k}}$

38) By increasing the load in the spring, the time period of spring:
a. increases b. decreases
c. remains unchanged d. becomes zero

39) The time period of a simple pendulum is equal to:
a. $2\pi\sqrt{\frac{l}{g}}$ b. $\frac{1}{2\pi}\sqrt{\frac{g}{l}}$ c. $2\pi\sqrt{\frac{l}{g}}$ d. $\frac{1}{2\pi}\sqrt{\frac{l}{g}}$

40) The time period of simple pendulum is independent of:
a. length b. mass
c. value of g d. acceleration

41) Which of the following have maximum wavelength?
a. gamma rays b. visible light
c. microwaves d. radio waves

42) Which of the following have maximum frequency?
a. gamma rays b. radio waves
c. x-rays d. microwaves

43) Ripple tank is used to:
a. firing bomb b. to study waves
c. swimming d. none of these

44) Bending of waves from their incident path is called.
a. reflection b. diffraction
c. refraction d. interference

45) According to the law of reflection:
a. sin i=sin r b. i=i+r
c. r=i /sinc d. i+r=0

46) The radio transmission can be heard in such areas where the waves cannot reach directly due to:
a. reflection b. refraction
c. interference d. diffraction

47) When two identical waves travelling in opposite direction along the same line combine to form:
a. interference b. diffraction
c. stationary waved d. none of these

48) Bending of waves around obstacles is called:
a. diffraction b. interference;
c. reflection d. refraction

49) The equation of wave speed is:
a. fs =λ/t b. λ=f/v
c. v=f/λ d. v=f/λ

50) The units of frequency are:
a. Hertz b. s^{-1}
c. cycles per second d. all of them