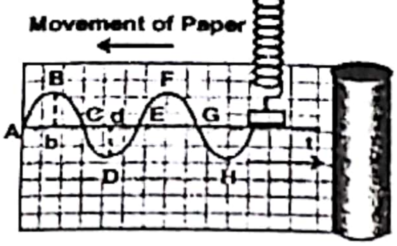
Chapter 7



OSCILLATIONS

KEY POINTS

Oscillatory motion:

Oscillatory motion is to and fro about a mean position.

Periodic motion:

Periodic motion is the one that repeats itself after equal interval of time.

Restoring force:

Restoring force opposes the change in shape or length of a body and is equal and opposite to the applied force.

Simple Harmonic Motion:

A vibratory motion in which acceleration is directly proportional to displacement from mean position and is always directed towards the mean position is known as SHM.

Characteristics

- $a \propto -x$
- a is directed towards mean position.
- **Time period** is defined as time taken by vibrating body to complete its one vibration and denoted by T.
- **Frequency** is number of vibrations per second and denoted by f

  $f = 1/T$

  Its unit is Hz. others units are vibrations/s, cycle/s, rev/sec
- **Amplitude** is maximum distance from mean position
- **Angular frequency** is $\omega = 2\pi/T \Rightarrow \omega = 2\pi f$
- **Phase** is angle which specifies the displacement and direction of motion of the point executing SHM i.e phase = $\theta = \omega t$
- Initial angle at t = 0 is called phase constant and denoted by φ
- **Instantaneous displacement**: $x = x_0 \sin\theta$
- **Instantaneous velocity**: $v = \omega\sqrt{x_o^2 - x^2}$
- **Instantaneous acceleration**: $a = -\omega^2 x$

A Horizontal Mass-Spring System:

- For spring, Hooke's law states that;

  stress $\propto$ strain

  $F = k\,x$

  where k = F/x is called spring constant or force constant.
- Vibrational angular frequency: $\omega = \sqrt{\dfrac{k}{m}}$
- Time period of the mass: $T = \dfrac{2\pi}{\omega} = 2\pi\sqrt{\dfrac{m}{k}}$

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Chapter- 7

- Instantaneous displacement: $x = x_o Sin\sqrt{\frac{k}{m}}t$
- Instantaneous velocity : $v = x_o\sqrt{\frac{k}{m}(x_o^2 - x^2)}$
- Time period: the vibratory motion of mass attached to an elastic spring is SHM and its time period is $T = 2\pi\sqrt{\frac{m}{k}}$

Simple Pendulum:

It consists of a heavy point mass suspended from a rigid support by means of almost weightless and inextensible string.

- *The* vibratory motion of the bob of simple pendulum is also SHM and its time period is $T = 2\pi\sqrt{\frac{l}{g}}$.

	Frequency	Time period	length
Simple pendulum	1 Hz	1 sec	0.25m
Second's pendulum	0.5 Hz	2 sec	0.99m

Energy Conservation in SHM:

- Maximum P.E is given as; $P.E = \frac{1}{2}kx_o^2$
- Maximum K.E(at mean position) given as; $K.E_{max} = \frac{1}{2}kx_o^2$
- Total energy of system = $\frac{1}{2}kx_o^2$
- At any instant P.E: P.E = $\frac{1}{2}kx^2$
- At any instant K.E: K.E = $\frac{1}{2}kx_o^2\left(1 - \frac{x^2}{x_o^2}\right)$

Free & Forced Oscillations:

- Oscillation of a system is called free oscillation if it oscillates without the interference of an external force.
- Frequency of free oscillation is called *natural frequency of the system*

Damped Oscillation:

- Damping is the process whereby energy is dissipated from oscillating system. e.g In shock absorber of a car

Resonance:

Resonance is the specific response of a system to a periodic force acting with the natural vibrating period of the system.

Sharpness of Resonance:

- Smaller the damping greater will be the amplitude and more sharp will be the resonance.
- A heavily damped system has a fairly flat resonance curve

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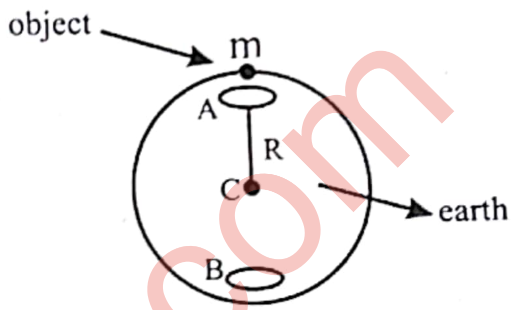
TOPICAL MULTIPLE CHOICE QUESTIONS

Topic 7.1: Simple Harmonic Motion

(1) **Vibratory motion is always under**
(a) an applied force
(b) an elastic restoring force and inertia
(c) periodic force
(d) gravitational force

(2) **Restoring force acts**
(a) towards mean position
(b) away from mean position
(c) may be a or b
(d) towards mean position if speed is fast

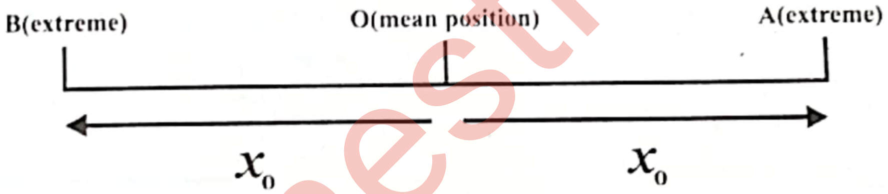
(3) **A bore or cavity is made in the earth which passes by its centre as shown in the figure below. A body of mass "m" is allowed to fell down towards centre of earth due to gravity from the point "A". What is true about motion of mass "m"**



(a) ball will stay at point "C"
(b) ball will emerge from point "B"
(c) ball will come back from point "A"
(d) ball will start executing S.H.M about centre "C".

(4) **Angular frequency is a characteristic of**
(a) translatory motion
(b) circular motion
(c) random motion
(d) Linear motion

(5) **A body executes S.H.M between points "A" & "B" such that it completes two and a half rotations. What will be the distance and displacement covered by it in this time?**

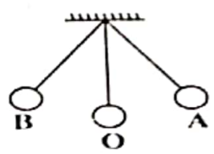


(a) $10x_0, 2x_0$
(b) $10x_0, x_0$
(c) $10x_0, 0$
(d) $0, 10x_0$

(6) **Under the action of restoring force, the body accelerates and it overshoots the rest position due to**
(a) velocity
(b) inertia
(c) external force
(d) equilibrium

(7) **In S.H.M, the acceleration of a body is directly proportional to**
(a) applied force
(b) amplitude
(c) displacement
(d) restoring force

(8) **Which of the following motions can't be considered as S.H.M?**



(a) a scale placed in a cavity vibrating
(b) a simple pendulum
(c) an object "P" moving along a circular path with uniform speed
(d) none of these

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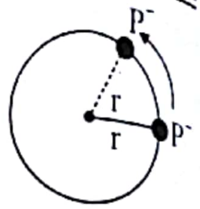
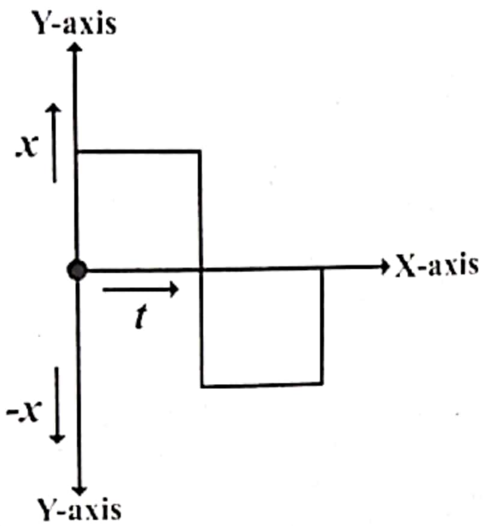


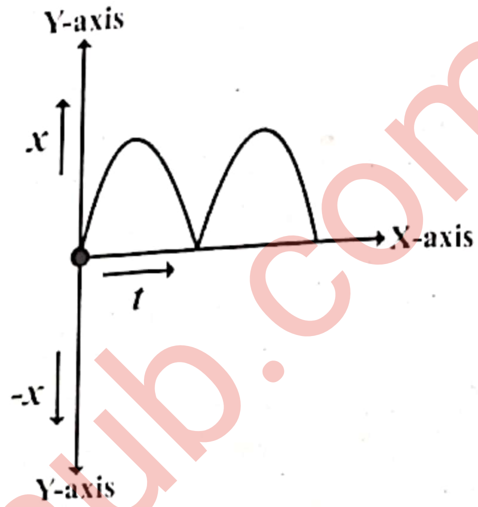
9) **SI unit of frequency is**
(a) vibration/s^2 (b) radian
(c) hertz (d) ms^{-1}

10) **A mass of 1kg is attached to a spring which produces an extension of 0.1cm. Its spring constant is**
(a) 10000 N/m (b) 10 N/m
(c) 1N/m (d) 1000N/m

11) **Which of the following is the waveform of S.H.M?**



(a)



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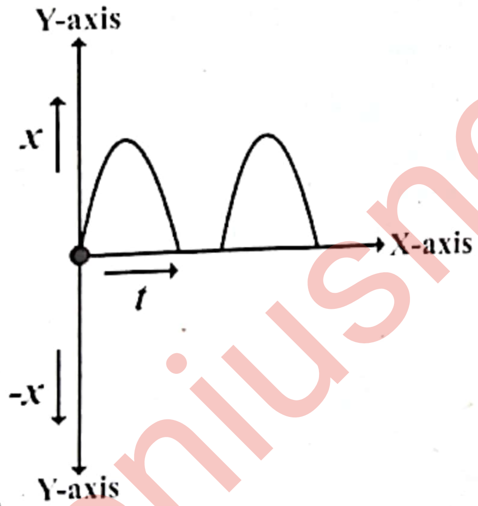
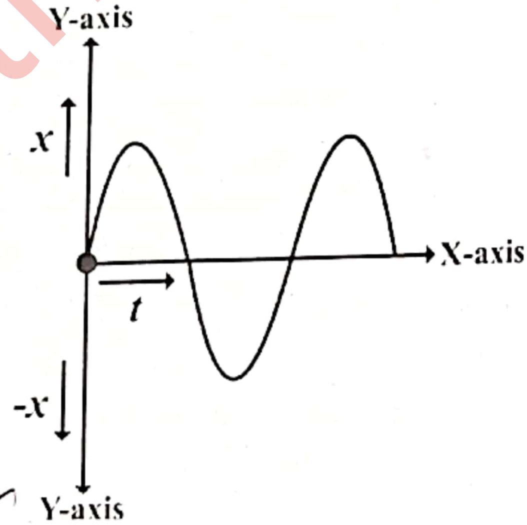


(c)



(d)

12) **The dimension of spring constant**
(a) $[MLT^{-1}]$ (b) $[MT^{-2}]$
(c) $[ML^{-2}]$ (d) $[MT^{-1}]$

13) **The S.I unit of time period**
(a) s^{-1} (b) s
(c) s^{-2} (d) Hertz

14) **The dimension of frequency is**
(a) $[T^{-1}]$ (b) $[T^{-2}]$
(c) $[T]$ (d) $[T^{-3}]$

(15) **The body oscillates due to a**
(a) frictional force (b) restoring force
(c) buoyant force (d) drag force

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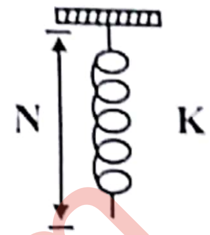
(16) The restoring force is given by

(a) $F_r = kx$ (b) $F_r = \frac{k}{x}$

(c) $F_r = \frac{-x}{k}$ (d) $F_r = -kx$

(17) A spring of "N" turns in the figure. If the spring constant is "K" then how does value of "K" varies if "N" are halved?



(a) becomes half (b) becomes double

(c) remains same (d) can't be predicted

(18) The unit of spring constant is

(a) Nm^{-2} (b) Nm^{-1}

(c) Nm (d) $Nm^{-1}s$

(19) The value of instantaneous displacement is zero when the body is at

(a) extreme position (b) mean position

(c) between mean and extreme position (d) none of these

(20) The restoring force is directly proportional to displacement is called

(a) Joule's law (b) Hooke's law

(c) Stoke's Law (d) Pascal Law

(21) The unit of spring constant k is same as that of

(a) force (b) pressure

(c) flow rate (d) surface tension

(22) The acceleration of a body executing S.H.M is directly proportional to

(a) amplitude (b) displacement

(c) frequency (d) time period

(23) The one complete round trip of an object in motion is called

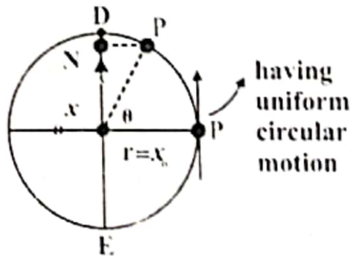
(a) time period (b) amplitude

(c) frequency (d) vibration

Topic 7.2:

SHM and Uniform Circular Motion

(24) In the figure an object "P" is moving along circular path of radius "X_0". What will be the relation for maximum velocity of projection of "P" as N and at what point?



(a) ωX_0,D (b) ωX_0,E

(c) ωX_0,O (d) $\omega\sqrt{X_0^2 - x^2}$,0

(25) At what distance from mean position the energy of vibrating body is half potential and half kinetic (x_0 = amplitude)

(a) $\frac{x_0}{2}$ (b) $\frac{x_0}{4}$

(c) $\frac{x_0}{\sqrt{2}}$ (d) $\sqrt{2}x_0$

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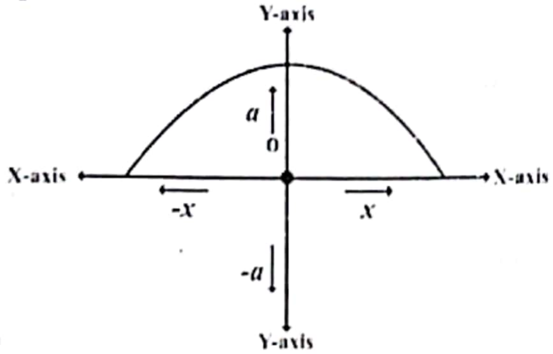
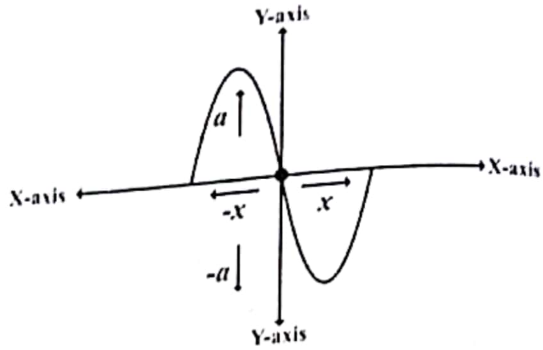
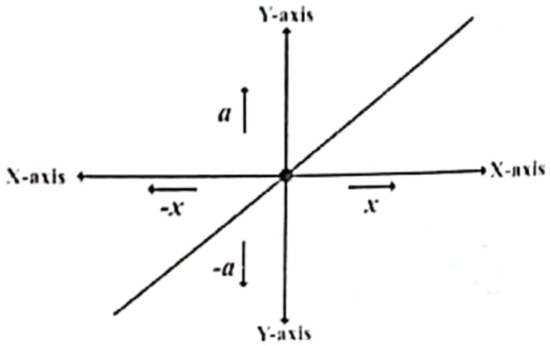
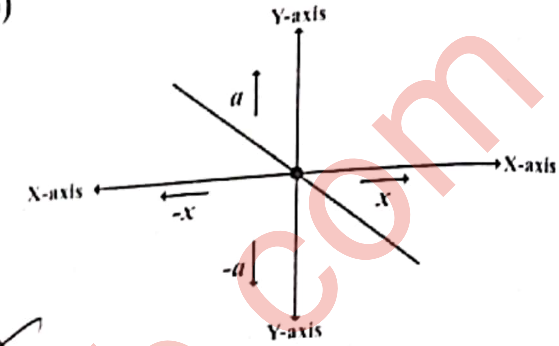
(26) **Which of the following curves best illustrate the graph between "a' and "x" for a simple harmonic oscillator?**

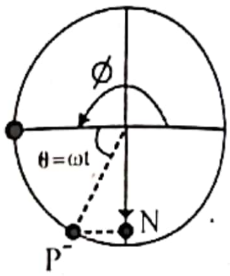
(a) 

(b) 

(c) 

(d) 

(27) **In the figure shown what must be the equation for instantaneous displacement of point "N" and initial phase?**



(a) $x=x_0\sin\theta, \phi = 0°$
(b) $x=x_0\cos\theta, \phi = 90°$
(c) $x=-x_0\sin\theta, \phi = 180°$
(d) $x=-x_0\cos\theta, \phi = 270°$

(28) **By increasing the weights on an oscillatory spring, the period of oscillation would be**

(a) increases
(b) decreased
(c) remain same
(d) may increase or decrease

(29) **The acceleration of projection of a point on the diameter moving on a circle is**

(a) $-\omega x$
(b) $-\omega x^2$
(c) $-\omega^2 x$
(d) ωx^2

(30) **Which of the following equation can be for instantaneous displacement for a simple harmonic oscillator?**

(a) $x=x_0\cos\theta$
(b) $x=-x_0\sin\theta$
(c) $x=-x_0\cos\theta$
(d) all of these

(31) **The maximum displacement of a body executing SHM is represented by**

(a) x
(b) x_0
(c) ωt
(d) $x_0 \omega$

Topic 7.3:

Phase

(32) **The phase determine the state of motion of the**

(a) rotatory point
(b) translatory point
(c) random point
(d) vibratory point

(33) **If a body starts its motion in a circular path from its extreme position its initial phase is**

(a) $\frac{\pi}{2}$
(b) $\frac{3\pi}{2}$
(c) π
(d) $\frac{\pi}{4}$

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(34) **The phase angle θ=ωt of a body performing SHM indicates**

(a) both direction and displacement
(b) only direction of displacement
(c) both magnitude and direction
(d) none of these

(35) **The expression for displacement** $x = x_o \sin(\omega t + 90^o)$ **is equal to**

(a) $x = x_o \sin \omega t$
(b) $x = x_o \cos \omega t$
(c) $x = x_o \tan \omega t$
(d) $x = -x_o \cos \omega t$

(36) The angle $\theta = \omega t$ executing SHM is known as

(a) amplitude
(b) displacement
(c) phase
(d) time period

Topic 7.4:

Horizontal Mass Spring System

(37) **If a mass is attached to an elastic spring then its maximum velocity v_o**

(a) $v_o = x_o\sqrt{\frac{m}{k}}$
(b) $v_o = x_o\sqrt{\frac{k}{m}}$
(c) $v_o = x\sqrt{\frac{k}{m}}$
(d) $v_o = x\sqrt{\frac{m}{k}}$

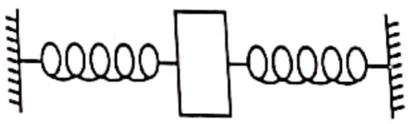
(38) **The angular frequency for a simple harmonic oscillator is**

(a) $\omega = \sqrt{\frac{k}{m}}$
(b) $\omega = \sqrt{\frac{g}{\ell}}$
(c) $\omega = 2\pi f$
(d) all of these

(39) **If four springs, each of spring constant K are connected in parallel then the resultant spring constant is**

(a) k
(b) 2k
(c) 4k
(d) $\frac{k}{4}$

(40) **A block of mass 0.1 kg is held between two rigid supports by two springs of force constants 8Nm^{-1} and 2Nm^{-1}. If the block is displaced along the direction of length of the springs, then the frequency of vibration is**



(a) $\frac{5}{\pi}$Hz
(b) $\frac{4}{\pi}$Hz
(c) 5π Hz
(d) 4π Hz

(41) **The acceleration for a mass spring system at any instant is given by**

(a) $a = \frac{k}{x}m$
(b) $a = \frac{k}{m}x$
(c) $a = -\frac{k}{m}x$
(d) $a = -\frac{k}{x}m$

(42) **The time period of the mass spring system is given by**

(a) $T = \frac{1}{2\pi}\sqrt{\frac{m}{k}}$
(b) $T = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$
(c) $T = 2\pi\sqrt{\frac{m}{k}}$
(d) $T = 2\pi\sqrt{\frac{k}{m}}$

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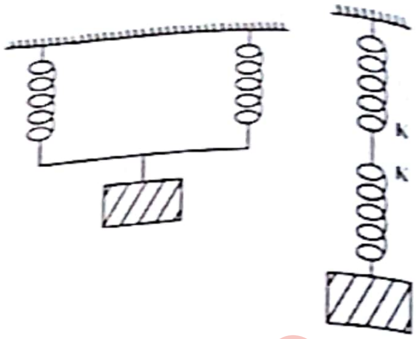
(43) Two identical springs, each of spring constant K, are connected in series and parallel as shown in the figure below. A mass "m" is suspended from them. The ratio of their frequencies of vertical oscillations will be



(a) 2:1 (b) 1:1
(c) 1:2 (d) 4:1

(44) The equation for the time period of vertical mass spring system is $T=2\pi\sqrt{\frac{x}{g}}$. What will be the new time period if such a mass-spring system is taken to moon where $T=2\pi\sqrt{\frac{x}{g}}$?

(a) $T'=6T$ (b) $T'=\frac{T}{6}$
(c) $T'=\sqrt{6}\text{-}T$ (d) remains same

(45) The instantaneous displacement "x" of mass m in "mass spring system" given by

(a) $x = x_o \sin\sqrt{\frac{k}{m}}t$ (b) $x = x_o \sin\sqrt{\frac{m}{k}}t$
(c) $x = x_o \cos\sqrt{\frac{k}{m}}t$ (d) $x = x_o \cos\sqrt{\frac{m}{k}}t$

Topic 7.5

Simple Pendulum

(46) A simple pendulum is mounted in a cabin which is moving towards hill side. To keep time period of simple pendulum constant length must be
(a) increased (b) decreased
(c) remains same (d) can't be predicted

(47) Time period of seconds pendulum on moon is
(a) 1/3 sec (b) 2 sec
(c) 3 sec (d) $\sqrt{6}$ sec

(48) Length of seconds pendulum is
(a) 0.996m (b) 0.992m
(c) 0.99m (d) 0.9m

(49) If a seconds pendulum is taken to moon then its time period will
(a) increase (b) decrease
(c) remains same (d) none of these

(50) The restoring force acting on the bob of simple pendulum of mass 'm' is
(a) mg (b) mg Sin θ
(c) -mg Sin θ (d) -mg Cos θ

(51) A simple pendulum is 50cm long. Its frequency of vibration on the surface of the earth is
(a) 1 Hz (b) 0.5 Hz
(c) 0.70 Hz (d) 0.65 Hz

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(52) **Frequency of seconds pendulum is**
(a) 1Hz (b) 2Hz
(c) 0.5Hz (d) 0.99Hz

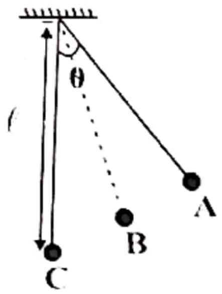
(53) **The time period of simple pendulum is directly proportional to**
(a) $\sqrt{\frac{m}{g}}$ (b) $\sqrt{l}$
(c) $\sqrt{g}$ (d) $\sqrt{\frac{g}{l}}$

(54) **When a bob of simple pendulum is at extreme position then it has maximum**
(a) K.E (b) P.E
(c) both a and b (d) no energy

(55) **In vibratory motion of a simple pendulum, the force is responsible for**
(a) mg cosθ (b) mg sinθ
(c) mg (d) mg tanθ

(56) **At mean position, the simple pendulum has**
(a) maximum K.E (b) maximum P.E
(c) zero K.E (d) minimum K.E

(57) **A simple pendulum is shown in the figure. At which point tension in the string will be maximum.**
(a) C (b) A
(c) B (d) none of these



(58) **The time period of simple pendulum depend upon**
(a) length of pendulum (b) amplitude of pendulum
(c) length and gravity (d) mass of pendulum

(59) **The component of weight $mg\sin\theta$ in simple pendulum is**
(a) along the center (b) perpendicular to string
(c) along the string (d) none of these

(60) **For simple pendulum the value ω is given by**
(a) $\omega = \sqrt{\frac{l}{g}}$ (b) $\omega = \sqrt{\frac{g}{l}}$
(c) $\omega = \sqrt{\frac{1}{gl}}$ (d) $\omega = \frac{g}{l}$

(61) **The three bodies, represented as P,Q and R in the Fig.67 below each show simple harmonic motion. In which of these systems will the period increase if the mass of the body increases?**
(a) P only (b) Q only
(c) P and Q only (d) Q and R only

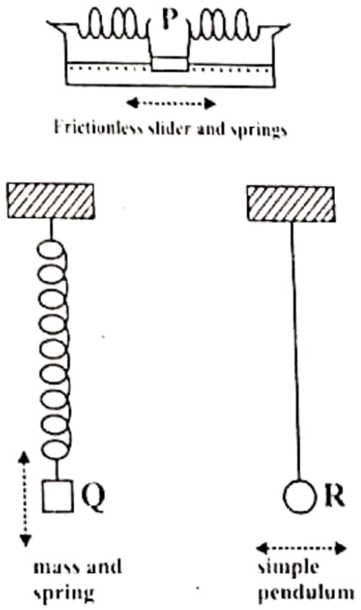


Fig. 67

(62) **A girl is taking swing such that she was in sitting position. Now if she stands up on swing then the frequency of ride will**
(a) increase (b) decrease
(c) remains same (d) can't be predicted

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(63) In simple pendulum the value of "g" can be calculated by

(a) $g = \frac{4\pi^2 \ell}{T^2}$ (b) $g = \frac{4\pi^2 \ell^2}{T^2}$

(c) $g = \frac{2\pi\sqrt{\ell}}{T^2}$ (d) $g = \frac{2\pi\sqrt{\ell}}{T}$

Topic 7.6:

Energy Conservation in SHM

(64) Total energy of mass spring system is equal to

(a) (K.E) max (b) (P.E) max

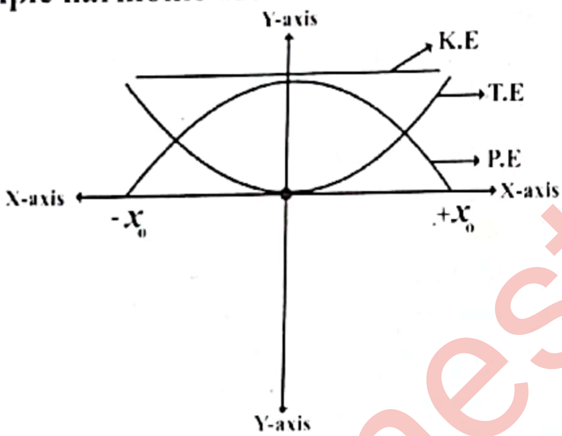
(c) Both a & b (d) neither a nor b

(65) In oscillation

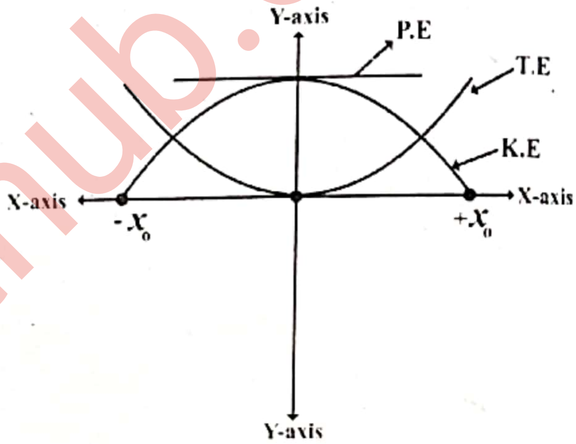
(a) P.E remains constant (b) K.E remains constant

(c) total energy remains constant (d) both P.E and K.E remains constant

(66) Which of the following curves best illustrates the graph for K.E, P.E and T.E for a simple harmonic oscillator?



(a)



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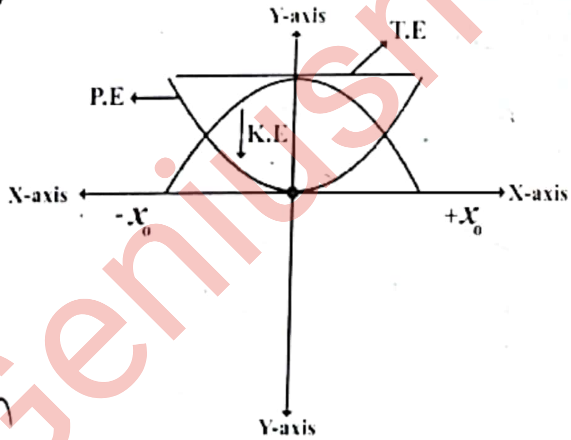

(c) (d) none of these

(67) In mass spring system the work done in displacing the mass 'm' through x_0 is

(a) $\frac{1}{2}kx_o$ (b) $\frac{1}{2}kx$

(c) $\frac{1}{2}kx_o^2$ (d) $\frac{1}{2}kx^2$

(68) The frequency of variation of K.E is

(a) f (b) $2f$

(c) $3f$ (d) $\frac{f}{2}$

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(69) **When the bob of simple pendulum is at extreme position the value of K.E is**
(a) maximum (b) zero
(c) minimum (d) none of these

(70) **At any instant 't' if the displacement is x, then P.E at that instant is given by**
(a) $P.E=\frac{1}{2}kx_0^2$ (b) $P.E=kx^2$
(c) $P.E=\frac{1}{2}kx^2$ (d) $P.E=2kx^2$

(71) **The maximum K.E of mass spring system is**
(a) $K.E=\frac{1}{2}kx_0^2$ (b) $K.E=\frac{1}{2}kx^2$
(c) $K.E=2kx_0^2$ (d) $K.E=kx_0^2$

(72) **At any instant the K.E of vibrating mass spring system is given by**
(a) $K.E=\frac{1}{2}kx_0^2\left(1-\frac{x^2}{x_0^2}\right)$ (b) $K.E=\frac{1}{2}kx_0^2$
(c) $K.E=\frac{1}{2}kx_0^2\left(1-\frac{x_0^2}{x^2}\right)$ (d) $K.E=\frac{1}{2}kx_0^2\left(1-\frac{x^2}{x_0^2}\right)$

(73) **The total energy of mass spring system**
(a) $\frac{1}{2}kx_0^2$ (b) $\frac{1}{2}k^2x_0^2$
(c) kx_0^2 (d) $\frac{1}{2}kx_0^2\left(1-\frac{x^2}{x_0^2}\right)$

(74) **The variation of P.E and K.E with displacement is essential for maintaining**
(a) oscillations (b) linear motion
(c) random motion (d) translatory motion

(75) **The periodic exchange of energy is a basic property of all**
(a) rotational system (b) oscillatory system
(c) translatory system (d) rotatory system

Topic 7.7:

Free and Forced Oscillation

(76) **A body is said to be free vibration when it oscillates**
(a) with interference of an external force (b) without interference of an external force
(c) with interference of an frictional force (d) without interference of an restoring force

(77) **The frequency of free vibration is known as**
(a) harmonic frequency (b) simple frequency
(c) natural frequency (d) relative frequency

(78) **If a freely oscillating system is subjected to an external force, then**
(a) forced vibrations take place (b) harmonic vibrations take place
(c) frictional force vibrations take place (d) all of these

(79) **Loud music is an example of**
(a) forced vibration (b) free vibration
(c) resonance (d) harmonic vibration

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Topic 7.8:

Resonance

(80) **The resonance occurs when the frequency of the applied force is equal to**
(a) harmonic frequency
(b) driven harmonic oscillator
(c) resonance
(d) relative frequency

(81) **The waves used is microwave oven has frequency**
(a) 124502 Hz
(b) 145MH
(c) 1425 MHz
(d) 2450 MHz

(82) **The wavelength of waves used in microwaves oven is**
(a) 15cm
(b) 12cm
(c) 10cm
(d) 8cm

(83) **In microwave oven, heating is produced by phenomenon of**
(a) resonance
(b) harmonic vibration
(c) free oscillation
(d) forced oscillation

(84) **Resonance occurs when the frequency of the applied force is ______ to one of natural frequency**
(a) equal
(b) smaller
(c) greater
(d) none of these

(85) **At resonance the transfer of energy is**
(a) zero
(b) minimum
(c) maximum
(d) none

(86) **Tuning a radio is an example of**
(a) mechanical resonance
(b) electrical resonance
(c) heating resonance
(d) chemical resonance

(87) **While tuning a radio when two frequencies (receiving and transmitting) are match, energy absorption is**
(a) zero
(b) minimum
(c) maximum
(d) none of these

Topic 7.9:

Damped Oscillation

(88) **Such oscillations in which the amplitude decreases gradually with time is called**
(a) resonance
(b) harmonic oscillation
(c) undamped oscillation
(d) damped oscillation

(89) **The amplitude of a vibrating body at resonance in vacuum is**
(a) maximum
(b) infinite
(c) minimum
(d) none of these

(90) **Damping is the process whereby energy is**
(a) gained
(b) remain same
(c) dissipated
(d) converted into other form of energy

(91) **Shock absorber of a car is an example of**
(a) free oscillations
(b) forced oscillations
(c) damped oscillations
(d) undamped oscillation

(92) **For vibrating system damping phenomena helps in**
(a) increasing the amplitude
(b) decreasing the amplitude
(c) decreasing time period
(d) increasing displacement

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MULTIPLE CHOICE QUESTIONS

(From Past Papers 2012-2017)
(Federal Board)

(1) The instantaneous P.E of spring mass system is given by ____ (FDR 2012)

(a) $P.E = \frac{1}{2}kx^2$ (b) $P.E = \frac{1}{2}kv^2$

(c) $P/E = \frac{1}{2}k^2x$ (d) $P.E = \frac{1}{2}kx^2$

(2) A simple pendulum is 50.0 cm long. Its frequency of vibration at a place where g = 9.8 ms^{-2} is ____ (FDR 2012)

(a) 0.70 Hz (b) 7Hz

(c) 6.2 Hz (d) 10Hz

(3) The instantaneous velocity of mass spring system is ____________ (FDR 2014)

(a) $v = v_0\sqrt{1-\frac{x^2}{x_o^2}}$ (b) $v = v_0\sqrt{1-\frac{x_o^2}{x^2}}$

(c) $v = x_0\sqrt{1-\frac{x^2}{x_o^2}}$ (d) $v = \frac{k}{m}\sqrt{1-\frac{x^2}{x_o^2}}$

(4) What is the total distance traveled by an object moving with simple harmonic motion in a time equal to its time period, if it amplitude x_o? (FDR 2015)

(a) zero (b) x_0

(c) $2x_0$ (d) $4x_0$

(5) The projection of a particle moving in a circle executes simple harmonic motion. Its time period "T" = __________? (FDR 2015)

(a) $\frac{\omega}{2\pi}$ (b) $\frac{2\pi}{\omega}$

(c) $2\pi f$ (d) $2\pi ft$

(6) What is the length of a simple pendulum whose time period is one second? (FDR 2016)

(a) 0.50 m (b) 0.25 m

(c) 2.00 m (d) 0.99 m

(7) For a mass spring system placed on a smooth horizontal surface oscillating with amplitude 'x_o'. At what displacement from the mean position its kinetic energy is equal to its elastic potential energy? (FDR 2016)

(a) $\frac{x_o}{\sqrt{2}}$ (b) $\frac{x_o}{4}$

(c) x_o (d) $\frac{x_o}{2}$

(8) A simple pendulum is moved from the Earth to the Moon. How does it change the period of oscillation? (Acceleration due to gravity on moon=1.6ms^{-2}) (FDR 2017)

(a) The period is increased by factor $\sqrt{6}$ (b) The period is increased by factor four

(c) The period is decreased by factor $\sqrt{6}$ (d) The period remains the same

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ANSWER KEYS

(Topical Multiple Choice Questions)

1	b	16	d	31	b	46	b	61	c	76	b	91	c
2	a	17	b	32	d	47	b	62	a	77	c	92	b
3	d	18	b	33	a	48	c	63	a	78	a	93	d
4	b	19	b	34	a	49	a	64	c	79	a	94	c
5	c	20	b	35	b	50	c	65	c	80	b	95	a
6	b	21	d	36	c	51	c	66	c	81	d		
7	c	22	b	37	b	52	c	67	c	82	b		
8	c	23	d	38	b	53	b	68	b	83	a		
9	c	24	c	39	c	54	b	69	b	84	a		
10	a	25	c	40	a	55	b	70	c	85	c		
11	d	26	d	41	c	56	a	71	a	86	b		
12	b	27	c	42	c	57	a	72	a	87	c		
13	b	28	a	43	c	58	c	73	a	88	d		
14	a	29	c	44	d	59	b	74	a	89	a		
15	b	30	d	45	a	60	b	75	b	90	c		

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SHORT QUESTIONS
(From Textbook Exercise)

7.1. Name two characteristics of simple harmonic motion.

Ans: The characteristics of simple harmonic motion are as follows.

- Acceleration is directly proportional to the displacement from the mean position. $a \propto -x$

Acceleration is always directed towards the mean position indicated by "–" sign.

- Total energy of particle executing SHM remain conserved [T.E = K.E + P.E]

7.2. Does frequency depends on amplitude for harmonic oscillators?

Ans: We know that for simple pendulum:

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

And we know that for a mass attached to a spring.

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

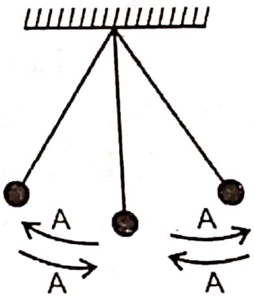
This shows that the frequency of harmonic oscillator is independent of amplitude.

7.3. Can we realize an ideal simple pendulum?

Ans: No, we cannot realize an ideal simple pendulum. An ideal simple pendulum consists of an inextensible weightless string attached with the heavy bob suspended from a frictionless support. Since, we cannot have weightless string and also friction cannot be eliminated. Therefore, we cannot realize an ideal simple pendulum.

7.4. What is the total distance traveled by an object moving with SHM in a time equal to its period, if its amplitude is A?

Ans: We know that time period is the time to complete one round trip about mean position. Therefore, in 1 time period, a body covers distance 4A, where A is the amplitude of the body.



7.5. What happens to the period of a simple pendulum if its length is doubled? What happens if the suspended mass is doubled?

Ans: We know that the time period of the simple pendulum is given by

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

If the length is doubled:

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

$$T' = \sqrt{2}\left(2\pi\sqrt{\frac{l}{g}}\right)$$

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

This shows that the time period becomes $\sqrt{2}$ times the initial time period.

As time period of a simple pendulum is independent of the mass of a bob, therefore, if the mass is doubled then the time period of simple pendulum remains same.

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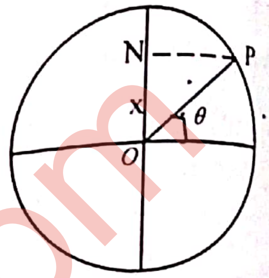
7.6. Does the acceleration of a simple harmonic oscillator remain constant during its motion? Is the acceleration ever zero? Explain.

Ans: Acceleration of harmonic oscillator does not remain constant. It is directly proportional to the displacement from the mean position.

$a \propto -x$

- At mean position: x = 0. Therefore: a = 0

7.7. What is meant by phase angle? Does it define angle between maximum displacement and the driving force?



Ans: "The angle which specifies the displacement as well as the direction of motion of point executing S.H.M. is called phase angle"

No, it does not define the angle between the maximum displacement and the driving force. It is the angle between the rotating vector and the reference line. Phase angle is θ = ώt, where ώ is angular frequency and t is any instant of time.

7.8. Under what conditions does the addition of two simple harmonic motions produce a resultant, which is also simple harmonic?

Ans: Under the following conditions, the addition of two simple harmonic motions produces a resultant, which is also simple harmonic.

- The two S.H.M are parallel.
- They have same frequency.
- They have constant phase difference.

7.9. Show that in SHM the acceleration is zero when the velocity is greatest and the velocity is zero when the acceleration is greatest?

Ans: **Acceleration is zero when velocity is greatest:**

We know that:

$a = -\omega^2 x$

$v = \omega\sqrt{x_0^2 - x^2}$

when, $x = 0$

$a = 0$

And, $v = \omega x_0$

Therefore, at mean position acceleration is zero and velocity is maximum.

Velocity is zero when acceleration is greatest:

When, $x = x_0$

$a = -\omega^2 x_0$

i.e. acceleration is maximum

$v = \omega\sqrt{x_0^2 - x^2}$

$\therefore x = x_0$

So, v = 0

Therefore, at extreme position acceleration is maximum and velocity is zero.

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7.10 In relation to SHM, explain the equations:

(i) $y = A\sin(\omega t + \phi)$

(ii) $a = -\omega^2 x$

Ans: **Explanation of Equations** $y = A\sin(\omega t + \phi)$

In this equation:

y = displacement, A = Amplitude

$\omega t + \phi$ = Phase angle, ϕ = Phase constant.

(ii) $a = -\omega^2 x$

a = Instantaneous acceleration

ω= Angular frequency.

x = Displacement.

"–" sign shows that the acceleration is directed towards the mean position.

7.11 Explain the relation between total energy, potential energy and kinetic energy for a body oscillating with SHM.

Ans: We know that:

$$(P.E.)_{max} = \frac{1}{2}kx_0^2$$

$$(K.E)_{max} = \frac{1}{2}kx_0^2$$

For any displacement x, the energy is partly P.E and partly K.E Hence

Total energy = P.E + K.E

$$= \frac{1}{2}kx^2 + \frac{1}{2}kx_0^2\left(1 - \frac{x^2}{x_0^2}\right)$$

$$= \frac{1}{2}kx_0^2$$

This shows that total energy during S.H.M. remains constant

7.12 Describe some common phenomena in which resonance plays an important role?

Ans: **(i) Suspension Bridge**

The column of soldiers, while marching on a bridge of long span are advised to break their steps. Their rhythmic march might set up oscillations of dangerously large amplitude in the bridge structure.

(ii) Tuning a Radio

Tuning a radio is the best example of electrical resonance. When we turn the knob of a radio, to tune a station, we are changing the natural frequency of the electric circuit of the receiver, to make it equal to the transmission frequency of the radio station. When the two frequencies match, energy absorption is maximum and this is the only station we hear.

(iii) Micro Wave Oven

The waves produced in this type of oven have a wavelength of 12cm at a frequency of 2450MHz. At this frequency the waves are absorbed due to resonance by water and fat molecules in the food, heating them up and so cooking the food.

7.13 If a mass spring system is hung vertically and set into oscillations, why does the motion eventually stop?

Ans: In the vertical mass spring system, the motion eventually stops due to friction and drag force, Energy is dissipated from the oscillating System, its amplitude decreases gradually and becomes smaller and eventually it stops.

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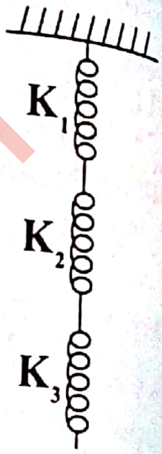
(1) Differentiate

Ans:

Oscillatory Motion	Periodic Motion
1. The kind of motion in which a body moves to and fro about its means position is called oscillatory motion	1. Such a motion which repeats itself in equal intervals of time is called periodic motion.
2. It does not take place in circle	2. It takes place in circle

(2) What are the rules for combining springs in a) series b) parallel combination. How it affects the time period of mass spring system?

Ans: Series combination:



When springs are combined in series combination then the strength of springs or spring constant decreases and becomes less then minimum value of "K" in combination.

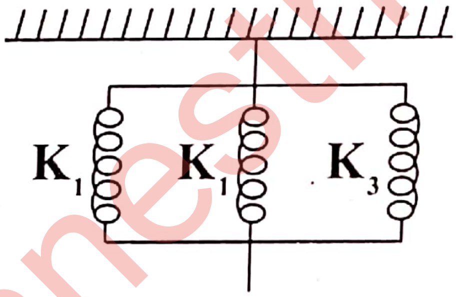
The relation for equivalent spring constant will be;

$$\frac{1}{keq} = \frac{1}{k_1} + \frac{1}{k_2} + \frac{1}{k_3}$$

Due to this as "K" decreases so "T" for mass-spring system increases.

Parallel combination:

When springs are combined in parallel combination then the strength or spring constant increases and becomes greater than the maximum value of "K" in combintaion.



The relation for equivalent spring constant is;

$$keq = k_1 + k_2 + k_3$$

As "K" increases so "T" of mass-spring system decreases.

(3) Find the P.E of a mass attached to a spring at an amplitude of 10 cm, if k is 10 N/m

Ans: P.E =?

$x_o = 10cm = \frac{10}{100} = 0.1$ m

$k = 10\frac{N}{m}$

$P.E = \frac{1}{2} k x_o^2$

$= \frac{1}{2}(10)(0.1)^2$

P.E = 0.05 J

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(4) What is second pendulum and also write its length , time period and frequency

Ans: **Second Pendulum**

A pendulum which complete one vibration in two seconds is called a second's pendulum

Time period 2 seconds

Length 0.99m or 1 meter

Frequency 0.5 Hz

(5) What is free and forced oscillation?

Ans: **Free Oscillation**

Oscillation of a system is called free oscillation if it oscillates without the interference of an external force. e.g. simple pendulum when slightly displaced from its mean position vibrates freely with its natural frequency that depends only upon the length of the pendulum.

Forced Oscillation

If freely oscillating system is subjected to an external force, then forced vibration will take place, the oscillation produced are called forced oscillation. The vibrations of a factory floor caused by the running of heavy machinery is an example of forced vibration. Another example of forced vibration is loud music produced by sounding wooden boards of strings instruments.

(6) State Basic conditions for frictionless system to execute S.H.M.

Ans:

(i) System must obey Hook's Law

(ii) The system must have inertia

(iii) There must be elastic restoring force acting on the system

(iv) $a \propto -x$

(7) What is the value of phase angle with reference to

(i) Complete revolution

(ii) Half the wave length

(iii) ¼ the of a vibration

Ans: The phase angles are

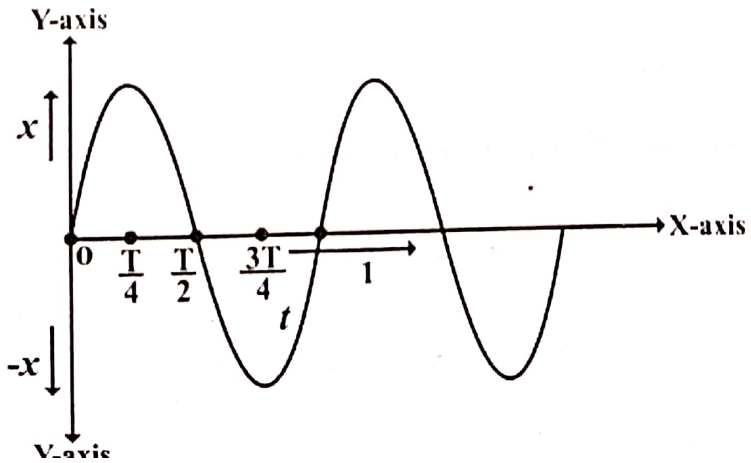
For complete revolution $\theta = 360^{o}$

For half the wavelength $\theta = 180^{o}$

For ¼ th of a vibration $\theta = 90^{o}$

(8) Prove graphically that frequency of variation of P.E for a S.H.M is twice than its natural frequency.

Ans: As we know that the curve for x-t for a simple harmonic oscillator is



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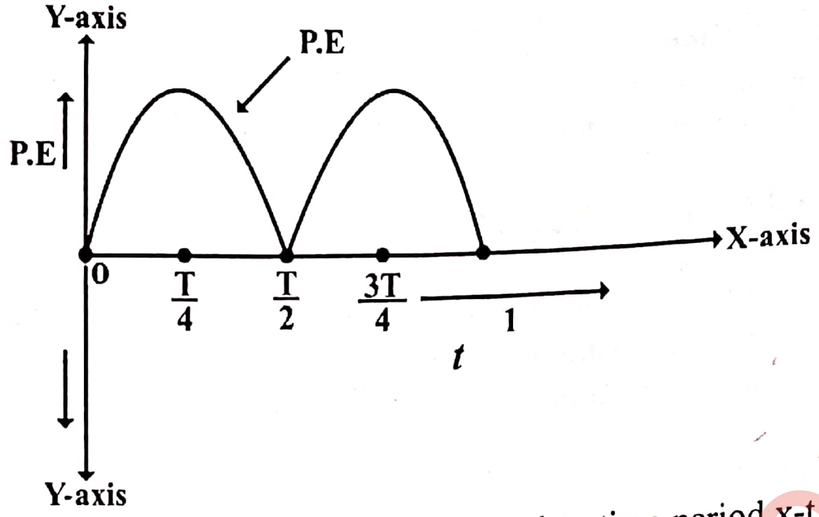
Now if we plot the graph for P.E & t for a simple harmonic oscillator then it is shown as;



From Fig-1 & Fig-2 it is very clear that in a complete time period x-t graph has one wave whereas the same time P.E has tow waves. Which proves that frequency of variation of P.E is always twice than natural frequency of a harmonic oscillator.

(9) Define resonance and give some examples,

Ans: The phenomenon of resonance occurs when frequency of the applied force is equal to the natural frequency of vibration of force (driven) harmonic oscillator.

For example;

- Tuning of radio is an example of electrical resonance
- A swing is an example of mechanical resonance
- Heating and cooking of food by microwave oven

(10) How long must a simple pendulum be in order to have a period of one second?

Ans: $\ell = ?$

t = 1s

We know that

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

$$T^2 = 4\pi^2\frac{\ell}{g}$$

$$\ell = \frac{gT^2}{4\pi^2}$$

$$\ell = \frac{9.8\times(1)^2}{4(3.14)^2}$$

$$\ell = 0.248m$$

$$\ell = 25cm$$

(11) In a mass-spring system, if force of 10N and displacement is 0.4 m. Find the value of spring constant.

Ans: F = 10N

x = 0.4 m

k=?

We know that

F= k x

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$k = \frac{F}{x}$

$= \frac{10}{0.4}$

$k = 25$ N/m

(12) A spring of spring constant 'k' is cut into two pieces of equal length. Then what will be the spring constant of each part?

Ans: By Hook's law

$F = kx$

$k = \frac{F}{x}$

Since spring is cut into two pieces of equal length

So $x' = \frac{x}{2}$

$F = k'\left(\frac{x}{2}\right)$

$k' = 2\left(\frac{F}{x}\right)$

$k' = 2k$

Hence spring constant of each part will be 2k.

(13) Which force actually provides the restoring force to the simple pendulum?

Ans: The vertical component of weight provides the restoring force which is directed towards the mean position and it is actually responsible for the motion of simple pendulum.

(14) Which physical quantity remains constant through out the oscillatory motion of simple pendulum?

Ans: Only the acceleration due to gravity 'g' remains constant through out the simple harmonic motion of the simple pendulum.

(15) If a heavy and a lighter masses of same size are set into vibration which of them will stop first?

Ans: The heavy ball is less affected by the air friction, so it is less damped then the lighter ball. Hence the lighter ball will stop first due to dissipation of energy.

(16) Why the soldiers are ordered to break their steps while crossing bridge?

Ans: The soldiers are ordered to break their steps while crossing the big bridge, because if the frequency of their steps coincides with the natural frequency of bridge, the bridge may be set into vibrations of large amplitude. Thus the bridge may collapse due to resonance.

(17) What are damped oscillations? Describe its applications.

Ans: Such type of oscillations in which the amplitude decreases steadily with time are called damped oscillation.

Application:

Shock absorber of a car is an example of damped oscillation which provides a damping force to prevent excessive oscillation. If the shock absorbers are defective then the car becomes bouncy and uncomfortable.

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(18) Is the motion of a simple pendulum Isochronous? Explain

Ans: Yes, if the time period of harmonic oscillator does not change with the amplitude, such a motion is said to be isochronous motion. For example, the motion of simple pendulum is isochronous since it is independent of its amplitude.

(19) Calculate the length of a simple pendulum if its frequency is 0.5 C.P.S ($g = 9.8\ m/s^2$)

Ans: $\ell = ?$

$f = 0.5\ c.p.s$

$g = 9.8\ m/s^2$

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

taking squaring on both sides

$$f^2 = \frac{1}{4\pi^2}\left(\frac{g}{l}\right)$$

$$\ell = \frac{g}{4\pi^2 f^2} \Rightarrow \ell = \frac{9.8}{4(3.14)^2 \times (0.5)^2}$$

$\ell = 0.99\,m$

(23) Write any three uses of simple pendulum?

Ans: **(i)** The value of g can be found by simple pendulum

(ii) We can find the frequency of vibrating body by simple pendulum

(iii) It may used to calculate the time period.

(24) How resonance is produced in tuning a radio set?

Ans: Tuning a radio is the best example of electrical resonance. When we turn the knob of a radio, to tune a station, we are changing the natural frequency of the electric circuit of the receiver, to make it equal to the transmission frequency of the radio station. When the two frequencies match, energy absorption is maximum and this is the only station we hear.

(25) A simple pendulum is mounted in a cabin which can move up or down in the gravity. What must be the equations for its time period if

(a) Cabin moves in equilibrium.

(b) Cabin accelerates upward.

(c) Cabin accelerates downward.

Ans: The equation for time period of a simple pendulum mounted in a cabin is;

$$T = 2\pi\sqrt{\frac{\ell}{g+a}} \rightarrow (i)$$

(a) **Cabin moves in equilibrium:** As in equilibrium a=0 so eq (i) becomes $T = 2\pi\sqrt{\frac{\ell}{g}}$ which shows that no change in time period will be observed in this case.

(b) **Cabin accelerate upwards:** If cabin accelerate upwards then eq (i) will persist and time period will decrease.

(c) **Cabin accelerate downwards:** If cabin accelerates downwards then eq (i) will become $T = 2\pi\sqrt{\frac{\ell}{g-a}}$ time period will increase

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(26) Define frequency and time period. Give relation between them?

Ans: **Time Period:** It is the time T required to complete one vibration.

Frequency: It is the number of vibrations executed by a body in one second and is expressed as vibrations per sec, or cycles per sec or Hertz.

The definitions of T and f show that the two quantities are related by the equation $f = \dfrac{1}{T}$

(27) Define phase angle.

Ans: The angle θ = ωt which specifies the displacement as well as the direction of motion of the point executing S.H.M is known as phase.

(28) What is the frequency of a second's pendulum?

Ans: Time period of second's pendulum = T = 2 second

Frequency of second's pendulum = f =?

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

$$= \frac{1}{2}$$

$$= 0.5 \text{ Hz}$$

(29) Define damping and resonance.

Ans: **Damping:**

Damping is a process whereby energy is dissipated from the oscillating system.

Resonance:

The enormous increase in the amplitude of the harmonic oscillator when the time period of the applied force becomes equal to the natural time period of harmonic oscillator is called resonance.

(30) What are the conditions used, while calculating time period of simple pendulum?

Ans: While calculating time period of simple pendulum the following conditions are mention as given below.

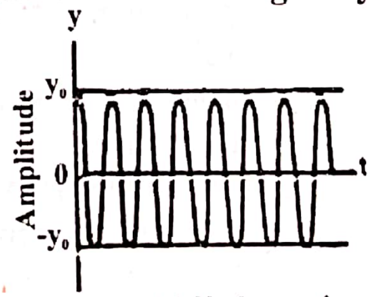
a. Angle should be very small

b. Neglecting the resistive forces

(31) Draw a graph to discuss the effect of damping on the amplitude of a vibrating body. What do you conclude?

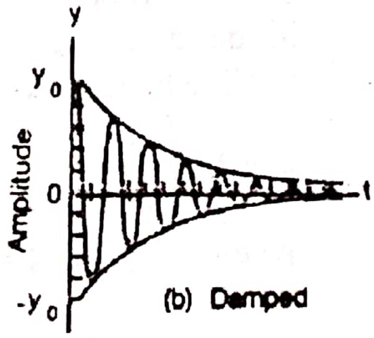
Ans: Such oscillations in which the amplitude decreases steadily with time are called damped oscillations. Describing the motion of a simple pendulum, this effect was completely ignored. As the bob of the pendulum moves to and fro, then in addition to the weight of the bob and the tension in the string, bob experiences viscous drag due to its motion through the air. Thus simple harmonic motion is an idealization Fig. (a)

The amplitude of this motion gradually becomes smaller and smaller because of friction and air resistance because the energy of the oscillator is used up in doing work against the resistive forces. Fig (b)



(a) Undamped

Fig. (a) Graph between amplitude and time



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SHORT QUESTIONS

(From past papers 2012-2017)
(Federal Board)

(1) What happens to the period of a simple pendulum if its length is doubled? What happens if the suspended mass is doubled? **(FDR 2012)**

(2) What are the conditions used, while calculating time period of simple pendulum? **(FDR 2013)**

(3) Compare expression of $a = \omega^2 x$ with the rate of change in velocity. **(FDR 2013)**

(4) A Simple pendulum is 50.0 cm long. What will be its frequency of vibration at a place where $g = 9.8 m/sec^2$? **(FDR 2014)**

(5) A body of mass 4 kg is attached to a spring of spring constant 196N/m and set into vibrations what is its vibrational angular frequency? **(FDR 2014)**

(6) Draw a graph to discuss the effect of damping on the amplitude of a vibrating body. What do you conclude? **(FDR 2015)**

7) State Hooke's law. Show that work done on a spring of spring constant 'k' is $\frac{1}{2}kx^2$ when it is extended upto a displacement 'x'. **(FDR 2016)**

) Name two characteristics of simple harmonic motion. Does Frequency depend on amplitude for harmonic oscillators? Also name some common phenomenon in which resonance plays an important role. **(FDR 2017)**

Define simple pendulum. What are the drawbacks of simple pendulum? Can simple pendulum experiment be done inside a satellite? **(FDR 2017)**

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