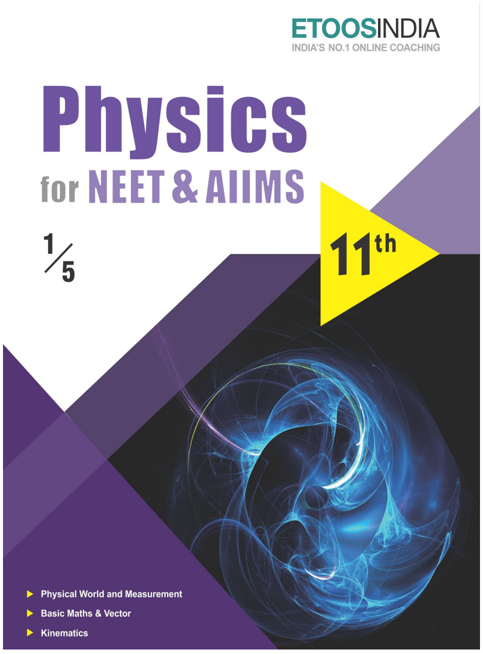
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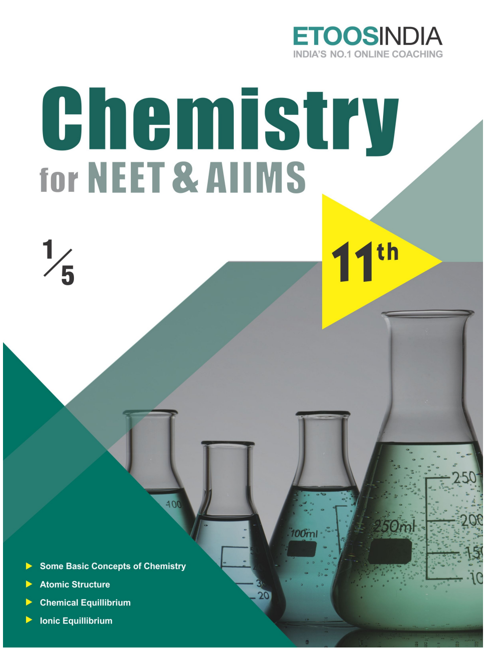
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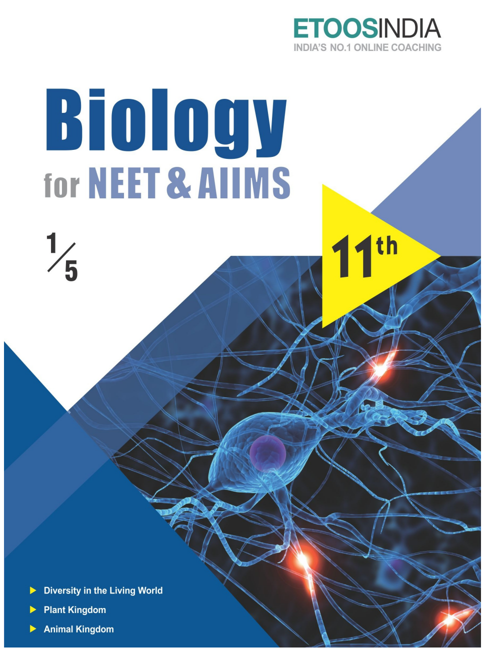
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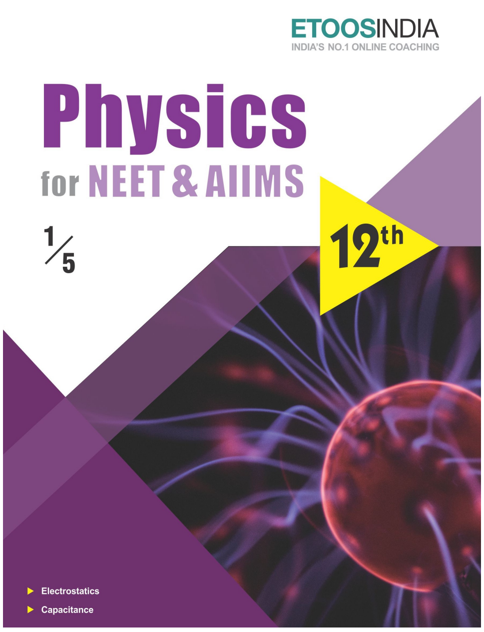
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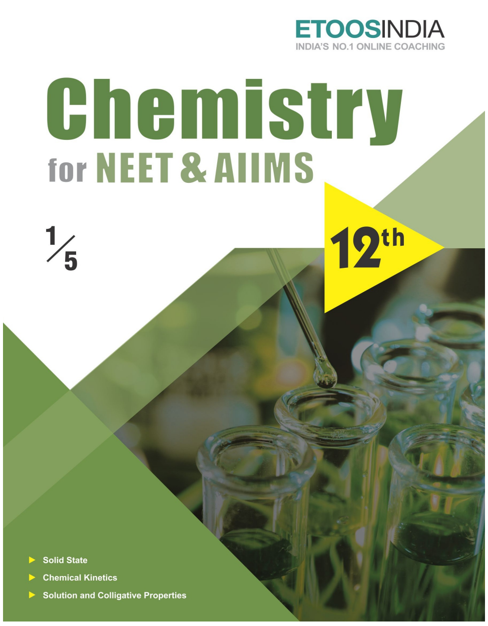
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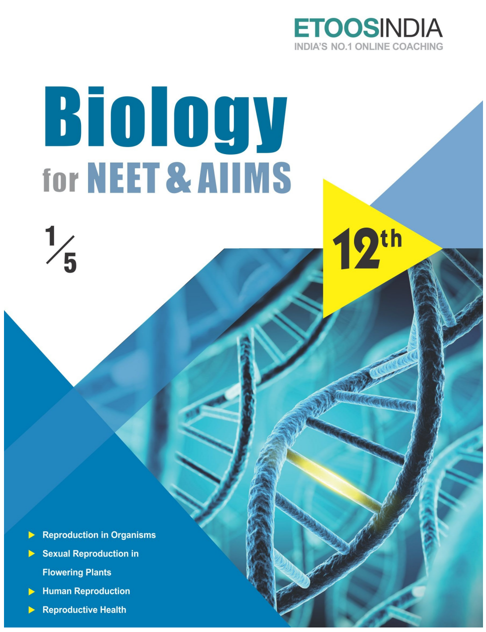
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Reproductive Health

CHAPTER 10

OSCILLATIONS

Life is a constant oscillation between the sharp horns of dilemmas.

"H. L. MENCKEN"

INTRODUCTION

When we look around us, we often find objects moving back and forth repeatedly. Some oscillations are annoying, some are amusing and some are dangerous, During an earthquake, buildings may be set oscillating os strongly that they are shaken apart. When an airplane is in flight, wings may oscillate edue to turbulence of the air, resulting in metal fatigue and even failure. When a tall building sways slowly, we may not even notice it. But it becomes annoying if it repeats more than 10 times/ second. When you are standing, the head tends to sway more than the feet, this sets off motion sensors in thebalancing region of the inner ear. some mechanisms are used to decrease sway of tall buildings. e.g., a large ball (5.4×10^5 kg) hangs on the 92^{nd} floor of one of the worlds talles buildings. How the sway of the buildings is countered? (You will find the answer for this in the section - Energy in simple harmonic motion.)

The study and control of oscillations are two of the main goals of both physics and Engineering. The back and forth motion of pistons in the engines of a car is an example of motion that repeats itself, but it is different from periodic motion of a planet around the sun. Here, the object moves to and fro about a mean position. Such a motion is called 'oscillatory' or vibratory motion' . Each atom / molecule of an object vibrates. We have sensation of sound due to vibration of air molecules. We use the vibrations of electrons in the antennas of radio and TV transmitters.

We see that the total mechanical energy at time t is independent of t. Thus, the mechanical energy remains constant.

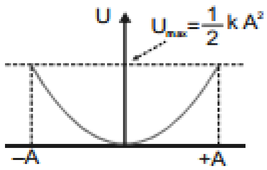
At the mean position x = 0, the potential energy is zero. The kinetic energy is $=\frac{1}{2}mv_o^2=\frac{1}{2}\omega^2A^2$. All the mechanical energy is in the form of kinetic energy here. At the particle is displaced away from the mean position, the kinetic energy decreases and the potential energy increase. At the extreme position x = ± A, the speed v is zero and the kinetic energy decreases to zero. The potential energy is increased to its maximum value $=\frac{1}{2}kA^2=\frac{1}{2}m\omega^2A^2$. All the mechanical energy is in the form of potential energy here.

ENERGY OF PARTICLE IN S.H.M.

Potential Energy (U or P.E.)

(i) In terms of displacement

The potential energy is related to force by the relation $F=-\frac{dU}{dx} \Rightarrow \int dU=-\int F dx$

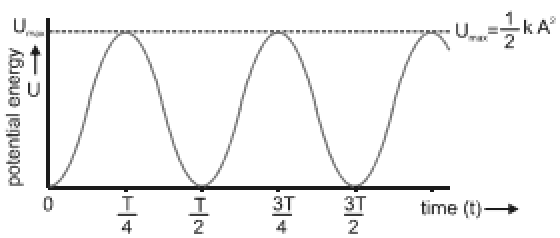


For S.H.M. F = – kx so $\int dU=-\int(-kx)dx=\int kx\,dx \Rightarrow U=\frac{1}{2}kx^2+C$

At $x=0, U=U_0 \Rightarrow C=U_0$ So $U=\frac{1}{2}kx^2+U_0$

Where the potenital energy at equilibrium position $=U_0$ when $U_0=0$ then $U=\frac{1}{2}kx^2$

(ii) In terms of time



Since $x=A\sin(\omega t+\phi), U=\frac{1}{2}kA^2\sin^2(\omega t+\phi)$

If initial phase (ϕ) is zero then $U=\frac{1}{2}kA^2\sin^2\omega t=\frac{1}{2}m\omega^2A^2\sin^2\omega t$

ETOOS KEY POINTS

(i) In S.H.M. the potential energy is a parabolic function of displacement, the potential energy is minimum at the mean position (x = 0) and maximum at extreme position (x = ± A)

(ii) The potential energy is the periodic function of time.

It is minimum at $t=0, \frac{T}{2}, T, \frac{3T}{2}\ldots$ and maximum at $t=\frac{T}{4}, \frac{3T}{4}, \frac{5T}{4}\ldots$

Etoos Tips & Formulas

1. Periodic Motion

Any motion which repeats itself after regular interval of time (i.e. time period) is called periodic motion or harmonic motion.

Ex. (a) Motion of planets around the sun.

(b) Motion of the pendulum of wall clock.

2. Oscillatory Motion

The motion of body is said to be oscillatory or vibratory motion if it moves back and forth (to and fro) about a fixed after regular interval of time.

The fixed point about which the body oscillates is called mean position or equilibrium position.

Ex. (a) Vibration of the wire of 'Sitar'

(b) Oscillation of the mass suspended from spring.

3. Simple Harmonic Motion (S.H.M.)

Simple harmonic motion is the simplest from of vibratory or oscillatory motion.

4. Some Basic Terms in SHM

(a) Mean Position

The point at which the restoring force on the particle is zero and potential energy is minimum, is known as its mean position.

(b) Restoring Force

The force acting on the particle which tends to bring the particle towards its means position, is known as its mean position.

Restoring force always acts in a direction opposite to that of displacement.

Displacement is measured from the mean position.

(c) Amplitude

The maximum (positive or negative) value of displacement of particle from mean position is defined as amplitude.

(d) Time Period (T)

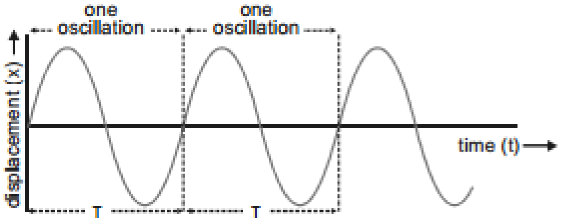
The maximum time after which the particle keeps on repeating its motion is known as time period.

The smallest time taken to complete one oscillation or vibration is also defined as time period.

It is given by $T = \frac{2\pi}{\omega} = \frac{1}{n}$ where ω is angular frequency and n is frequency.

(e) One oscillation or One vibration

When a particle goes on one side from mean position and returns back and then it goes to other side from returns back to mean position, then this process is known as one oscillation.



SOLVED EXAMPLE

Ex.1 Pendulum A is a physical pendulum made from a thin rigid and uniform rod whose length is ℓ. One end of this rod is attached to the ceiling by a frictionless hinge so that rod is free to swing back and forth. Pendulum B is a simple pendulum whose length is also ℓ. The ratio $\frac{T_A}{T_B}$ for small angular oscillations-

(A) $\sqrt{\frac{3}{2}}$ (B) $\sqrt{\frac{2}{3}}$

(C) $\frac{2}{3}$ (D) $\frac{3}{2}$

Sol. $T_A = 2\pi\sqrt{\frac{I}{mg\ell}} = 2\pi\sqrt{\frac{m\ell^2/3}{mg\ell/2}} = 2\pi\sqrt{\frac{2\ell}{3g}}$ &

$T_B = 2\pi\sqrt{\frac{\ell}{g}} \Rightarrow \frac{T_A}{T_B} = \sqrt{\frac{2}{3}}$

Ex.2 A simple pendulum has time period 2s. The point of suspension is now moved upward according to relation $y = (6t - 3.75\,t^2)$m where t is in second and y is the vertical displacement in upward direction. The new time period of simple pendulum will be

(A) 2s (B) 1s

(C) 4s (D) None of these

Sol. $T_1 = 2s = 2\pi\sqrt{\frac{\ell}{g}}$, $T_2 = 2\pi\sqrt{\frac{\ell}{g'}}$ where $g' = g + \frac{d^2y}{dt^2}$

$= 10 - 7.5 = 2.5 = \frac{g}{4} \Rightarrow T_2 = 2\pi\sqrt{\frac{\ell}{g/4}} = 2 \times 2 = 4s$

Ex.3 A point particle of mass 0.1 kg is executing SHM of amplitude 0.1 m. When the particle passes through the mean position, its KE is 8×10^{-3} J. Find the equation of motion of this particle if the initial phase of oscillation is 45°.

(A) $y = 0.1\cos(3t + \pi/4)$ (B) $y = 0.1\sin(6t + \pi/4)$

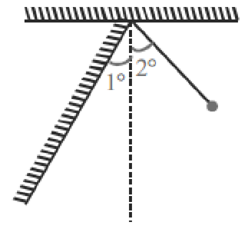
(C) $y = 0.1\sin(4t + \pi/4)$ (D) $y = 0.1\cos(4t + \pi/4)$

Sol. At mean position KE $= \frac{1}{2}m\omega^2a^2 = 8 \times 10^{-3}$

$\Rightarrow \omega = 4$rad/sec

Now let equation of SHM be $y = 0.1\sin(4t + \phi)$. At t $= 0$, $\phi = 45° = \frac{\pi}{4}$. Therefore $y = 0.1\sin\left(4t + \frac{\pi}{4}\right)$

Ex.4 A simple pendulum of length 1m is allowed to oscillate with amplitude 2°. It collides



elastically with a wall inclined at 1° to the vertical. Its time period will be : (use $g = \pi^2$)

(A) 2/3 sec (B) 4/3 sec

(C) 2 sec (D) None of these

Sol. Time period for half part

$\because T = 2\pi\sqrt{\frac{\ell}{g}} = 2\pi\sqrt{\frac{1}{g}} = \frac{2\pi}{\pi} = 2\text{ sec}.$

So 2° part will be covered in a time $t = \frac{T}{2} = 1$ sec.

For the left 1° part : $\theta = \theta_0 \sin(\omega t)$

$\Rightarrow 1° = 2°\sin\left(\frac{2\pi}{T} \times t\right) \Rightarrow \frac{1}{2} = \sin\left(\frac{2\pi}{2} \times t\right)$

$\Rightarrow \frac{\pi}{6} = \pi \times t \Rightarrow t = 1/6$ sec.

Total time $= \frac{T}{2} + 2t \Rightarrow 1 + 2 \times \frac{1}{6} = 1 + \frac{1}{3} = \frac{4}{3}$ sec.

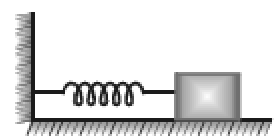
Ex.5 Spring of spring constant 1200 Nm^{-1} is mounted on a smooth frictionless surface and attached to a block of mass 3 kg. Block is pulled 2 cm to the right and released. The angular frequency of oscillation is

(A) 5 rad/sec

(B) 30 rad/sec

(C) 10 rad/sec

(D) 20 rad/sec



Sol. Angular frequency

$\omega = \sqrt{\frac{K}{m}} = \sqrt{\frac{1200}{3}} = 20\text{ rad/sec}$

Ex.6 The time period of oscillation of a mass m suspended from a spring is 2 seconds. If another 2 kg mass is also suspended along with m the time period increases by 1 second. The value of mass m is

(A) 2 kg (B) 1 kg

(C) 1.6 kg (D) 2.6 kg

Exercise # 1 SINGLE OBJECTIVE NEET LEVEL

1. The motion of a particle is given by $x = A \sin \omega t + B \cos \omega t$. The motion of of the particle is
(A) Not simple harmonic
(B) Simple harmonic with amplitude A + B
(C) Simple harmonic with amplitude (A + B) / 2
(D) Simple harmonic with amplitude $\sqrt{A^2 + B^2}$

2. A particle starts S.H.M. from the mean position. Its amplitude is A and time period is T. At the time when its speed is half of the maximum speed, its displacement y is
(A) $\frac{A}{2}$ (B) $\frac{A}{\sqrt{2}}$
(C) $\frac{A\sqrt{3}}{2}$ (D) $\frac{2A}{\sqrt{3}}$

3. Two points are located at a distance of 10 m and 15 m from the source of oscillation. The period of oscillation is 0.05 sec and the velocity of the wave is 300 m/sec. What is the phase difference between the oscillations of two points
(A) π (B) $\frac{\pi}{6}$
(C) $\frac{\pi}{3}$ (D) $\frac{2\pi}{3}$

4. Two particles are executing simple harmonic motion of the same amplitude A and frequency ω along the x-axis. Their mean position is separated by distane $X_0(X_0 > A)$. If the maximum separation between them is $(X_0 + A)$, the phase difference between their motion is
(A) $\pi/2$ (B) $\pi/3$
(C) $\pi/4$ (D) $\pi/6$

5. The equationof a simple harmonic wave is given by $y = 6 \sin 2\pi(2t - 0.1x)$, where x and y are in mm and t is in seconds. The phase difference between two particles 2 mm apart at any instant is
(A) 54° (B) 72°
(C) 18° (D) 36°

6. The equation of S.H.M. is $y = a \sin (2\pi nt + \alpha)$, then its phase at time t is
(A) $2\pi nt$ (B) α
(C) $2\pi nt + \alpha$ (D) $2\pi t$

7. A simple harmonic oscillator oscillates, with an amplitude A. At what point of its motion, is the power delivered to it by the restoring force maximum
(A) When it is at a displacement $\pm\frac{A}{\sqrt{2}}$ from the equilibrium point and moving towards the equilibrium point
(B) When it is the maximum displacement
(C) When it passes through the equilibrium point, either way
(D) When it is at a displacement $\pm\frac{A}{\sqrt{2}}$ from the equilibrium point and moving away from the equilibrium point

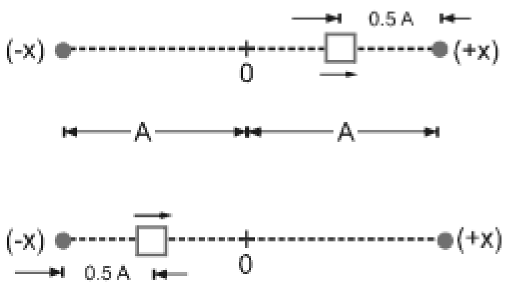
8. A simple harmonic oscillator has an amplitude a and time period T. The time required by it to travel from x = a to x = a/2 is
(A) T/6 (B) T/4
(C) T/3 (D) T/2

9. The displacement of a particle along the x axis is given by $x = a \sin^2 \omega t$. The motion of the particle corresponds to
(A) Simple harmonic motion of frequency $\omega/2\pi$
(B) Simple harmonic motion of frequency ω/π
(C) Simple harmonic motion of frequency $3\omega/2\pi$
(D) Non simple harmonic motion

10. Out of the following functions representing motion of a particle which represents SHM
(1) $y = \sin \omega t - \cos \omega t$
(2) $y = \sin^3 \omega t$
(3) $y = 5\cos\left(\frac{3\pi}{4} - 3\omega t\right)$
(4) $y = 1 + \omega t + \omega^2 t^2$
(A) Only (1) and (2)
(B) Only (1)
(C) Only (4) does not represent SHM
(D) Only (1) and (3)

Exercise # 2 SINGLE OBJECTIVE AIIMS LEVEL

1. Two bodies performing S.H.M. have same amplitude and frequency. Their phases at a certain instant are as shown in the figure. The phase difference between them is



(A) $\frac{11}{6}\pi$ (B) π

(C) $\frac{5}{3}\pi$ (D) $\frac{3}{5}\pi$

2. The equation of motion of a particle of mass 1 g is $\frac{d^2x}{dt^2} + \pi^2 x = 0$ where x is displacement(in m)from mean position. The frequency of oscillation is (in Hz) :

(A) $\frac{1}{2}$ (B) 2

(C) $5\sqrt{10}$ (D) $\frac{1}{5\sqrt{10}}$

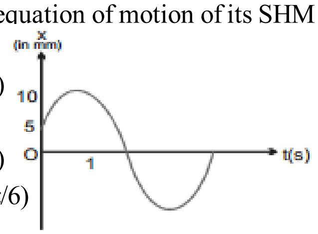
3. The figure shows the displacement time graph of a particle executing S.H.M. If the time period of oscillation is 2 s the equation of motion of its SHM is

(A) $x = 10\sin(\pi t + \pi/3)$

(B) $x = 10\sin \pi t$

(C) $x = 10\sin(\pi t + \pi/6)$

(D) $x = 10 \sin(2\pi t + \pi/6)$



4. A small mass executes linear S.H.M. about O with amplitude 'a' and period 'T'. Its displacement from O at time T/8 after passing through O is

(A) a/8 (B) $\frac{a}{2\sqrt{2}}$

(C) a/2 (D) $\frac{a}{\sqrt{2}}$

5. Two particle executes S.H.M. of same amplitude and frequency along the same straight line. They pass one another when going in opposite directions, each time their displacement is half of their amplitude. The phase difference between them is :–

(A) 30° (B) 60°

(C) 90° (D) 120°

6. A particle performing S.H.M. is found at its equilibrium at t = 1 s and it is found to have a speed of 0.25 m/s at t = 2 s. If the period of oscillation is 6s Calculate amplitude of oscillation

(A) $\frac{3}{2\pi}$ m (B) $\frac{3}{4\pi}$ m

(C) $\frac{6}{\pi}$ m (D) $\frac{3}{8\pi}$ m

7. A particle executes S.H.M. along a straight line with mean position x = 0, period 20 s and amplitude 5 cm. The shortest time taken by the particle to go from x = 4 cm to x = –3cm is

(A) 4 s (B) 7 s

(C) 5 s (D) 6 s

8. Two particles A and B perform SHM along the same straight line with the same amplitude 'a', same frequency 'f' and same equilibrium position 'O'. The greatest distance between them is found to be 3a/2. At some instant of time they have the same displacement from mean position. What is this displacement?

(A) a/2 (B) $a\sqrt{7}/4$

(C) $\sqrt{3}/a2$ (D) 3a/4

9. A particle executes S.H.M. in a straight line. In the first second starting from rest it travels a distance 'a' and in the next second a distance 'b' in the same direction. The amplitude of S.H.M. will be

(A) $\frac{2a^2}{3a-b}$ (B) a – b

(C) 2a – b (D) a / b

Exercise # 3 PART - 1 MATRIX MATCH COLUMN

1. A particle of mass 2 kg is moving on a straight line under the action of force F = (8 – 2x) N. The particle is released at rest from x = 6 m. For the subsequent motion (All the values in the right column are in their S.I. units.)

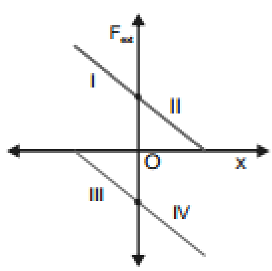
	Column- I		Column-II
(A)	Equilibrium position is at x =	(P)	$\pi/4$
(B)	Amplitude of S.H.M is	(Q)	$\pi/2$
(C)	Time taken to go directly from x = 2 m to x = 4 m	(R)	4
(D)	Energy of S.H.M. is	(S)	6
(E)	Phase constant of S.H.M. assuming equation of the form $A\sin(\omega t + \phi)$	(T)	2

2. In $y = A\sin wt + A\sin\left(\omega t + \frac{2\pi}{3}\right)$

	Column-I		Column-II
(A)	Motion	(P)	is periodic but not SHM
(B)	Amplitude	(Q)	is SHM
(C)	Initial phase	(R)	A
(D)	Maximum velocity	(S)	$\pi/3$
		(T)	$\omega A/2$
		(U)	None

3. A block is executing SHM on a rough horiozntal surface under the action of an external variable force. The force is plotted against the position x of the particle from the mean position.

	Column I		Column II
(A)	x positive, v positive	(P)	I
(B)	x positive, v negative	(Q)	II
(C)	x negative, v positive	(R)	III
(D)	x negative, v negative	(S)	IV



Exercise # 4 PART - 1 PREVIOUS YEAR (NEET/AIPMT)

1. A pendulum is displaced to an angle θ from its equilibrium position, then it will pass through its mean position with a velocity v equal to **[CBSE AIPMT 2000]**

(A) $\sqrt{2gl}$ (B) $\sqrt{2gl\sin\theta}$

(C) $\sqrt{2gl\cos\theta}$ (D) $\sqrt{2gl(1-\cos\theta)}$

2. Two simple harmonic motions given by, x = a sin (ωt + Δ) and y = a sin$\left(\omega t+\delta+\frac{\pi}{2}\right)$ act on a particle simultaneously, then the motion of particle will be **[CBSE AIPMT 2000]**

(A) circular anit-clockwise

(B) circular clockwise

(C) elliptical anti-clockwise

(D) elliptical closkwise

3. In SHM restoring force is F = – kx, where k is force constant, x is displacement and a is amplitude of motion, then total energy depends upon **[CBSE AIPMT 2001]**

(A) k, and m (B) k, x, m

(C) k, a (D) k, x

4. A mass is suspended separately by two springs to spring constants k_1 and k_2 in successive order. The time periods of oscillationss in the two cases are T_1 and T_2 respectively. If the same mass be suspended by connecting the two springs in parallel, (as shown in figure) then the time period of oscillations is T. The correct relation is **[CBSE AIPMT 2002]**

(A) $T_2 = T_1^2 + T_2^2$ (B) $T^{-2} = T_1^{-2} + T_2^{-2}$

(C) $T^{-1} = T_1^{-1} + T_2^{-1}$ (D) $T = T_1 + T_2$

5. When a damped harmonic oscillator completes 100 oscillations, its amplitude is reduced to $\frac{1}{3}$ of its initial value. What will be its amplitude when its completes 200 oscillations?

(A) $\frac{1}{5}$ (B) $\frac{2}{3}$

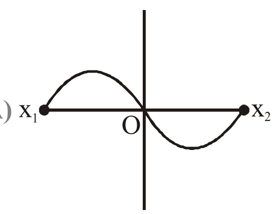
(C) $\frac{1}{6}$ (D) $\frac{1}{9}$

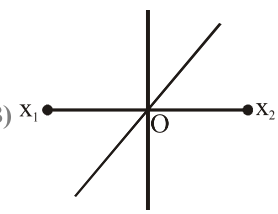
6. The displacement of particle between maximum potential energy position and maximum kinetic energy position in simple harmonic motion is **[CBSE AIPMT 2002]**

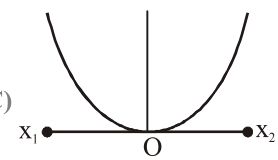
(A) $\pm\frac{a}{2}$ (B) ± a

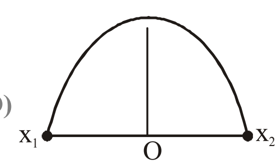
(C) ± 2 a (D) ± 1

7. A particle of mass m oscillates with simple harmonic motion between points x_1 and x_2, the equilibrium position being O. Its potential energy is plotted. It will be as given below in the graph **[CBSE AIPMT 2003]**

(A) 

(B) 

(C) 

(D) 

8. The potintial energy of a simple harmonic oscillator when the particle is half way to its end point is **[CBSE AIPMT 2003]**

(A) $\frac{1}{4}E$ (B) $\frac{1}{2}E$

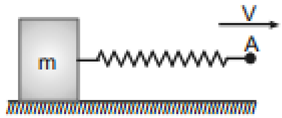
(C) $\frac{2}{3}E$ (D) $\frac{1}{8}E$

(where, E is the total energy)

MOCK TEST

STRAIGHT OBJECTIVE TYPE

1. A block of mass ' m ' is attached to a spring in natural length of spring constant ' k ' . The other end A of the spring is moved with a constant velocity v away from the block . Find the maximum extension in the spring.



(A) $\frac{1}{4}\sqrt{\frac{mv^2}{k}}$ (B) $\sqrt{\frac{mv^2}{k}}$ (C) $\frac{1}{2}\sqrt{\frac{mv^2}{k}}$ (D) $2\sqrt{\frac{mv^2}{k}}$

2. A system is shown in the figure. The time period for small oscillations of the two blocks will be.

(A) $2\pi\sqrt{\frac{3m}{k}}$ (B) $2\pi\sqrt{\frac{3m}{2k}}$ (C) $2\pi\sqrt{\frac{3m}{4k}}$ (D) $2\pi\sqrt{\frac{3m}{8k}}$

3. Two particles P and Q describe S.H.M. of same amplitude a, same frequency f along the same straight line from the same mean positon. The maximum distance between the two particles is a $\sqrt{2}$. The phase difference between the particle is:

(A) zero (B) $\pi/2$ (C) $\pi/6$ (D) $\pi/3$

4, The time taken by a particle performing SHM on a straight line to pass from point A to B where its velocities are same is 2 seconds. After another 2 seconds it returns to B. The time period of oscillation is (in seconds):

(A) 2 (B) 4 (C) 6 (D) 8

5. A particle performs S.H.M. on x–axis with amplitude A and time period T. The time taken by the particle to travel a distance A/5 starting from rest is:

(A) $\frac{T}{20}$ (B) $\frac{T}{2\pi}\cos^{-1}\left(\frac{4}{5}\right)$

(C) $\frac{T}{2\pi}\cos^{-1}\left(\frac{1}{5}\right)$ (D) $\frac{T}{2\pi}\sin^{-1}\left(\frac{1}{5}\right)$

6. A rod of length ℓ is in motion such that its ends A and B are moving along x-axis and y-axis respectively. It is given that $\frac{d\theta}{dt}$ = 2 rad/s always. P is a fixed point on the rod. Let M be the projection of P on x-axis. For the time interval in which θ changes from 0 to $\frac{\pi}{2}$, choose the correct statement,

(A) The acceleration of M is always directed towards right
(B) M executes SHM
(C) M moves with constant speed
(D) M moves with constant acceleration

11th Class Modules Chapter Details

Physics
5
Modules

Chemistry
5
Modules

Mathematics
5
Modules

PHYSICS

Module-1

1. Physical World & Measurements
2. Basic Maths & Vector
3. Kinematics

Module-2

1. Law of Motion & Friction
2. Work, Energy & Power

Module-3

1. Motion of system of particles & Rigid Body
2. Gravitation

Module-4

1. Mechanical Properties of Matter
2. Thermal Properties of Matter

Module-5

1. Oscillations
2. Waves

CHEMISTRY

Module-1(PC)

1. Some Basic Conceps of Chemistry
2. Atomic Structure
3. Chemical Equilibrium
4. Ionic Equilibrium

Module-2(PC)

1. Thermodynamics & Thermochemistry
2. Redox Reaction
3. States Of Matter (Gaseous & Liquid)

Module-3(IC)

1. Periodic Table
2. Chemical Bonding
3. Hydrogen & Its Compounds
4. S-Block

Module-4(OC)

1. Nomenclature of Organic Compounds
2. Isomerism
3. General Organic Chemistry

Module-5(OC)

1. Reaction Mechanism
2. Hydrocarbon
3. Aromatic Hydrocarbon
4. Environmental Chemistry & Analysis Of Organic Compounds

BIOLOGY

Module-1

1. Diversity in the Living World
2. Plant Kingdom
3. Animal Kingdom

Module-2

1. Morphology in Flowering Plants
2. Anatomy of Flowering Plants
3. Structural Organization in Animals

Module-3

1. Cell: The Unit of Life
2. Biomolecules
3. Cell Cycle & Cell Division
4. Transport in Plants
5. Mineral Nutrition

Module-4

1. Photosynthesis in Higher Plants
2. Respiration in Plants
3. Plant Growth and Development
4. Digestion & Absorption
5. Breathing & Exchange of Gases

Module-5

1. Body Fluids & Its Circulation
2. Excretory Products & Their Elimination
3. Locomotion & Its Movement
4. Neural Control & Coordination
5. Chemical Coordination and Integration

12th Class Modules Chapter Details

Physics
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Modules

Chemistry
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Modules

Mathematics
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Modules

PHYSICS	CHEMISTRY	BIOLOGY
Module-1 1. Electrostatics 2. Capacitance **Module-2** 1. Current Electricity 2. Magnetic Effect of Current and Magnetism **Module-3** 1. Electromagnetic Induction 2. Alternating Current **Module-4** 1. Geometrical Optics 2. Wave Optics **Module-5** 1. Modern Physics 2. Nuclear Physics 3. Solids & Semiconductor Devices 4. Electromagnetic Waves	**Module-1(PC)** 1. Solid State 2. Chemical Kinetics 3. Solutions and Colligative Properties **Module-2(PC)** 1. Electrochemistry 2. Surface Chemistry **Module-3(IC)** 1. P-Block Elements 2. Transition Elements (d & f block) 3. Co-ordination Compound 4. Metallurgy **Module-4(OC)** 1. HaloAlkanes & HaloArenes 2. Alcohol, Phenol & Ether 3. Aldehyde, Ketone & Carboxylic Acid **Module-5(OC)** 1. Nitrogen & Its Derivatives 2. Biomolecules & Polymers 3. Chemistry in Everyday Life	**Module-1** 1. Reproduction in Organisms 2. Sexual Reproduction in Flowering Plants 3. Human Reproduction 4. Reproductive Health **Module-2** 1. Principles of Inheritance and Variation 2. Molecular Basis of Inheritance 3. Evolution **Module-3** 1. Human Health and Disease 2. Strategies for Enhancement in Food Production 3. Microbes in Human Welfare **Module-4** 1. Biotechnology: Principles and Processes 2. Biotechnology and Its Applications 3. Organisms and Populations **Module-5** 1. Ecosystem 2. Biodiversity and Conservation 3. Environmental Issues