SIMPLE HARMONIC MOTION
PREVIOUS EAMCET QUESTIONS
ENGINEERING

1. The displacement of a particle executing SHM is given by :y = 5 sin $\left(4t+\frac{\pi}{3}\right)$. If T is the time period and the mass of the particle is 2 gms, the kinetic energy of the particle when t = $\frac{T}{4}$ is given by **[2009 E]**

1) 0.4 Joules 2) 0.5 Joules 3) 3 Joules 4) 0.3 Joules

Ans : 4

Sol: The given equation is $y=5\sin\left(4t+\frac{\pi}{3}\right)$ ……(1)

comparing with the equation $y=A\sin(\omega t+\phi)$

From the equation, $\omega=4rads^{-1}$

$$\therefore T=\frac{2\pi}{\omega}=\frac{2\pi}{4}=\frac{\pi}{2}s$$

When $t=\frac{T}{4}$, $y=5\sin\left(\frac{\pi}{2}+\frac{\pi}{3}\right)$

$$=5\cos\left(\frac{\pi}{3}\right)=2.5m$$

$$\therefore K.E.=\frac{1}{2}m\omega^2\left[A^2-y^2\right]$$

$$=\frac{1}{2}\times2\times10^{-3}\times(4)^2\left[(5)^2-(2.5)^2\right]=0.3J$$

2. A particle is executing simple harmonic motion with an amplitude A and time period T. The displacement of the particle after 2 T period from its initial position is : **[2008 E]**

1) A 2) 4A 3) 8A 4) Zero

Ans : 4

Sol: After a time period of T or integral multiples of T the particle comes to mean position. Hence displacement is zero.

3. The magnitude of maximum acceleration is times that of maximum velocity of a simple harmonic oscillator. The time period of the oscillator in seconds is **(2007 E)**

1) 4 2) 2 3) 1 4) 0.5

Ans : 2

Sol: $a_{\max}=A\omega^2$ ….(1) $v_{\max}=A\omega$ ………..(2)

$\therefore a_{\max}=\pi V_{\max}$ [given]

$$\therefore A\omega^2=\pi(A\omega)$$

$$\therefore \omega=\pi$$

$$\therefore T=\frac{2\pi}{\omega}=\frac{2\pi}{\pi}=2s$$

4. The time period of a simple pendulum is T. When the length is increased by 10cm, the period is T_1. When the length is decreased by 10cm, its period is T_2. Then relation between T, T_1, T_2 is

(2004 E)

1) $\frac{2}{T_2}=\frac{1}{T_1^2}+\frac{1}{T_2^2}$ 2) $\frac{2}{T_2}=\frac{1}{T_1^2}-\frac{1}{T_2^2}$ 3) $2T^2=T_1^2+T_2^2$ 4) $2T^2=T_1^2-T_2^2$

Ans : 3

Sol: The time period of a simple pendulum is

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

When the length increases by 10cm then

$$T_1=2\pi\sqrt{\frac{l+10}{g}} \text{ ....(2)}$$

When the length decreases by 10cm then

$$T_2=2\pi\sqrt{\frac{l-10}{g}} \text{ ....(3)}$$

Squaring (2) & (3) and adding

$$T_1^2+T_2^2=4\pi^2\left[\frac{l+10+l-10}{g}\right]$$

$$=4\pi^2\left[\frac{2l}{g}\right]$$

$$= 2T^2 \therefore T_1^2+T_2^2=2T^2$$

5. When a body of mass 1.0 kg is suspended from a certain light spring hanging vertically, its length increases by 5cm. By suspending 2.0 kg block to the spring and if the block is pulled through 10cm and released, the maximum velocity of it in m/s is (Acceleration due to gravity = 10 m/s^2) **(2003E)**

1) 0.5 2) 1 3) 2 4) 4

Ans : 3

Sol: Force = mg = kx where 'k' is force constant

$$\Rightarrow k=\frac{mg}{x}=200Nm^{-1}$$

From law of conservation of energy

$$\frac{1}{2}kx_1^2=\frac{1}{2}m_1v^2$$

$$\therefore V^2=\frac{kx_1^2}{m_1}=\frac{200\times\left(10^{-1}\right)^2}{2}=1$$

$$\therefore V=1ms^{-1}$$

6. A body of mass 'm' is suspended to an ideal spring of force constant 'k'. The expected change in the position of the body due to an additional force 'F' acting vertically downwards is : **(2005 E)**

1) $\frac{3F}{2k}$ 2) $\frac{2F}{k}$ 3) $\frac{5F}{2k}$ 4) $\frac{4F}{k}$

Ans : 2

Sol: If F is the force acting and K is the force constant. Let the change in position of the body due to addition force is x. So

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

$$\Rightarrow x = \frac{2F}{k}$$

7. An object is attached to the bottom of a light vertical spring and set vibrating. The maximum speed of the object is 15 cm/sec and the period is 628 milli seconds. The amplitude of the motion in centimeters is **(2003 E)**

1) 3.0 2) 2.0 3) 1.5 4) 1.0

Ans : 3

Sol: Given $V_{max} = 15cms^{-1} = 15\times10^{-2}ms^{-1}$

T = 628 ms $= 628\times10^{-3}s$

$$V_{max} = A\omega = A\times\frac{2\pi}{T}$$

$$\Rightarrow A = \frac{15\times10^{-2}\times628\times10^{-3}}{2\times3.14}$$

$= 15\times10^{-3}m$

= 1.5 cm

8. A body executes S.H.M. under the action of a force F_1 with a time period 4/5 seconds. If the force is changed to F_2 it executes S.H.M. with time period 3/5 seconds. If both the forces F_1 and F_2 act simultaneous in the same direction on the body. Its time period in seconds is **(2002 E)**

1) 12/25 2) 24/25 3) 25/24 4) 25/12

Ans : 3

Sol: Force F $= mr\omega^2 = mr\left[\frac{2\pi}{T}\right]^2 = \frac{4\pi^2 mr}{T^2}$

$\therefore$ As the two forces are acting simultaneously

Resultant force $= F = F_1 + F_2$

$$\therefore \frac{1}{T_2} = \frac{1}{T_1^2} + \frac{1}{T_2^2}$$ [Since m & r are constants)

$$\frac{1}{T} = \sqrt{\frac{1}{T_1^2} + \frac{1}{T_2^2}}$$

$$\Rightarrow \frac{1}{T} = \sqrt{\frac{25}{16} + \frac{25}{9}} = \frac{25}{12}\ T = \frac{12}{25}s$$

9. If the displacement (x) and velocity (v) of a particle executing S.H.M. are related through the expression $4v^2 = 25 - x^2$ then its time period is **(2002 E)**

1) π 2) 2π 3) 4π 4) 6π

Ans : 3

Sol: Give expression is $4V^2 = 25 - x^2$ ……………………………(1)

Dividing equation (1) by 4

$$V^2 = \frac{25}{4} - \frac{x^2}{4}$$

$$\Rightarrow V = \frac{1}{2}\sqrt{25 - x^2}$$ ……………..(2)

Comparing (2) with $V = \omega\sqrt{A^2 - x^2}$

$$\omega = \frac{1}{2} \Rightarrow \frac{2\pi}{T} = \frac{1}{2}$$

$$\Rightarrow T = 4\pi \text{ s}$$

10. Two particles P and Q start from origin and execute S.H.M. along x-axis with same amplitude but with periods 3 seconds and 6 seconds respectively. The ratio of the velocities of P and Q when they are at mean position is **(2001 E)**

1) 1 : 2 2) 2 : 1 3) 2 : 3 4) 3 : 2

Ans : 2

Sol: Velocity of a particle executing S.H.M. V = $\omega\sqrt{A^2 - y^2}$

But $\omega = \frac{2\pi}{T}$ $\therefore V = \frac{2\pi}{T}\sqrt{A^2 - y^2}$

As $V \propto \frac{1}{T}$

$$\therefore \frac{V_1}{V_2} = \frac{T_2}{T_1} = \frac{6}{3} \therefore V_1 : V_2 = 2:1$$

11. A body is executing S.H.M. at a displacement x its P.E. is E_1 and at a displacement y its P.E is E_2. The P.E at displacement (x+y) is **(2001 E)**

1) $\sqrt{E} = \sqrt{E_1} - \sqrt{E_2}$ 2) $\sqrt{E} = \sqrt{E_1} + \sqrt{E_2}$ 3) $E = E_1 + E_2$ 4) $E = E_1 - E_2$

Ans : 3

Sol: The potential energy stored in a body E = $\frac{1}{2}kx^2$

$$\therefore E_1 = \frac{1}{2}kx^2 \Rightarrow \sqrt{E_1} = \sqrt{\frac{K}{2}}.x$$ ………………………(1)

$$\therefore E_2 = \frac{1}{2}ky^2 \Rightarrow \sqrt{E_2} = \sqrt{\frac{K}{2}}.y$$ ………………………(2)

$\therefore$ Potential energy (E) at displacement (x+y) $= \frac{1}{2}k\left(x + y\right)^2$

$$\Rightarrow \sqrt{E} = \sqrt{\frac{k}{2}}(x+y) \ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

From (1), (2) and (3)

$$\sqrt{\frac{k}{2}}(x+y) = \sqrt{\frac{k}{2}}(x) + \sqrt{\frac{k}{2}}(y)$$

$$\therefore \sqrt{E} = \sqrt{E_1} + \sqrt{E_2}$$

12. A body of mass 1kg executing S.H.M., its displacement y cm at t seconds is given by y=6sin (100t + $\pi/4$). Its maximum kinetic energy is **(2000 E)**

1) 6J 2) 18J 3) 24J 4) 36J

Ans : 2

Sol: Comparing the given equation with $y = A\sin(\omega t + \phi)$

We get $A = 6\times10^{-2}m$, ω = 100 rads^{-1}, $\phi = \frac{\pi}{4}rad$

$$(KE)_{\max} = \frac{1}{2}m\omega^2A^2 = \frac{1}{2}\times1\times(100)^2\times(6\times10^{-2})^2$$

= 18 J

13. A particle executing S.H.M. has an amplitude of 6 cm. Its acceleration at a distance of 2cm from the mean position is 8cm/s^2. The maximum speed of particle is **(2000E)**

1) 8cm/s 2) 12 cm/s 3) 16 cm/s 4)24cm/s

Ans : 2

Sol:

$$a = \omega^2 y \Rightarrow 8 = \omega^2(2)$$

$$\omega^2 = 4 \Rightarrow \omega = 2rads^{-1}$$

$$V_{\max} = A\omega = 6\times2 = 12cms^{-1}$$

MEDICAL

14. A simple pendulum is executing SHM with a period of 6sec between two extreme positions B and C about a point 'O'. If the length of the arc BC is 10cm. how long will the pendulum take the move from position C to a position D towards 'O' exactly midway between 'C' and 'O' **[2009 M]**

1) 0.5sec 2) 1sec 3)1.5 sec 4) 3 sec

Ans : 2

Sol: Time period T = 12s

Amplitude A = 5 cm

The equation of SHM is y = $A\sin\left(\frac{2\pi}{T}\right)t$

$$\therefore \frac{A}{2} = A\sin\left(\frac{2\pi}{T}\right)t$$

$$\Rightarrow \sin\left(\frac{\pi}{6}\right) = \sin\left(\frac{\pi}{6}\right)t$$

$$\Rightarrow t = 1s$$

15. A girl swings on a cradle in sitting position. If she stands, the time period of cradle **[2008 M]**

1) decreases 2) increases
3) remains constant 4) first increases then it remains constant

Ans :

Sol: As the length of the pendulum decreases time period also decreases

16. The displacement of a particle of mass 3 gm executing simple harmonic motion is given by y = 3sin(0.2t) in SI units. The kinetic energy of the particle at a point which is at a distance equal to of its amplitude from its mean position is **(2007 M)**
1) 12 x 10^{-3} J 2) 25 x 10^{-3} J 3) 0.48 x 10^{-3} J 4) 0.24 x 10^{-3} J

Ans :

Sol: Given equation is y=3sin(0.2t) comparing with standard equation

$$y = A\sin(\omega t)$$

A = 3 m, ω =0.2, $m = 3\times10^{-3} kg$

$$\therefore K.E = \frac{1}{2}m\omega^2\left(A^2 - x^2\right)$$

$$= \frac{1}{2}\times3\times10^{-3}\times(0.2)^2\left(3^2 - 1^2\right)$$

$$= 0.48\times10^{-3} J$$

17. The simple harmonic motion of a particle is represented by the equation $x = 4\cos\left[88t + \frac{\pi}{4}\right]$. The frequency (in Hz) and the initial displacement (in m) of the particle are **(2006 M)**
1) $14, 2\sqrt{2}$ 2) $16, 2\sqrt{2}$ 3) $14, 3\sqrt{2}$ 4) $16, 3\sqrt{2}$

Ans : 2

Sol: Comparing the given equation with $x = A\cos(\omega t + \phi)$

i) $\omega t = 88t \Rightarrow \omega = 88 \Rightarrow 2\pi n = 88 \Rightarrow n = 14Hz$

ii) Initial displacement [t=0]

$$\therefore x = 4\cos\left(\frac{\pi}{4}\right) = \frac{4}{\sqrt{2}} = 2\sqrt{2}$$

18. A body executing S.H.M. has a maximum velocity of 1 and a maximum acceleration of 4. Its amplitude in metres is **(2005 M)**
1) 1 2) 0.75 3) 0.5 J 4) 0.25

Ans : 4

Sol: $V_{\max} = A\omega$, $a_{\max} = A\omega^2$

$$\frac{V_{\max}^2}{a_{\max}} = \frac{A^2\omega^2}{A\omega^2} = A = \frac{(1)^2}{4} = 0.25m$$

19. The equation of motion of particle executing SHM is $a + 16\pi^2 x = 0$. In this equation a is the linear acceleration in m/s², of the particle at a displacement x in meters. The time period of SHM, in seconds is **(2004 E)**

1) 1/4 2) 1/2 3) 1 4) 2

Ans : 2

Sol: Given that $a + 16\pi^2 x = 0$

$$\Rightarrow a = -16\pi^2 x$$

-ve sign indicates that acceleration and displacement are opposite in directions

Time period T = $2\pi\sqrt{\dfrac{displacement}{acceleration}}$

$$= 2\pi\sqrt{\frac{1}{16\pi^2}}$$

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

20. The time period of a particle in simple harmonic motion is 8 seconds. At t = 0 it is at the mean position. The ratio of the distances travelled by it is the first and second seconds is: **(2003 M)**

1) $\dfrac{1}{2}$ 2) $\dfrac{1}{\sqrt{2}}$ 3) $\dfrac{1}{\sqrt{2}-1}$ 4) $\dfrac{1}{\sqrt{3}}$

Ans : 3

Sol: The equation of a particle executing S.H.M is $y = A\sin\omega t$

$\therefore$ distance traveled in 1s

$$y_1 = A\sin\left(\frac{2\pi}{8}\right) = \frac{A}{\sqrt{2}} = S_1$$

Distance traveled in 2 seconds = $y_2 = A\sin\left(\dfrac{2\pi\times 2}{8}\right) = A$

S_2 = Distance traveled in 2nd second = y_2 - y_1

$$= A - \frac{A}{\sqrt{2}}$$

$$= \frac{A}{\sqrt{2}}\left[\sqrt{2}-1\right]$$

$$\therefore \frac{S_1}{S_2} = \frac{A/\sqrt{2}}{\dfrac{A}{\sqrt{2}}\left[\sqrt{2-1}\right]}$$

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

21. The mass and diameter of a planet are two times those of earth. If a seconds pendulum is taken to it, the time period of the pendulum in seconds is **(2002 M)**

1) $\dfrac{1}{\sqrt{2}}$ 2) 1/2 3) 2 4) $2\sqrt{2}$

Ans : 4

Sol: We known that $g = \dfrac{GM}{R^2}$

$$\therefore \frac{g_p}{g_E} = \frac{M_p}{M_E}\times\left(\frac{R_E}{R_p}\right)^2$$

$$= \frac{2M_E}{M_E} \times \left(\frac{R_E}{2R_E}\right)^2 = \frac{1}{2}$$

We know that time period of simple pendulum

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

$$\Rightarrow \frac{T_P}{T_E} = \sqrt{\frac{g_E}{g_p}}$$

$$\Rightarrow \frac{T_P}{2} = \sqrt{\frac{2}{1}}$$

$$\Rightarrow T_P = 2\sqrt{2}s$$

22. If two bodies of same mass are executing S.H.M. with frequencies in the ratio 1 : 2 and amplitudes in the ratio 2:3 then the ratio of their total energies is **(2001M)**

1) 1: 3   2) 1: 9   3) 1 : 4   4) 1: 6

Ans : 2

Sol: E = Total energy of a body executing SHM = $\frac{1}{2}m\omega^2 A^2$

$$= \frac{1}{2}m\left(2\pi n\right)^2 A^2$$

$$\therefore \frac{E_1}{E_2} = \frac{n_1^2 A_1^2}{n_2^2 A_2^2} = \left(\frac{1}{2}\right)^2 \times \left(\frac{2}{3}\right)^2 = \frac{1}{9}$$

23. The time period of a light loaded spring is 3.5 seconds. On changing the load by 1kg, the period decreases by 0.5 seconds. The initial load on the spring is **(2001 M)**

1) 3 (10/13) kg   2) 4 (10/13) kg   3) 5 (10/13) kg   4) 6 (10/13) kg

Ans : 1

Sol: The time period of a mass loaded spring = T = $2\pi\sqrt{\frac{m}{k}}$

$$\therefore \frac{T_1}{T_2} = \sqrt{\frac{m_1}{m_2}}$$

$$\Rightarrow \frac{3.5}{3} = \sqrt{\frac{m}{m-1}}$$

On simplifying $m = 3\frac{10}{13}kg$

24. A particle is executing simple harmonic motion with an amplitude of 4cm. At the mean position the velocity of the particle is 10 cm/s. The distance of the particle from the mean position when its speed becomes 5cm/s is **(2000 M)**

1) $\sqrt{3}$ cm   2) $\sqrt{5}$ cm   3) $2\sqrt{3}$ cm   4) $2\sqrt{5}$ cm

Ans : 3

Sol: Amplitude = 4 cm

Maximum velocity V_{max}= 10cm/sec

But V_{max} = $a\omega$

$$\therefore \omega = \frac{V_{\max}}{a} = \frac{10}{4} = 2.5 rads^{-1}$$

Velocity $V = \omega\sqrt{a^2 - y^2}$

$$\Rightarrow 5 = \frac{5}{2}\sqrt{16 - y^2}$$

$$\Rightarrow y = 2\sqrt{3}cm$$

25. A particle executes simple harmonic motion with a period of Ts and amplitude A m. The shortest time it takes to reach point $\frac{A}{\sqrt{2}}$ m from its mean position in seconds is **(2000 M)**

1) T
2) $\frac{T}{4}$
3) $\frac{T}{8}$
4) $\frac{T}{16}$

Ans : 3

Sol: Time period = T sec

Amplitude = A metre

Displacement = $\frac{A}{\sqrt{2}}$ metre

We know y = $a\sin\omega t$

$$\Rightarrow \frac{A}{\sqrt{2}} = A\sin\left(\frac{2\pi}{T}\right)t$$

$$\Rightarrow \sin 45^0 = \sin\left(\frac{2\pi}{T}\right)t$$

$$\Rightarrow t = \frac{T}{8}\sec$$