Physicsaholics

DPP – 2 (SHM)

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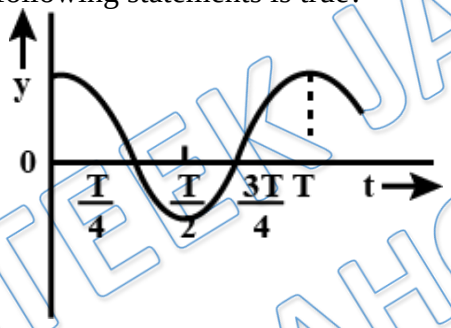
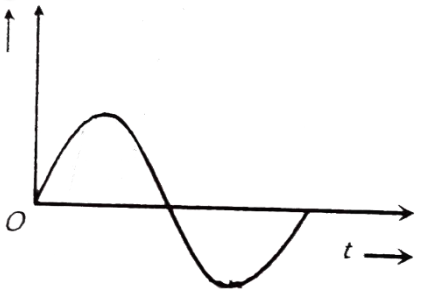
Q 1. In S.H.M. which one of the following graphs is a straight line ?
(a) P.E. against displacement
(b) acceleration against time
(c) total energy against displacement
(d) velocity against displacement

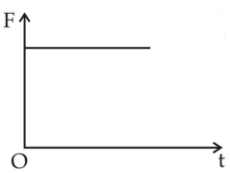
Q 2. The displacement time graph of a particle executing S.H.M. (in straight line) is shown. Which of the following statements is true?

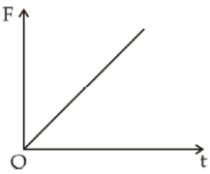


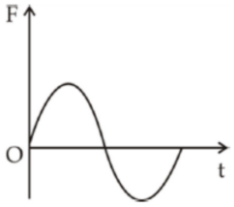
(a) the velocity is maximum at t = T/2
(b) the acceleration is zero at t = T
(c) the force is maximum at t = 3T/4
(d) the potential energy equals the total oscillation energy at t = T/2

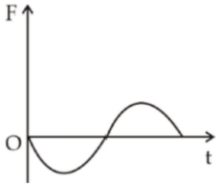
Q 3. The displacement time graph of a particle executing S.H.M. is as shown in the figure. The corresponding force-time graph of the particle is



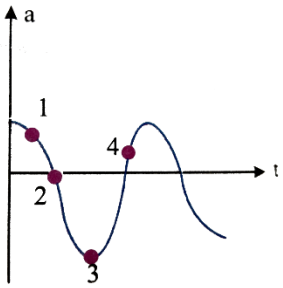
(a) 

(b) 

(c) 

(d) 

Q 4. Acceleration-time graph of a particle executing SHM is as shown in figure. Select the correct alternatives(s)



(a) Displacement of particle at 1 is positive
(b) Velocity of particle at 2 is negative
(c) Potential energy of particle at 3 is minimum
(d) Speed of particle at 4 is decreasing

Q 5. What is the ratio between the potential energy and the total energy of a particle executing SHM, when its displacement is half of its amplitude?
(a) 1 : 1 (b) 1 : 2
(c) 1 : 3 (d) 1 : 4

Q 6. A particle is executing SHM with an amplitude 4 cm. the displacement at which its energy is half kinetic and half potential is
(a) 1 cm (b) $\sqrt{2}$ cm
(c) 2 cm (d) $2\sqrt{2}$ cm

Q 7. A particle performing SHM with amplitude 10cm. At What distance from mean position the kinetic energy of the particle is thrice of its potential energy ?
(a) 5 cm (b) 3 cm
(c) 7 cm (d) 1 cm

Q 8. A particle executes SHM with an amplitude of 10 cm and frequency 2 Hz. At $t = 0$, the particle is at a point where potential energy and kinetic energy are same. The equation for its displacement is
(a) x = 0.1 sin $\left(4\pi t + \frac{\pi}{4}\right)$m (b) x = 0.1 sin$(4\pi t)$m
(c) x = 0.1 sin $\left(4\pi t + \frac{\pi}{3}\right)$m (d) x = 0.1 sin $\left(4\pi t - \frac{\pi}{3}\right)$m

Q 9. A particle starts SHM at time t=0. Its amplitude is A and angular frequency is ω. At time t=0 its kinetic energy is $\frac{E}{4}$. Assuming potential energy to be zero at mean position, the displacement-time equation of the the particle cannot be written as (E = total mechanical energy of oscillation).

(a) $x = A\cos\left(\omega t + \frac{\pi}{6}\right)$ (b) $x = A\sin\left(\omega t + \frac{\pi}{3}\right)$

(c) $x = A\sin\left(\omega t - \frac{2\pi}{3}\right)$ (d) $x = A\cos\left(\omega t - \frac{\pi}{4}\right)$

Q 10. A particle starts Simple harmonic motion from the mean position. Its amplitude is a and total energy E. At on instant its kinetic energy is $\frac{3E}{4}$. Its displacement at that instant is

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

(c) $\sqrt{3}\frac{a}{2}$ (d) zero

Q 11. The total energy of a vibrating particle in SHM is E. If its amplitude and time period are doubled, its total energy will be :-

(a) 16E (b) 8E

(c) 4E (d) E

Q 12. The amplitude of a particle executing SHM is made three-fourth keeping its time period constant. Its total energy will be

(a) $\frac{E}{2}$ (b) $\frac{3E}{4}$

(c) $\frac{9E}{16}$ (d) none of these

Q 13. A particle starts its SHM from mean position at t = 0. If its time period is T and amplitude A then the distance travelled by the particle in the time from $t = 0 \rightarrow t = \frac{5T}{4}$ is

(a) A (b) 3A

(c) 4A (d) 5A

Q 14. In simple harmonic motion of a particle, maximum kinetic energy is 40 J and maximum potential energy is 60 J. then

(a) minimum potential energy will be 30 J

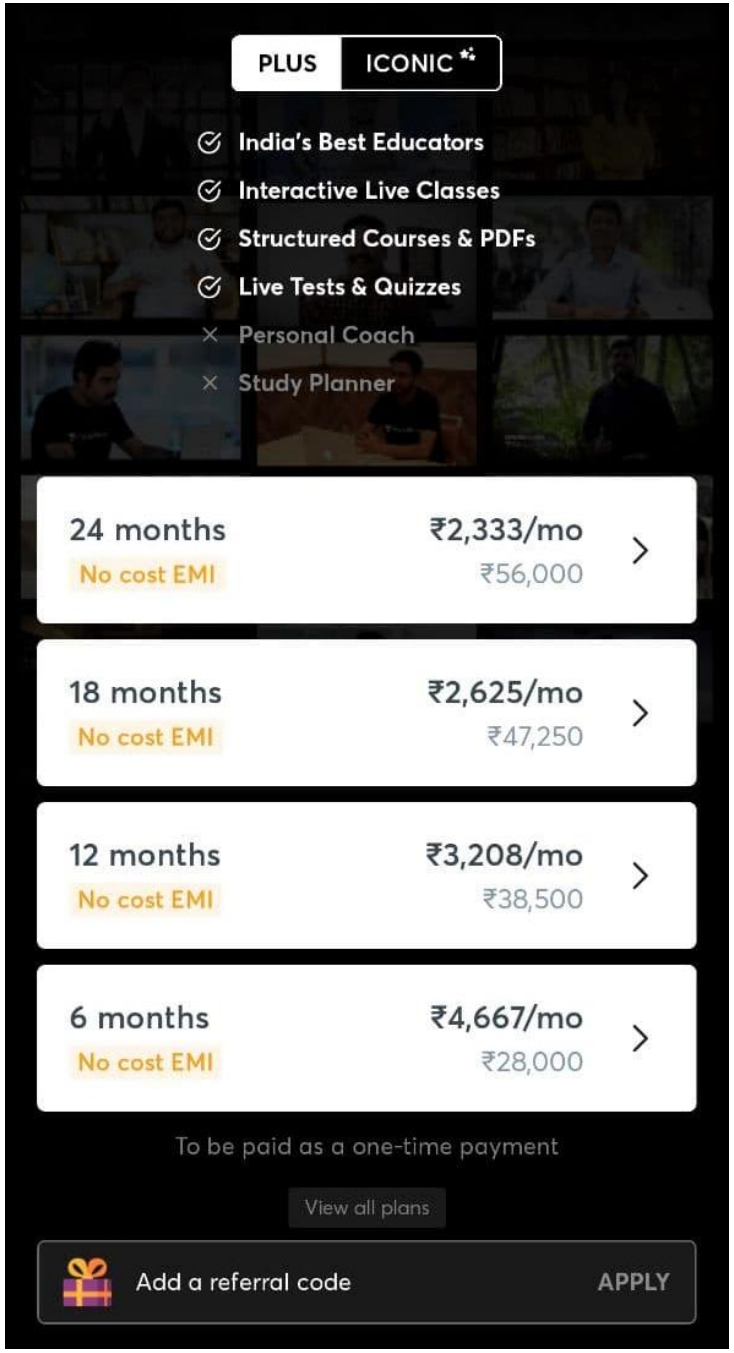
(b) potential energy at half the displacement will be 30 J

(c) kinetic energy at half the displacement is 40 J

(d) potential energy or kinetic energy at some intermediate position cannot be found the given data

Answer Key

Q.1 c	**Q.2 d**	**Q.3 d**	**Q.4 d**	**Q.5 d**
Q.6 d	**Q.7 a**	**Q.8 a**	**Q.9 d**	**Q.10 b**
Q.11 d	**Q.12 c**	**Q.13 d**	**Q.14 b**	



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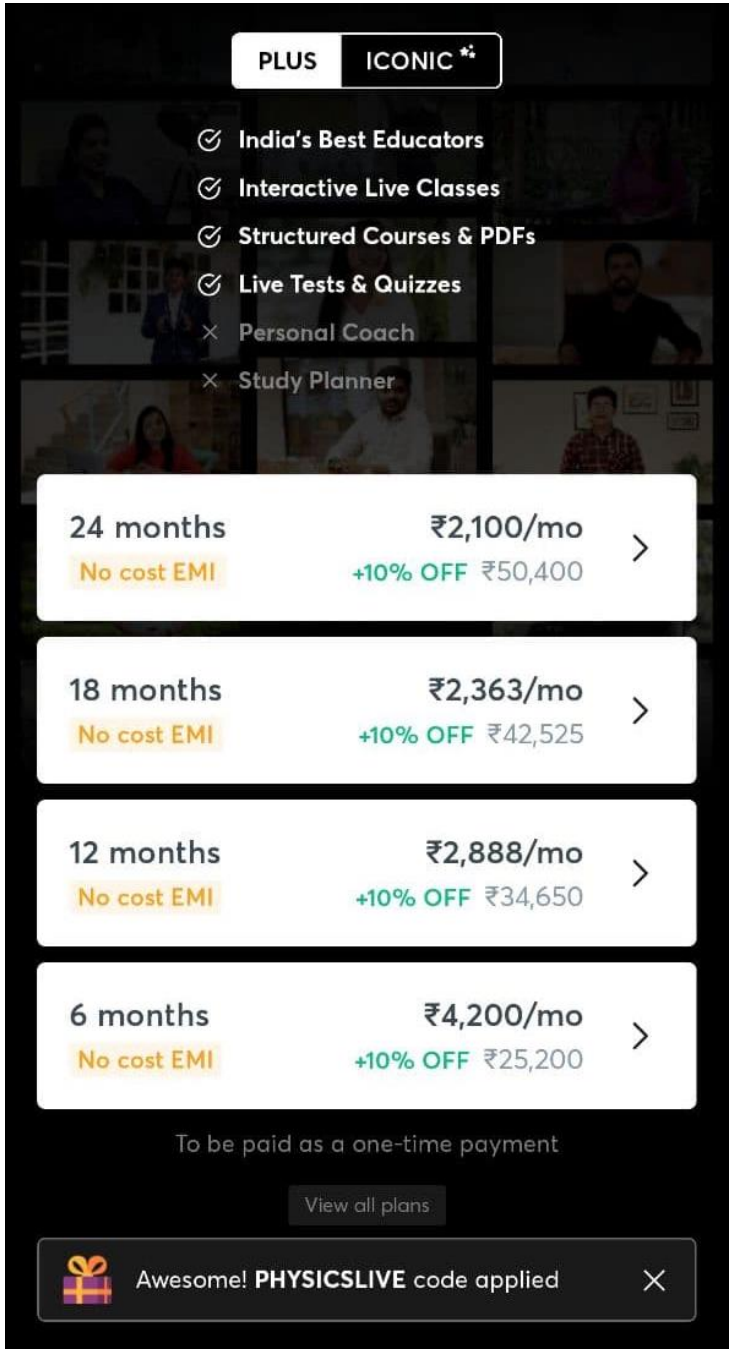


NEET & JEE Main
Physics DPP - Solution

DPP-2 SHM: Energy in SHM , S.H.M. as Projection of Circular Motion

By Physicsaholics Team

Solution: 1

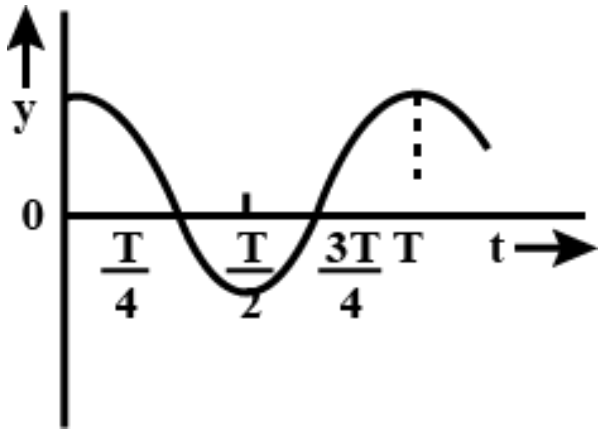
As; $TE = \frac{1}{2} m\omega^2 A^2$

So; TE = Always constant

So; TE / 'x' curve is straight line.

Ans. c

Solution: 2



Velocity is maximum when particle is at origin an moving in positive direction.

so; V_{max} at $t = \frac{3T}{4}$

acceleration of particle is zero when it is at equilibrium position

so; $a = 0$ & $F = 0$

at; $t = \frac{T}{4}$ and $\frac{3T}{4}$

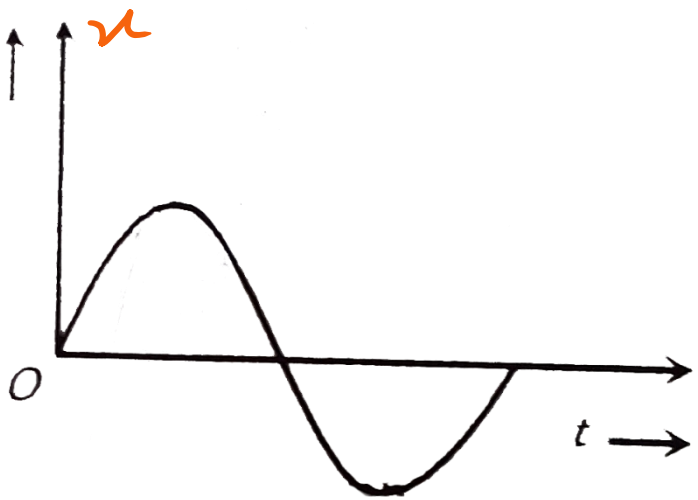
at $t = \frac{T}{2}$;

$TE = (PE)_{t=\frac{T}{2}}$

∴ at this time displacement is maximum; so total energy is stored in the form of potential energy.

Ans. d

Solution: 3



$a = -\omega^2 x$

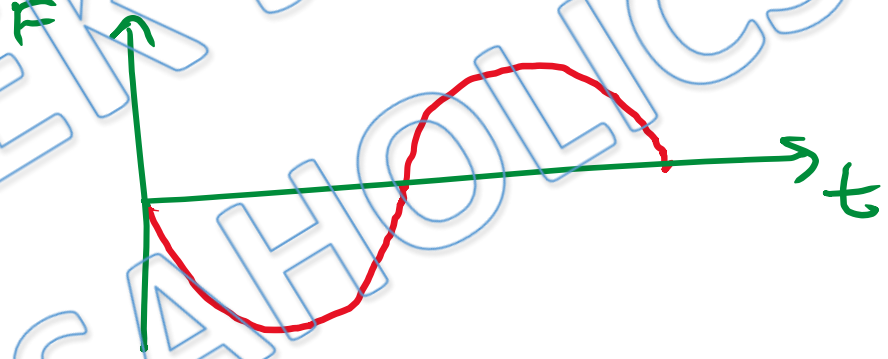
$x = A\sin\omega t$

so; $a = -A\omega^2 \sin\omega t$

$F = ma$

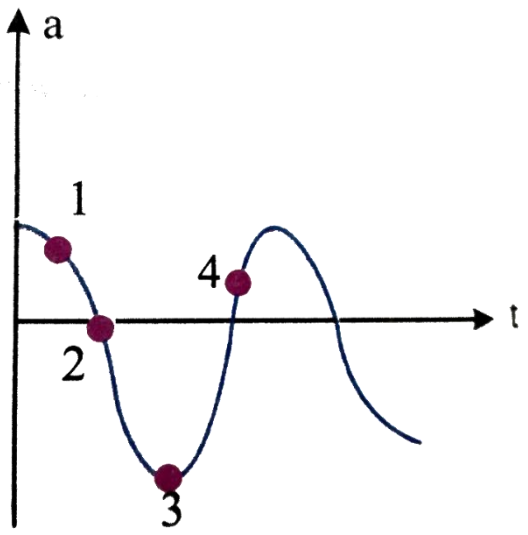
$F = -m\omega^2 A \sin\omega t$

so, for $F = -m\omega^2 A \sin\omega t$



Ans. d

Solution: 4



$\Rightarrow a = -\omega^2 x$

$x = -\frac{a}{\omega^2}$

so; at point 1

$a = +ve$

so; $x = -ve$.

$\Rightarrow$ at $t = 2$ sec

$a = 0$;

means particle is at mean position

and; before (2); $a = +ve$

and; after (2); $a = -ve$

means particle is moving from $-ve$ to $+ve$ displacement.

so; at point (2)

$v = +ve$

$\Rightarrow$ at point (3)

$a = min = -(\omega^2 A)$

at maximum displacement

so; PE is maximum at this point

$\Rightarrow$ at point (4)

a is increasing when we increase the the time after point (4)

means; particle is moving away from origin.

so; speed will decrease.

Ans

Ans. d

Solution: 5

$$PE = \frac{1}{2} m\omega^2 x^2$$

$$PE = \frac{1}{2} m\omega^2 \left(\frac{A}{2}\right)^2$$

$$PE = \frac{1}{4}\left(\frac{1}{2} m\omega^2 A^2\right)$$

$$\because TE = \frac{1}{2} m\omega^2 A^2$$

$$\text{So; } \frac{PE}{TE} = \frac{\frac{1}{4}\left(\frac{1}{2} m\omega^2 A^2\right)}{\frac{1}{2} m\omega^2 A^2}$$

$$\boxed{\frac{PE}{TE} = \frac{1}{4}} \quad \text{Ans}$$

Ans. d

Solution: 6

when; $PE = \frac{1}{2}(TE)$

$\Delta KE = \frac{1}{2}(TE)$

means; $PE = KE$

$\frac{1}{2}m\omega^2 x^2 = \frac{1}{2}m\omega^2(A^2 - x^2)$

$x^2 = A^2 - x^2$

$2x^2 = A^2$

$x = \pm \frac{A}{\sqrt{2}}$

so; $x = \pm \frac{4}{\sqrt{2}}$

$x = \pm 2\sqrt{2}$ cm Ans

Ans. d

Solution: 7

$A = 10\ cm$

$KE = 3\ PE$

$\frac{1}{2}m\omega^2(A^2 - x^2) = 3\,\frac{1}{2}m\omega^2 x^2$

$A^2 - x^2 = 3x^2$

$4x^2 = A^2$

$x = \pm \frac{A}{2}$

$x = \pm \frac{10}{2}$

$\boxed{x = \pm 5\ cm}$ Ans.

Ans. a

Solution: 8

$PE = KE$

at $x = \pm \frac{A}{\sqrt{2}}$

$x = A \sin(\omega t + \phi)$

$f = 2\,Hz$

$\omega = 2\pi f = 4\pi$ rad/s

$x = A \sin(4\pi t + \phi)$

$A = 10\,cm = 0.1\,m$

$x = 0.1 \sin(4\pi t + \phi)$

if at $t = 0$; $x = \frac{A}{\sqrt{2}} = \frac{0.1}{\sqrt{2}}\,m$

$\frac{0.1}{\sqrt{2}} = 0.1 \sin(0 + \phi)$

$\sin\phi = \frac{1}{\sqrt{2}}$

$\phi = \frac{\pi}{4}$

and; If at $t = 0$; $x = -\frac{A}{\sqrt{2}} = -\frac{0.1}{\sqrt{2}}$

$-\frac{0.1}{\sqrt{2}} = 0.1 \sin(0 + \phi$

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

$\phi = -\frac{\pi}{4}, \frac{5\pi}{4}, \ldots$ etc.

So; $x = 0.1 \sin(4\pi t - \frac{\pi}{4})$ ✓

(or)

$x = 0.1 \sin(4\pi t + \frac{\pi}{4})$

Ans.

Ans. a

Solution: 9

$x = A\sin(\omega t + \phi)$

given; at; $t = 0$

$KE = \frac{E}{4}$

$v = A\omega\cos(\omega t + \phi)$

at $t = 0$;

$v = A\omega(\cos\phi)$

$KE = \frac{1}{2}mv^2$

$KE = \frac{1}{2}m\omega^2A^2\cos^2\phi$

$TE = E = \frac{1}{2}m\omega^2A^2$

$KE = \frac{E}{4}$

so; $\frac{1}{2}m\omega^2A^2\cos^2\phi = \frac{1}{2}m\omega^2A^2 \times \frac{1}{4}$

$\cos^2\phi = \frac{1}{4}$

$\cos\phi = \pm\frac{1}{2}$

so; $\phi = \frac{\pi}{3}, \frac{2\pi}{3}, \frac{4\pi}{3}, \frac{5\pi}{3}, \ldots$ etc

(a) $x = A\cos(\omega t + \frac{\pi}{6}) = A\sin[\frac{\pi}{2} + (\omega t + \frac{\pi}{6})]$

$x = A\sin(\omega t + \frac{2\pi}{3})$ ✓

(b) $x = A\sin(\omega t + \frac{\pi}{3})$ ✓

(c) $x = A\sin(\omega t - \frac{2\pi}{3}) = A\sin[2\pi + (\omega t - \frac{2\pi}{3})]$

$x = A\sin(\omega t + \frac{\pi}{3})$ ✓

(d) $x = A\cos(\omega t - \frac{\pi}{4}) = A\sin(\frac{\pi}{2} + (\omega t - \frac{\pi}{4}))$

$x = A\sin(\omega t + \frac{\pi}{4})$ ✗

so; Ans : D

Ans. d

Solution: 10

$TE = E = \frac{1}{2}m\omega^2 a^2$ (let; $x = a\sin\omega t$ [$\because$ at $t=0$; $\phi=0$]

when; $KE = \frac{3}{4}E = \frac{3}{4}\left(\frac{1}{2}m\omega^2 a^2\right)$ $\Rightarrow t = \frac{\pi}{6\omega}$

$x = a\sin\left(\omega \times \frac{\pi}{6\omega}\right) = a\sin\frac{\pi}{6}$

$\therefore KE = \frac{1}{2}m\omega^2 a^2\cos^2\omega t$

$\boxed{x = \frac{a}{2}}$ Ans.

$\frac{1}{2}m\omega^2 a^2\cos^2\omega t = \frac{3}{4}\left(\frac{1}{2}m\omega^2 a^2\right)$ (i); $\cos\omega t = -\sqrt{3}/2$; $\omega t = \frac{5\pi}{6}$

$\cos^2\omega t = \frac{3}{4}$ $t = \frac{5\pi}{6\omega}$

$\cos\omega t = \pm\frac{\sqrt{3}}{2}$ $x = a\sin\left(\omega\cdot\frac{5\pi}{6\omega}\right) = a\sin\left(\frac{5\pi}{6}\right)$

$= a\sin\left(\pi - \frac{\pi}{6}\right) = a\sin\frac{\pi}{6}$

$\cos\omega t = \frac{\sqrt{3}}{2}$

$\omega t = \frac{\pi}{6}$

$\boxed{x = \frac{a}{2}}$ Ans.

Ans. b

Solution: 11

$$E = \frac{1}{2} m \omega^2 A^2$$

If $T' = 2T$

$$\frac{2\pi}{\omega'} = 2\left(\frac{2\pi}{\omega}\right)$$

$$\boxed{\omega' = \frac{\omega}{2}}$$

& $A' = 2A$

So, $E' = \frac{1}{2} m \left(\frac{\omega}{2}\right)^2 (2A)^2$

$$E' = \frac{1}{2} m \omega^2 A^2$$

$$\boxed{E' = E}$$ Ans.

Ans. d

Solution: 12

$$E = \frac{1}{2} m \omega^2 A^2$$

Now; T = same

$\Rightarrow \omega$ = same.

$\omega' = \omega$

but $A' = \frac{3}{4} A$

So; $E' = \frac{1}{2} m (\omega)^2 \left(\frac{3}{4} A\right)^2$

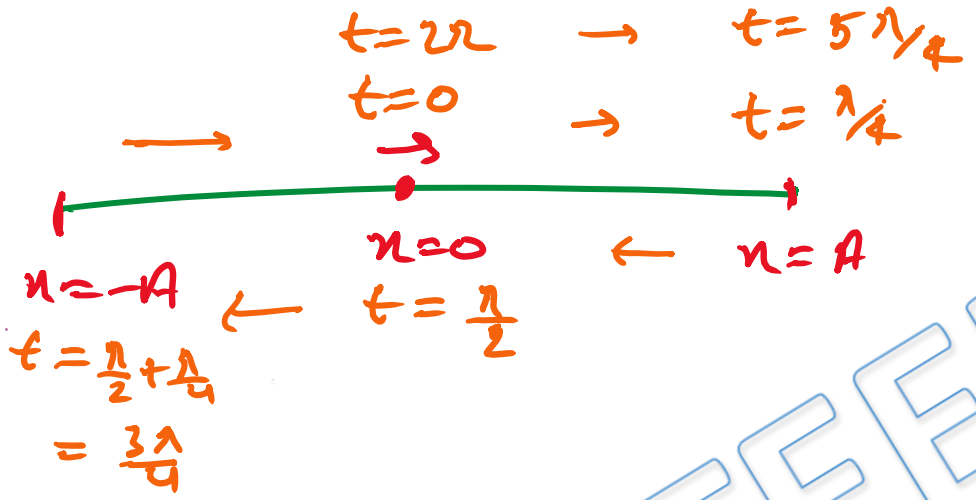
$E' = \frac{1}{2} m \omega^2 A^2 \left(\frac{3}{4}\right)^2$

$E' = E \left(\frac{3}{4}\right)^2$

$$\boxed{E' = \frac{9}{16} E}$$ Ans

Ans. c

Solution: 13



So; distance covered

$$d = (A + A + A + A + A)$$

$$\boxed{d = 5A} \text{ Ans.}$$

Ans. d

Solution: 14

$(KE)_{max} = 40\ J$

$(PE)_{max} = 60\ J$

means; $60 - 40 = 20\ J$

at mean position;

PE of particle

is $\underline{20\ J}$

so; Minimum $\underline{PE = 20\ J}$

$\therefore (KE)_{max} = \frac{1}{2} m\omega^2 A^2 = 40\ J$ — (1)

at; $x = A/2$

$KE = \frac{1}{2} m\omega^2 \left(A^2 - \left(\frac{A}{2}\right)^2\right) = \frac{1}{2} m\omega^2 \left(\frac{3A^2}{4}\right)$ — (2)

$\frac{(1)}{(2)} \Rightarrow \frac{40}{KE} = \frac{\frac{1}{2} m\omega^2 A^2}{\frac{1}{2} m\omega^2 A^2 \left(\frac{3}{4}\right)}$

$KE = 30\ J.$

so; at $x = A/2$

$PE = 20 + \left((KE)_{max} - (KE)_{x=A/2}\right)$

$PE = 20 + (40 - 30)$

$\boxed{PE = 30\ J}$ Ans.

Ans. b

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