JEE MAIN ANSWER KEY & SOLUTIONS

SUBJECT :- PHYSICS
CLASS :- 11th **PAPER CODE :- CWT-10**
CHAPTER :- SIMPLE HARMONIC MOTION

ANSWER KEY

1.	(C)	**2.**	(C)	**3.**	(A)	**4.**	(C)	**5.**	(C)	**6.**	(D)	**7.**	(D)
8.	(D)	**9.**	(D)	**10.**	(C)	**11.**	(D)	**12.**	(C)	**13.**	(C)	**14.**	(C)
15.	(A)	**16.**	(C)	**17.**	(B)	**18.**	(C)	**19.**	(B)	**20.**	(A)	**21.**	8
22.	2	**23.**	75	**24.**	3	**25.**	10 N	**26.**	40 cm	**27.**	5	**28.**	20
29.	2	**30.**	6										

SOLUTIONS

1. (C)

Sol. $x = A\cos\omega t$, $y = A\sin\omega t$ or $x^2 + y^2 = A^2$
Thus the motion of the particle is on a circle.

2. (C)

Sol. The total distance moved by particle in one time period is four times the amplitude.

3. (A)

Sol. Total Energy of S.H.M. remoins constant so average energy = Total energy

4. (C)

Sol. In case (i), springs are connected in parallel, so, effective force constant is
$k_1 = k + k = 2k$
In case (ii), springs are connected in series so, effective force constant k_2 is given by

$$\frac{1}{k_2} = \frac{1}{k} + \frac{1}{k} = \frac{2}{k}$$

$$\Rightarrow \quad k_2 = \frac{k}{2}$$

In case (i), time period

$$T_1 = 2\pi\sqrt{\frac{M}{k_1}} = 2\pi\sqrt{\frac{M}{2k}}$$

and in case (ii), time period

$$T_2 = 2\pi\sqrt{\frac{M}{k_2}} = 2\pi\sqrt{\frac{M}{k/2}}$$

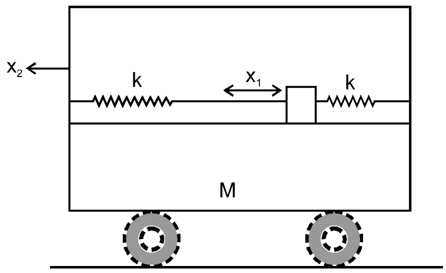
$$= 2\pi\sqrt{\frac{2M}{k}}$$

$$\therefore \quad \frac{T_1}{T_2} = \sqrt{\frac{1}{4}}$$

$$= \frac{1}{2} = 0.5$$

5. (C)

Sol. Let displacement of block is x_1 and of cart is x_2 as shown



by linear momentum conservation

$mv_1 = Mv_2 \quad \Rightarrow v_2 = \frac{mv_1}{M}$

For 1st particle. Force equation can be written as

$F = 2k(x_1 + x_2) = m\omega^2 x_1$

$$2k\left(x_1 + \frac{m}{M}\alpha_1\right) = m\omega^2 \Rightarrow \omega^2 = 2k\left(\frac{M+m}{Mm}\right)$$

$$\text{So} \quad T = 2\pi\sqrt{\frac{Mm}{2k(M+m)}}$$

6. (D)

Sol. $T = 2\pi\sqrt{\frac{\ell}{g}}$, As it does not depend on anplipude

$\therefore$ % change in time period is 0 % Herce option (D) is correct.

7. (D)

Sol. $y = 10\left(\frac{1}{2}\sin 3\pi t + \frac{\sqrt{3}}{2}\cos 3\pi t\right) = 10\sin(3\pi t + \frac{\pi}{3})$

thus amplitude is 10 m or 1000 cm

8. (D)

Sol. $P_{AV} = \frac{1}{4}KA^2$ and $K_{AV} = \frac{1}{4}KA^2$

9. (D)

Sol. Time perisd = T = $2\pi\sqrt{\frac{m}{K}}$

Spring dirided into two equal parts ⟶ Lengh reduced to half

We know K × $\frac{1}{\ell}$

∴ K become twice

$K_{new} = 2\pi\sqrt{\frac{m}{K_{new}}} = 2p\sqrt{\frac{m}{2K}}$

$= \frac{1}{\sqrt{2}}\left(2p\sqrt{\frac{m}{K}}\right) = \frac{T}{\sqrt{2}}$

10. (C)

Sol. $f_1 = \frac{1}{2\pi}\sqrt{\frac{K}{m_1}}$ $\quad f_2 = \frac{1}{2\pi}\sqrt{\frac{K}{m_2}}$

$f_2 = \frac{f_1}{2}$ or $m_2 = 4m_1$ or $m_2 - m_1 = 3$ kg

11. (D)

Sol. PE is related to reference. Only when PE at mean position is taken zero, the assertion is true.

12. (C)

Sol. Kinetic energy of particle of mass m in SHM at any point is

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

and potential energy = $\left(\frac{1}{2}m\omega^2x^2\right)$

where a is amplitude of particle and x is the distance from mean position.

So, at mean position, x = 0

K.E. $= \frac{1}{2}m\omega^2a^2$ (maximum)

P.E. $= 0$ (minimum)

13. (C)

Sol. $T = 2\pi\sqrt{\frac{M}{k}}$ ......(i)

$T' = 2\pi\sqrt{\frac{M+m}{k}}$

$\Rightarrow \frac{5T}{3} = 2\pi\sqrt{\frac{M+m}{k}}$ z......(ii)

Form equation (i) and (ii)

$\therefore \frac{3}{5} = \sqrt{\frac{M}{M+m}}$ $\quad \frac{9}{25} = \frac{M}{M+m}$

$\Rightarrow 9M + 9m = 25M$

$\Rightarrow 16M = 9m$

$\frac{m}{M} = \frac{16}{9}$

14. (C)

Sol. In simple harmonic motion when a particle is displaced to a position from its mean position, then its kinetic energy gets converted into potential energy and vice-versa. Hence, total energy of a particle remains constant or the total energy in simple harmonic motion does not depend on displacement x.

15. (A)

Sol. $x = A\cos\omega t$

K.E. $= \frac{1}{2}k(A^2 - x^2)$ $\quad = \frac{1}{2}kA^2\sin^2\omega t$

$= \frac{1}{2}kA^2\frac{(1-\cos 2\omega t)}{2}$ $\quad = \frac{kA^2}{4}(1 - \cos 2\omega t)$

Freque of K.E. is double of acceleration.

16. (C)

Sol. $A\omega^2 = g$

$\Rightarrow A = g/\omega^2$.

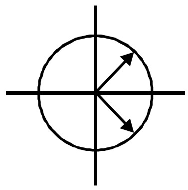
17. (B)

Sol. $x_1 = A\sin(\omega t + \phi_1)$

$x_2 = A\sin(\omega t + \phi_2)$

$x_1 - x_2 = A\left[2\sin\left[\omega t + \frac{\phi_1+\phi_2}{2}\right]\sin\left[\frac{\phi_1-\phi_2}{2}\right]\right]$

$A = 2A\sin\left(\frac{\phi_1-\phi_2}{2}\right)$



$\frac{\phi_1-\phi_2}{2} = \frac{\pi}{6}$

$\phi_1 = \frac{\pi}{3}$ **Ans.**

18. (C)

Sol. $v = \omega\sqrt{A^2 - \left(\frac{2A}{3}\right)^2}$ $\quad v = \sqrt{5}\frac{A\omega}{3}$

$v_{new} = 3v = \sqrt{5}A\omega$

So the new amplitude is given by

$v_{new} = \omega\sqrt{A_{new}^2 - x^2} \Rightarrow \sqrt{5}A\omega$

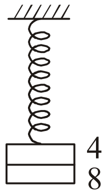
$= \omega\sqrt{A_{new}^2 - \left(\frac{2A}{3}\right)^2}$

$A_{new} = \frac{7A}{3}$

19. (B)

Sol. $kx_1 = (4 + 8)g \quad kx_2 = 4g$

$k(x_1 - x_2) = kA = 8g$



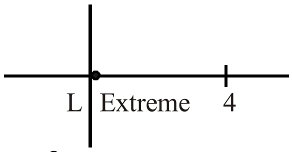
$A = \frac{8g}{1000}$

20. (A)

Sol. We can say motion of a pendulum is angular SHM if angular amplitude i.e. 'θ' is very very small.

21. 8

Sol.



$a = 0 \Rightarrow$ mean

$0 = 2(4 - x) \Rightarrow x_{mean} = 4$

$\Rightarrow A = 4m$

$\Rightarrow x_{max} = 8$

22. 2

Sol. $x_1 = A_1 \cos(\omega t) \quad x_2 = A_2 \cos(\omega t)$

$x_1 - x_2 = (A_1 - A_2)\cos(\omega t)$

$6 = 12\cos(\omega t)$

$\omega t = \frac{\pi}{3} \Rightarrow t = \frac{\pi}{3\omega} = \frac{T}{6} = 2s$

23. 75

Sol. $\omega = \sqrt{\frac{k_{eq}}{m}} = \sqrt{40}$

when spring breaks new $\omega = \sqrt{20}$

Equilibrium position of original system

$(2k)x_0 = mg$

or $\quad x_0 = \frac{1}{4}$ m

New equilibrium is at kx = mg

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

thus $\quad v_{max} = Aw = (\sqrt{40}) \times \left(\frac{1}{2}\right)$

$\sqrt{10} = \sqrt{20}\sqrt{A^2 - \frac{1}{16}}$

$\frac{1}{2} = A^2 - \frac{1}{16}$

$A^2 = \frac{1}{2} + \frac{1}{16} = \frac{8+1}{16} = \frac{9}{16} \quad \Rightarrow A = \frac{3}{4}$ m

24. 3

Sol. $y = A \sin \omega t$

$\frac{A}{2} = A \sin \omega t$

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

$\frac{2\pi}{T} t = \frac{\pi}{6}$

$t = \frac{T}{12}$

Total time period = $\frac{T}{3}$ =

Ratio = $\frac{T}{\left(\frac{T}{3}\right)} = 3$

25. 10 N

Sol. $T_a = 2\pi\sqrt{\frac{m}{\left(\frac{k_1k_2}{k_1+k_2}\right)}} \qquad T_a = 2T_b$

$T_b = 2\pi\sqrt{\frac{m}{(k_1+k_2)}}$

$\frac{k_1+k_2}{k_1 \times k_2} = 4\left(\frac{1}{k_1+k_2}\right)$

$(k_1+k_2)^2 = 4(k_1k_2)$

$(10+k_2)^2 = 4(10k_2) \Rightarrow k_2 = 10$ N/m **Ans.**]

26. 40 cm

Sol. $g = A\omega^2 \Rightarrow \qquad A = \frac{10}{(0.5)^2} = 40$ cm

27. 5

Sol. $kx_0 = mg$

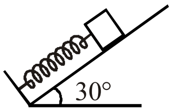
$x_0 = \frac{\sqrt{2}g}{200}$

$\theta = \omega \times t = \frac{2\pi}{T} \times \frac{3T}{8} = \frac{3\pi}{4}$

$S = x_0 \cos\frac{\pi}{4} = \frac{x_0}{\sqrt{2}} = 5$ cm

28. 20

Sol. $\frac{1}{2}kx_0^2 - mgx_0 \sin 30° = 0$



$x_0 = \frac{mg}{k} = \frac{20}{100} = 20$ cm

29. 2

Sol. $T = 2\pi\sqrt{\frac{\ell}{g}} \Rightarrow \frac{n\Delta T}{nT} = \frac{\Delta l}{2l}$

$\frac{T}{100T} = \frac{\Delta l}{2l}$

$\frac{\Delta l}{l} = \frac{200}{100} = 2$

30. 6

Sol. $\omega_1 = \sqrt{\frac{1200}{3}} = 20$

$\omega_2 = \sqrt{\frac{1200}{27}} = \frac{20}{3}$

$\omega_1 t = (2x + 1)\frac{\pi}{2}$

$\omega_2 t = (2m + 1)\frac{\pi}{2} \Rightarrow \frac{3}{1} = \frac{2n+1}{2m+1}$

$2n + 1 = 3$

$\omega_1 t = \frac{3\pi}{2} \Rightarrow t = \frac{6\pi}{80}$