JEE MAIN ANSWER KEY & SOLUTIONS

SUBJECT :- PHYSICS
CLASS :- 11th **PAPER CODE :- CWT-14**
CHAPTER :- MECHENICAL WAVE

ANSWER KEY

1.	(D)	**2.**	(D)	**3.**	(C)	**4.**	(D)	**5.**	(B)	**6.**	(C)	**7.**	(B)
8.	(C)	**9.**	(A)	**10.**	(D)	**11.**	(C)	**12.**	(D)	**13.**	(A)	**14.**	(C)
15.	(C)	**16.**	(A)	**17.**	(B)	**18.**	(A)	**19.**	(B)	**20.**	(C)	**21.**	7
22.	15	**23.**	98	**24.**	10	**25.**	600	**26.**	1	**27.**	1000	**28.**	214
29.	12	**30.**	125										

SOLUTIONS

1. (D)

Sol. $\frac{P}{4\pi r^2}$ = I for an isotropic point sound source.

$\Rightarrow$ P = I.4πr²

= (0.008 w/m²) (4.π.10²)

= 10 watt. **Ans.**

2. (D)

Sol. Energy per unit area associated with progressive sound wave I = $2\pi^2a^2n^2$ sV if we increase amplitude to $\sqrt{2}$ times or frequency to $\sqrt{2}$ times I will be doubled.

So % increment 41% of either amplitude or frequency

3. (C)

Sol. The excess pressure inside the soap bubble in inversely proportional to radius of soap bubble i.e. P $\propto$ 1/r, r being the radius of bubble. It follows that pressure inside a smaller bubble is greater than that inside a bigger bubble. Thus, if these two bubbles are connected by a tube, air will flow from smaller bubble to bigger bubble and the bigger bubble grows at the expense of the smaller one.

4. (D)

Sol. Path difference is λ between B and G.

5. (B)

Sol. Distance between boat = $\frac{\lambda}{2}$ = 10 m

$\Rightarrow$ λ = 20m

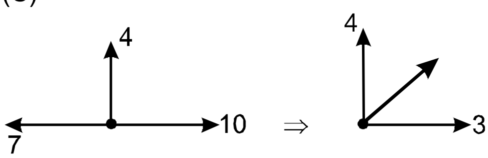
time penod T = 4 sec .

$\therefore$ V = λ / T = 20 m / 4sec.

= 5m/s.

6. (C)

Sol.



Resultant Amplitude = $\sqrt{3^2+4^2}$ = 5μm

7. (B)

Sol. Second overtone of open pipe = $\frac{3V}{2\ell_1}$

second overtone of closed pipe = $\frac{5V}{4\ell_2}$

Since, these frequency are same

$\therefore \quad \frac{3V}{2\ell_1} = \frac{5V}{4\ell_2}$

$\Rightarrow \quad \frac{\ell_1}{\ell_2} = \frac{4\times3}{2\times5} = \frac{6}{5}$

Now, the ratio of fundamental frequencies :

$\frac{f_1}{f_2} = \frac{\frac{V}{2\ell_1}}{\frac{V}{4\ell_2}} \Rightarrow \frac{2\ell_2}{\ell_1}$

= 10 : 6 = 5 : 3 **Ans.**

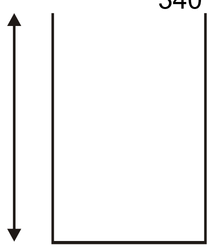
8. (C)

Sol. For closed organ pipe f = $\frac{(2n+1)v}{4\ell}$,

(n = 0,1,2......)

$\frac{(2n+1)v}{4\ell} < 1250$

(2n + 1) < 1250 × $\frac{4\times0.85}{340}$



(2n + 1) < 12.5

2n < 11.50

n < 5.25

So n = 0, 1, 2, 3.....5

So we have 6 possibileties

9. (A)

Sol. $n = \frac{V}{\lambda} = \frac{.21}{15\times10^{-3}} = \frac{210}{15}$

$V_{max} = A\,\omega = 5 \times 10^{-3} \times \frac{210}{15} \times 2\pi$

$= 70 \times 2 \times \frac{22}{7} \times 10^{-3} = .44$m/sec.

10. (D)

Sol. The standard wave equation is

$y = a \sin(\omega t - kx)$

The given wave equation is

$y = a \sin\left(100t - \frac{x}{10}\right)$

Compare it with the standard wave equation we obtain

$\omega = 100,\ k = \frac{1}{10}$

Velocity of the wave,

$v = \frac{\omega}{k} = \frac{100}{\frac{1}{10}} = 100 \times 10 = 1000$ m/s

11. (C)

Sol. Velocity of sound in air (V) = $\sqrt{\frac{\gamma RT}{M}}$

$\Rightarrow V^2 \alpha T$ (in kelvin)

not $V^2 \alpha T$ (in ^{0}C)

Hence (B) is incorrect.

Velocity of transverse wave in a string :

$V = \sqrt{\frac{T}{\mu}} = V^2 \alpha T$

Hence (C) is a correct graph.

12. (D)

Sol. Find the parameters and put in the general wave equation.

Here, A = 2 cm

direction = +ve x direction

$v = 128$ ms^{-1}

and $5\lambda = 4$

Now, $k = \frac{2\pi}{\lambda} = \frac{2\pi \times 5}{4} = 7.85$

and $v = \frac{\omega}{k} = 128$ ms^{-1}

$\Rightarrow$ $\omega = v \times k = 128 \times 7.85 = 1005$

As, $y = A \sin(kx - \omega t)$

$\therefore$ $y = 2\sin(7.85x - 1005t)$

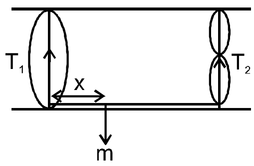
$= (0.02)$m $\sin(7.85x - 1005t)$

13. (A)

Sol. $\frac{\lambda_1}{2} = \ell \Rightarrow \lambda_1 = 2\ell$

$\lambda_2 = \ell \Rightarrow \therefore \frac{\lambda_1}{\lambda_2} = 2$

$\frac{v_1/f}{v_2/f} = 2$



$\frac{v_1}{v_2} = 2 = \sqrt{\frac{T_1/\mu}{T_2/\mu}} \Rightarrow \frac{T_1}{T_2} = 4$ ——(1)

Now moment about P : $T_1 x = T_2(\ell - x)$

$\ell - x = 4x$ $x = \ell/5$

14. (C)

Sol. $A_{eq} = \sqrt{A_1^2 + A_2^2 + 2A_1A_2\cos\phi}$

$A_{eq} = \sqrt{4^2 + 3^2 + 2(4)(3)\cos\frac{\pi}{2}}$

$A_{eq} = 5.$

15. (C)

Sol. $A_r = 0.02 \times 0.75 = 0.015$; $y_r = +0.015 \sin 8\pi\left[t + \frac{x}{20}\right]$; their is no phase difference of π produced as the reflection is from rarer medium.

16. (A)

Sol. $v_y = \sqrt{\frac{T_y}{\mu_y}}$

$T_y = \left\{\int_0^y \mu_0 e^y dy\right\} g$

$T_y = \mu_0(e^y - 1).g$

$v_y = \sqrt{g - \frac{g}{e^y}}$

$v_y^2 = g(1 - e^{-y}).$

17. (B)

Sol.

Fundamental frequency of wire (f_{wire}) = $\frac{v}{2\ell}$

(A) 

$f = \frac{v}{4\ell}, \frac{3v}{4\ell}, \frac{5v}{4\ell}$

cannot match with f_{wire}

(B)  $f = \frac{v}{2(2\ell)}, \frac{2v}{2(2\ell)}, \frac{3v}{2(2\ell)}$ its second harmonic $\frac{2v}{2(2\ell)}$ matches with f_{wire}.

(C) , $f = \frac{v}{2(\ell/2)}, \frac{2v}{2(\ell/2)}$

cannot match with f_{wire}

(D)  $f = \frac{v}{4(\ell/2)}, \frac{3v}{4(\ell/2)}$ .....

cannot match with f_{wire}

18. (A)

Sol. For first resonance with 400 Hz tuning fork

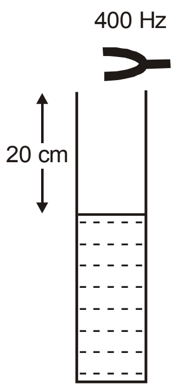
$$\ell_{eq} = \frac{V}{4f_0} = \frac{V}{4(400)} = (19 + 1) = 20 \text{ cm}$$

If we use 1600 Hz tuning fork

$$\frac{V}{4f_0} = \frac{V}{4 \times (1600)} = \frac{20}{4} = 5 \text{ cm}$$

for Resonance

$$\ell_{eq} = \frac{V}{4f_0}, \frac{3V}{4f_0}, \frac{5V}{4f_0}, \frac{7V}{4f_0}, \ldots$$



1 cm + ℓ = 5 cm , 15 cm , 25 cm , 35 cm , 45 cm .....

ℓ = 4 cm , 14 cm , 24 cm , 34 cm , 44 cm .....

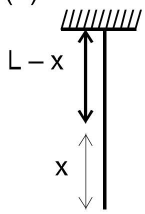
water level should be further lowered by

24 – 19 = 5 cm

34 – 19 = 15 cm

19. (B)

Sol.



For the pulse :

$$V = \sqrt{\frac{\mu x g}{\mu}} = \sqrt{xg} = \frac{dx}{dt}$$

$$\frac{dx}{dt} = \sqrt{xg} \Rightarrow \int_0^x \frac{dx}{\sqrt{x}} = \sqrt{g}\int_0^t dt$$

$$t = 2\sqrt{\frac{x}{g}} \quad \text{———(1)}$$

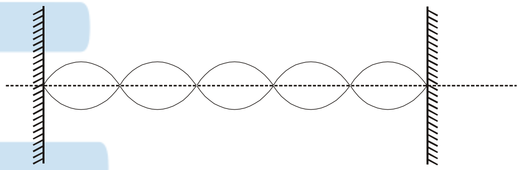
for the particle $L - x = \frac{1}{2}gt^2$

$$t = \sqrt{\frac{2(L-x)}{g}} \quad \text{———(2)}$$

1 = 2 $\Rightarrow$ $\therefore x = \frac{L}{3}$ from the bottom

20. (C)

Sol. There are 5 complete loops.



Total number of nodes = 6

(B) $\omega = 628 \text{ sec}^{-1}$

$k = 62.8 \text{ m}^{-1} = \frac{2\pi}{\lambda} \Rightarrow \lambda = \frac{1}{10}$

$v_w = \frac{\omega}{k} = \frac{628}{62.8} = 10 \text{ ms}^{-1}$ $L = \frac{5\lambda}{2} = 0.25$

(C) 2A = 0.01 = maximum amplitude of antinode

(D) $f = \frac{v}{2\ell} = \frac{10}{2 \times 0.25} = 20$ Hz.

21. 7

Sol. The number of beats will be the difference of frequencies of the two strings.

Frequency of first string $f_1 = \frac{1}{2\ell_1}\sqrt{\frac{T}{m}}$

$$= \frac{1}{2 \times 51.6 \times 10^{-2}}\sqrt{\frac{20}{10^{-3}}} = 137.03 \text{ Hz}$$

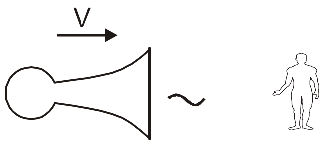
Similarly , frequency of second string

$$\frac{1}{2 \times 49.1 \times 10^{-2}}\sqrt{\frac{20}{10^{-3}}} = 144.01$$

Number of beats = $f_2 - f_1$ = 144 –137 = 7 beats

22. 15

Sol. $f' = f \dfrac{C}{C - V}$



$10000 = 9500 \times \dfrac{300}{300 - V}$

$300 - V = 3 \times 95$

$V = 15$ m/s **Ans**

23. 98

Sol. Motor cycle has travelled a distance s. Its velocity at that point

$v = \sqrt{2as}$

The observed frequency $f' = f \dfrac{330 - v}{330}$

$\Rightarrow \quad 0.94 = \dfrac{330 - v}{330}$

$\Rightarrow \quad v = 0.06 \times 330$ m/s

$= 19.8$ m/s

$s = \dfrac{v^2}{2a} = \dfrac{19.8^2}{2 \times 2} = 9.9^2 = 98$ m

24. 10

Sol. $\dfrac{P}{4\pi r^2} = I$ for an isotropic point sound source.

$\Rightarrow \quad P = I.4\pi r^2$

$= \quad (0.008 \text{ w/m}^2)(4.\pi.10^2) = 10.048$

$\cong \quad 10$ watt. **Ans.**

25. 600

Sol. The frequency is a characteristic of source. It is independent of the medium.

26. 1

Sol. $f = \dfrac{1}{2\ell}\sqrt{\dfrac{T}{\rho A}} \quad \therefore \dfrac{f_1}{f_2} = \dfrac{\dfrac{1}{2L}\sqrt{\dfrac{T}{\rho}\pi 4r^2}}{\dfrac{1}{4L}\sqrt{\dfrac{T}{\rho \pi r^2}}} = \dfrac{1}{1} = 1$

27. 1000

Sol. **Key Ideal :** The standard wave equation is

$y = a \sin(\omega t - kx)$

The given wave equation is

$y = a \sin\left(100t - \dfrac{x}{10}\right)$

Compare it with the standard wave equation, we obtain

$\omega = 100,\ k = \dfrac{1}{10}$

Velocity of the wave,

$v = \dfrac{\omega}{k} = \dfrac{100}{\dfrac{1}{10}} = 100 \times 10 = 1000$ m/s

28. 214

Sol. $V = \sqrt{\dfrac{T}{\mu}} = \sqrt{\dfrac{4.5 \times 10^7}{0.05}}$

$\dfrac{n}{2\ell}\sqrt{\dfrac{4.5 \times 10^7}{0.05}} = 420 \qquad \text{———(1)}$

$\dfrac{n+1}{2\ell}\sqrt{\dfrac{4.5 \times 10^7}{0.05}} = 490 \qquad \text{———(2)}$

$1 \div 2 \Rightarrow \dfrac{n}{n+1} = \dfrac{6}{7} \Rightarrow n = 6$

Put n in (1) $\quad \therefore \dfrac{6}{2\ell}\, 3 \times 10^2 = 420$

$\ell = \dfrac{30000}{140} \qquad \ell = \dfrac{1500}{7} = 214$ cm

29. 12

Sol. $\dfrac{\lambda_n}{2} = 6$ cm $\Rightarrow \dfrac{2L}{2n} = 6$

$\Rightarrow \quad n = \dfrac{L}{6}$

$\dfrac{\lambda_{n+1}}{2} = 4$ cm $\Rightarrow \dfrac{2L}{2(n+1)} = 4$

$\Rightarrow \quad n+1 = \dfrac{L}{4}$

$\Rightarrow \quad \dfrac{L}{4} - \dfrac{L}{6} = 1 \quad \Rightarrow \quad L = 12$ cm

30. 125

Sol. Length of BC to AC is $\dfrac{20}{80} = \dfrac{1}{4}$

So, value of loops in BC to AC will also be 1 : 4

So, of vibration will be

$f_1 = \dfrac{1}{4(0.2)}\sqrt{\dfrac{T}{\mu}} = 125$ Hz

$f_2 = \dfrac{3}{4(0.2)}\sqrt{\dfrac{T}{\mu}} = 275$ Hz.