Waves JEE Main PYQ - 3

Total Time: 1 Hour : 15 Minute **Total Marks:** 120

Instructions

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1. Test will auto submit when the Time is up.
2. The Test comprises of multiple choice questions (MCQ) with one or more correct answers.
3. The clock in the top right corner will display the remaining time available for you to complete the examination.

Navigating & Answering a Question

1. The answer will be saved automatically upon clicking on an option amongst the given choices of answer.
2. To deselect your chosen answer, click on the clear response button.
3. The marking scheme will be displayed for each question on the top right corner of the test window.

Waves

1. Let K_1 and K_2 be the maximum kinetic energies of photo-electrons emitted when two monochromatic beams of wavelength λ_1 and λ_2, respectively are incident on a metallic surface. If $\lambda_1 = 3\lambda_2$ then: **(+4, -1)**

a. $K_1 > \frac{K_2}{3}$

b. $K_1 < \frac{K_2}{3}$

c. $K_1 = \frac{K_2}{3}$

d. $K_2 <= \frac{K_1}{3}$

---

2. Match List-I with List-II List-I List-II **(+4, -1)**

Lis I		List II	
a.	Ultraviolet rays	i.	Study crystal structure
b.	Microwaves	ii.	Greenhouse effect
c.	Infrared waves	iii.	Sterilizing surgical instrument
d.	X-rays	iv	Radar system

Choose the correct answer from the options given below :

a. (a)-(iii), (b)-(iv), (c)-(ii), (d)-(i)

b. (a)-(iii), (b)-(i), (c)-(ii), (d)-(iv)

c. (a)-(iv), (b)-(iii), (c)-(ii), (d)-(i)

d. (a)-(iii), (b)-(iv), (c)-(i), (d)-(ii)

---

3. In the wave equation $y = 05 \sin \frac{2\pi}{\lambda}(400t - x)m$ the velocity of the wave will be : **(+4, -1)**

a. $200m/s$

b. $200\sqrt{2}m/s$

c. $400 m/s$

d. $400\sqrt{2} m/s$

---

4. A person driving car at a constant speed of 15 m/s is approaching a vertical wall. The person notices a change of 40 Hz in the frequency of his car's horn upon reflection from the wall. The frequency of horn is ____ Hz. **(+4, -1)**

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5. A train blowing a whistle of frequency $320 Hz$ approaches an observer standing on the platform at a speed of $66 m/s$ .The frequency observed by the observer will be ____ Hz,
(Given speed of sound $= 330 ms^{-}$ 1) **(+4, -1)**

---

6. The distance between two consecutive points with phase difference of 60° in a wave of frequency $500\, Hz$ is $60\, m$ The velocity with which wave is traveling is ___ km/s **(+4, -1)**

---

7. **The displacement equations of two interfering waves are given by** **(+4, -1)**
$y_1 = 10 \sin\left(\omega t + \frac{\pi}{3}\right)$ **cm ,**
$y_2 = 5[\sin \omega t + \sqrt{3} \cos \omega t]$ **cm respectively.**
The amplitude of the resultant wave is ___ cm

---

8. A travelling wave is described by the equation $y(x, t) = [0.05 \sin(8x - 4t)]m$ The velocity of the wave is : [all the quantities are in SI unit] **(+4, -1)**

a. $4\, ms^{-1}$

b. $8\, ms^{-1}$

c. $0.5\, ms^{-1}$

d. $2\, ms^{-1}$

---

9. **Given below are two statements :** **(+4, -1)**
Statement I : For transmitting a signal, size of antenna (f) should be comparable to wavelength of signal (at least $l = \frac{\lambda}{4}$ in dimension)
Statement II : In amplitude modulation, amplitude of carrier wave remains

constant (unchanged)
In the light of the above statements, choose the most appropriate answer from the options given below,

a. Statement I is correct but Statement II is incorrect

b. Both Statement I and Statement II are incorrect

c. Both Statement I and Statement II are correct

d. Statement I is incorrect but Statement II is correct

---

10. For a solid rod, the Young's modulus of elasticity is $32 \times 10^{11} Nm^{-2}$ and density is $8 \times 10^{3} kgm^{-3}$ The velocity of longitudinal wave in the rod will be (+4, -1)

a. $3.65 \times 10^{3} ms^{-1}$

b. $18.96 \times 10^{3} ms^{-1}$

c. $145.75 \times 10^{3} ms^{-1}$

d. $6.32 \times 10^{3} ms^{-1}$

---

11. The amplitude of $15 \sin(1000\pi t)$ is modulated by $10 \sin(4\pi t)$ signal The amplitude modulated signal contains frequency (ies) of (+4, -1)

A $500\ Hz$
B $2\ Hz$
C $250\ Hz$
D $498\ Hz$
E $502\ Hz$
Choose the correct answer from the options given below:

a. B Only

b. A and B Only

c. A, D and E Only

d. A Only

---

12. A steel wire with mass per unit length $70 \times 10^{-3} kg\, m^{-1}$ is under tension of $70\, N$. The speed of transverse waves in the wire will be: **(+4, -1)**

a. $10\, m/s$

b. $100\, m/s$

c. $200\, \pi m/s$

d. $50\, m/s$

---

13. A wave on a string is described by (,) = 0 . 005 sin (6 . 28 - 314) in which all quantities are in SI units. It's wavelength is _____. **(+4, -1)**

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14. What should be the length of a half-wave dipole antenna for a carrier wave having frequency 3×10^8 Hz? **(+4, -1)**

a. (A) 0.5 m

b. (B) 5 m

c. (C) 1 m

d. (D) 0.1 m

---

15. The total length of a sonometer wire between fixed ends is $110\, cm$. Two bridges are placed to divide the length of wire in ratio $6 : 3 : 2$. The tension in the wire is $400\, N$ and the mass per unit length is $0.01\, kg/m$. What is the minimum common frequency with which three parts can vibrate ? **(+4, -1)**

a. 1100 Hz

b. 1000 Hz

c. 166 Hz

d. 100 Hz

16. A sonometer wire of length $114\,cm$ is fixed at both the ends. Where should the two bridges be placed so as to divide the wire into three segments whose fundamental frequencies are in the ratio $1:3:4$? **(+4, -1)**

a. At 36 cm and 84 cm from one end

b. At 24 cm and 72 cm from one end

c. At 48 cm and 96 cm from one end

d. At 72 cm and 96 cm from one end

---

17. A granite rod of $60\,cm$ length is clamped at its middle point and is set into longitudinal vibrations. The density of granite is $2.7 \times 10^3\,kg/m^3$ and its Young's modules is $9.27 \times 10^{10}\,Pa$. What will be the fundamental frequency of the longitudinal vibrations ? **(+4, -1)**

a. 5 kHz

b. 2.5 kHz

c. 10 kHz

d. 7.5 kHz

---

18. Equation of travelling wave on a stretched string of linear density $5\,g/m$ is $y = 0.03\,sin(450\,t - 9x)$ where distance and time are measured is SI units. The tension in the string is : **(+4, -1)**

a. 10 N

b. 12.5 N

c. 7.5 N

d. 5 N

---

19. An engine approaches a hill with a constant speed. When it is at a distance of $0.9\,km$, it blows a whistle whose echo is heard by the driver after 5 seconds. If the speed of sound in air is $330\,m/s$, then the speed of the engine is : **(+4, -1)**

a. 32 m/s

b. 27.5 m/s

c. 60 m/s

d. 30 m/s

---

20. A tuning fork vibrates with frequency $256\,Hz$ and gives one beat per second with the third normal mode of vibration of an open pipe. What is the length of the pipe ? (Speed of sound in air is $340\,ms^{-1}$) **(+4, -1)**

a. 220 cm

b. 190 cm

c. 180 cm

d. 200 cm

---

21. A tuning fork of frequency $480\,Hz$ is used in an experiment for measuring speed of sound (n) in air by resonance tube method. Resonance is observed to occur at two successive lengths of the air column, l_1 = 30 cm and l_2 = $70\,cm$. Then, v is equal to : **(+4, -1)**

a. $332\,ms^{-1}$

b. $379\,ms^{-1}$

c. $384\,ms^{-1}$

d. $338\,ms^{-1}$

---

22. A travelling harmonic wave is represented by the equation $y(x,t) = 10^{-3}sin(50t + 2x)$, where x and y are in meter and t is in seconds. Which of the following is a correct statement about the wave? The wave is propagating along the **(+4, -1)**

a. negative x-axis with speed $25\,ms^{-1}$

b. The wave is propagating along the positive x-axis with speed $25\,ms^{-1}$

c. The wave is propagating along the positive x-axis with speed $100\,ms^{-1}$

d. The wave is propagating along the negative x-axis with speed $100\,ms^{-1}$

---

23. A transverse wave is represented by : $y = \frac{10}{\pi}\sin\left(\frac{2\pi}{T}t - \frac{2\pi}{\lambda}x\right)$ For what value of the wavelength the wave velocity is twice the maximum particle velocity ? **(+4, -1)**

a. 40 cm

b. 20 cm

c. 10 cm

d. 60 cm

---

24. A train is moving on a straight track with speed $20\,ms^{-1}$. It is blowing its whistle at the frequency of $1000\,Hz$. The percentage change in the frequency heard by a person standing near the track as the train passes him is close to (speed of sound $= 320\,ms^{-1}$) **(+4, -1)**

a. 12%

b. 6%

c. 18%

d. 24%

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25. A toy-car, blowing its horn, is moving with a steady speed of $5\,m/s$, away from a wall. An observer, towards whom the toy car is moving, is able to **(+4, -1)**

hear 5 beats per second. If the velocity of sound in air is $340\,m/s$, the frequency of the horn of the toy car is close to :

a. 680 Hz

b. 510 Hz

c. 340 Hz

d. 170 Hz

---

26. A string of length $1\,m$ and mass $5\,g$ is fixed at both ends. The tension in the string is $8.0\,N$. The siring is set into vibration using an external vibrator of frequency $100\,Hz$. The separation between successive nodes on the string is close to : **(+4, -1)**

a. 16.6 cm

b. 20.0 cm

c. 10.0 cm

d. 33.3 cm

---

27. A uniform string of length $20\,m$ is suspended from a rigid support. A short wave pulse is introduced at its lowest end. It starts moving up the string. The time taken to reach the support is : (take $g = 10\,ms^{-2}$) **(+4, -1)**

a. $2\pi\sqrt{2}s$

b. $2s$

c. $2\sqrt{2}s$

d. $\sqrt{2}s$

---

28. Two factories are sounding their sirens at $800\,Hz$. A man goes from one factory to other at a speed of $2\,m/s$. The velocity of sound is $320\,m/s$. The number of beats heard by the person in one second will be : **(+4, -1)**

a. 2

b. 4

c. 8

d. 10

---

29. A wire of length L and mass per unit length $6.0 \times 10^{-3}\, kgm^{-1}$ is put under tension of $540\, N$. Two consecutive frequencies that it resonates at are: $420\, Hz$ and $490\, Hz$. Then L in meters is : **(+4, -1)**

a. $8.1\, m$

b. $2.1\, m$

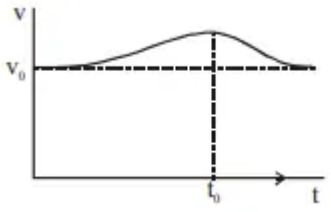
c. $1.1\, m$

d. $5.1\, m$

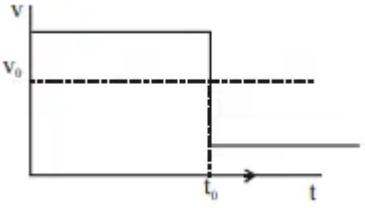
---

30. A sound source S is moving along a straight track with speed v, and is emitting sound of frequency v_0 (see figure). An observer is standing at a finite distance, at the point O, from the track. The time variation of frequency heard by the observer is best represented by : **(+4, -1)**
(t_0 represents the instant when the distance between the source and observer is minimum)

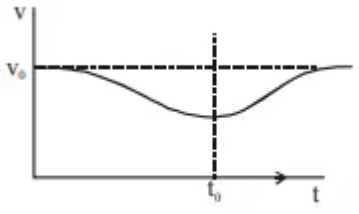
a.



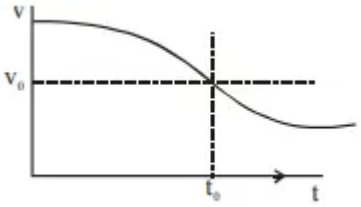
b.



c.



d.



Answers

1. **Answer: b**

Explanation:

$K_1 = \frac{hc}{\lambda_1} - \Phi = \frac{hc}{3\lambda_2} - \Phi$....(i)
and
$K_2 = \frac{hc}{\lambda_2} - \Phi$....(ii)
from (i) and (ii) we can say
$3K_1 = K_2 - 2\varphi$
$K1 < \frac{K2}{3}$

Concepts:

1. Waves:

Waves are a disturbance through which the energy travels from one point to another. Most acquainted are surface waves that tour on the water, but sound, mild, and the movement of subatomic particles all exhibit wavelike properties. inside the most effective waves, the disturbance oscillates periodically (see periodic movement) with a set frequency and wavelength.

Types of Waves:

Transverse Waves -

Waves in which the medium moves at right angles to the direction of the wave.

Examples of transverse waves:

- Water waves (ripples of gravity waves, not sound through water)
- Light waves
- S-wave earthquake waves
- Stringed instruments
- Torsion wave

The high point of a transverse wave is a crest. The low part is a trough.

Longitudinal Wave -

A longitudinal wave has the movement of the particles in the medium in the same dimension as the direction of movement of the wave.

Examples of longitudinal waves:

- Sound waves
- P-type earthquake waves
- Compression wave

---

2. **Answer: a**

Explanation:

i. UV rays are used to sterilize surgical material.
ii. Microwaves are used in radar system
iii. Infrared are used for green house effect
iv. X-rays are used to study crystal structure.

Hence, the correct option is (A) : (a)-(iii), (b)-(iv), (c)-(ii), (d)-(i)

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3. **Answer: c**

Explanation:

From the given options the correct answer is option (C): 400 m/s.

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---

4. Answer: 420 - 420

Explanation:

$f = f_0(\frac{V+V_c}{V-V_c})$
$f = f_0(\frac{330+15}{330-15})$
$f = f_0\frac{345}{315}$
$f - f_0 = 40$
$f_0(\frac{345-315}{315}) = 40$
$f_0 = \frac{40\times315}{30}$
$f_0 = 420Hz$

So, the answer is $420\ Hz$

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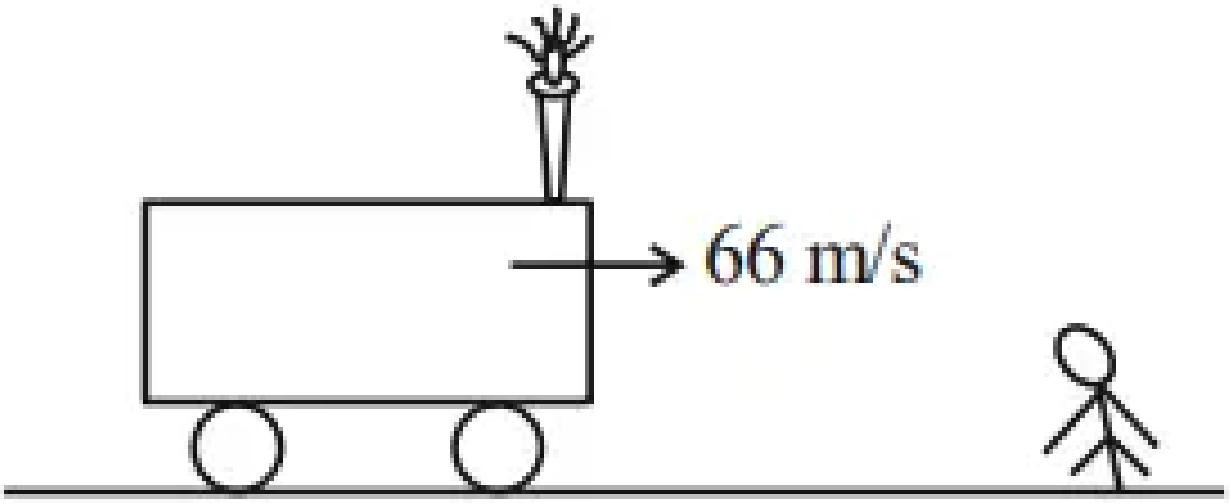
5. **Answer: 400 - 400**

Explanation:

The correct answer is 400



$f_{app} = f\left(\frac{v}{v-v_s}\right)$
$= 320(\frac{330}{330-66})$
$= 400Hz$

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---

6. Answer: 18 - 18

Explanation:

1. The phase difference is given by:

$$\Delta\phi = k\Delta x,$$

where $k = \frac{2\pi}{\lambda}$ is the wave number.
2. Substituting $\Delta\phi = \frac{\pi}{3}$ and $\Delta x = 6\,\text{m}$:

$$\frac{\pi}{3} = \frac{2\pi}{\lambda} \cdot 6.$$

Simplify:

$$\lambda = 36\,\text{m}.$$

3. The wave velocity is:

$$v = \lambda f = 36 \cdot 500 = 18000\,\text{m/s} = 18\,\text{km/s}.$$

Thus, the velocity is **18 km/s**. Wave velocity depends on the wavelength and frequency. Use the relation $v = \lambda f$ to calculate the speed of propagation.

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7. Answer: 20 - 20

Explanation:

The resultant displacement y is the sum of y_1 and y_2. We can write y_2 in a simplified form:

$$y_2 = 5\sin(\omega t) + 5\sqrt{3}\cos(\omega t)$$

Now, we can find the resultant amplitude using the formula for the amplitude of two interfering waves:

$$A_{\text{result}} = \sqrt{A_1^2 + A_2^2 + 2A_1A_2\cos(\phi_1 - \phi_2)}$$

where $A_1 = 10\,\text{cm}$ and $A_2 = 5\,\text{cm}$. The phase difference is $\frac{\pi}{3}$. After calculating, the amplitude is found to be 20 cm.

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8. **Answer: c**

Explanation:

The general equation of a wave is given by:

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

where $k = 8\,\mathrm{m}^{-1}$ and $\omega = 4\,\mathrm{rad/s}$. The velocity of the wave is:

$$v = \frac{\omega}{k} = \frac{4}{8} = 0.5\,\mathrm{ms}^{-1}$$

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9. **Answer: a**

Explanation:

Statement I: The size of the antenna for efficient signal transmission should be comparable to the wavelength of the signal. Specifically, for effective resonance, the length of the antenna is ideally $\frac{\lambda}{4}$, where λ is the wavelength of the signal.
Hence, **Statement I is correct**.

Statement II: In amplitude modulation (AM), the amplitude of the carrier wave changes depending on the information signal, while the frequency and phase remain constant. Therefore, **Statement II is incorrect**.

Thus, the correct answer is that Statement I is correct, while Statement II is incorrect.

Concepts:

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---

10. **Answer: d**

Explanation:

The velocity of longitudinal wave in the rod will be :

$v = \sqrt{\frac{3.2\times10^{11}}{8\times10^{3}}}$

= $6.32 \times 10^{3}\ m/s$

The Correct Option is (D) $6.32 \times 10^{3}\ ms^{-1}$

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---

11. Answer: c

Explanation:

Carrier wave frequency

$V_C = \frac{100\pi}{2\pi} = 500\ Hz$

Modulating wave frequency

$V_m = \frac{4\pi}{2\pi} = 2\ Hz$

$\therefore V_C - V_m, V_c, V_c + V_m$

$= 498\ Hz, 500\ Hz, 502\ Hz$

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---

12. **Answer: b**

Explanation:

$$v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{70}{70 \times 10^{-3}}} = 100 m/s$$

Concepts:

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Longitudinal Wave -

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- Compression wave

---

13. Answer: 1 - 1

Explanation:

Explanation:
Given:
The wave on a string is described by
$(,) = 0.005\sin(6.28 - 314)$...(i)
Displacement of a general plane progressive wave is given as
$(,) = \sin(-)$....(ii)
where,
$= \frac{2}{}$, wave number and $= \frac{2}{}$, angular frequency
Substituting the values in eq. (ii), we get
$(,) = \sin(\frac{2}{} - \frac{2}{})$...(iii)
Comparing eqs. (i), (ii) and (iii), we get
$= 0.005$
$= 6.28 = \frac{2}{}$
$= \frac{2}{6.28}$
$= \frac{2\times3.14}{6.28} = \frac{6.28}{6.28} = 1$m
Hence, the correct answer is 1.

---

14. Answer: a

Explanation:

Explanation:
Given:Frequency of the carrier wave $= 3\times10^{8}$ HzWe have to find the length of a half-wave dipole antenna.Let be the length of the half-wave dipole antenna. Then $= \frac{}{2}$
$= \frac{}{2}$ Using [=] $= \frac{3\times10^{8}}{2\times3\times10^{8}} = 0.5$ mHence, the correct option is (A).

---

15. **Answer: b**

Explanation:

$\ell_1 : \ell_2 : \ell_3 = 6 : 3 : 2$ so $\ell_1 = 60\,cm$ $\ell_2 = 30\,cm$ $\ell_3 = 20\,cm$ $60, 30, 20$ $\frac{\lambda}{2} = 10\,cm$ $f = \frac{200}{2} = 1000\,Hz$

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---

16. Answer: d

Explanation:

Total length of the wire, $L = 114\,cm$ $n_2 : n_2 : n_3 = 1 : 3 : 4$ Let L_1, L_2 and L_3 be the lengths of the three As $n \propto \frac{1}{L}$ $\therefore L_1 : L_2 : L_3 = \frac{1}{1} : \frac{1}{3} : \frac{1}{4} = 12 : 4 : 3$ $\therefore L_1 = 72\,cm\,\left(\frac{12}{12+4+3} \times 114\right)$ $L_2 = 24\,cm\,\left(\frac{4}{19} \times 114\right)$ and $L_3 = 18\,cm\,\left(\frac{3}{19} \times 114\right)$ Hence the bridges should be placed at $72\,cm$ and $72 + 24 = 96\,cm$ from one end. parts

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---

17. **Answer: a**

Explanation:

$$f_0 = \frac{V}{2L} = \frac{1}{2L}\sqrt{\frac{Y}{\rho}} = \frac{1}{2\times 0.6}\sqrt{\frac{9.27\times 10^{10}}{2.7\times 10^{3}}} = 4.88\,kHz \approx 5\,kHz$$

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18. Answer: b

Explanation:

$$y = 0.03 \sin(450t - 9x)$$
$$v = \frac{\omega}{k} = \frac{450}{9} = 50 m/s$$
$$v = \sqrt{\frac{T}{\mu}} \Rightarrow \frac{T}{\mu} = 2500$$
$$\Rightarrow T = 2500 \times 5 \times 10^{-3}$$
$$= 12.5\ N$$

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19. Answer: d

Explanation:

Let after 5 sec engine at point C

$t = \frac{AB}{330} + \frac{BC}{330}$

$5 = \frac{0.9 \times 1000}{330} + \frac{BC}{330}$

$\therefore BC = 750\,m$

Distance travelled by engine in 5\, sec

$= 900\,m - 750\,m = 150\,m$

Therefore velocity of engine

$= \frac{150m}{5sec} = 30\,m/s$

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20. **Answer: d**

Explanation:

Given: Frequency of tuning fork $= 256Hz$.
It gives one beat per second with the third normal mode of vibration of an open pipe.

Therefore, frequency of open pipe $= (256 + 1)Hz$
Speed of sound in air is $340 m/s$.
Now we know, frequency of third normal mode of vibration of an open pipe is given as
$f = \frac{3v_{\text{sound}}}{2l}$
$\Rightarrow \frac{3\times340}{2l} = 255$
$\Rightarrow l = \frac{3\times340}{2\times255} = 2\,m = 200\,cm$

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21. Answer: c

Explanation:

$$v = 2f(l_2 - l_1)$$
$$v = 2 \times 480 \times (70 - 30) \times 10^{-2}$$
$$v = 960 \times 40 \times 10^{-2}$$
$$v = 38400 \times 10^{-2} m/s$$
$$v = 384\, m/s$$

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22. Answer: a

Explanation:

$y = a\ \sin(\omega t + kx)$
$\Rightarrow$ wave is moving along $-ve$ x-axis with speed
$v = \frac{\omega}{K} \Rightarrow v = \frac{50}{2} = 25m/\sec$

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23. Answer: a

Explanation:

$V = 2\,(V_p)_{max}$
$\because V = f\lambda$
$f\lambda = 2\omega A$
$\lambda = 4\pi A$
$= 4\pi \times \frac{10}{\pi}$
$= 40\,cm$

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---

24. Answer: a

Explanation:

$f_1 = 1000\left(\frac{320}{300-20}\right) = 1066\,Hz$
$f_2 = 1000\left(\frac{320}{300+20}\right) = 941\,Hz$
$\therefore$ Change is $\simeq 12\%$

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---

25. **Answer: d**

Explanation:

$F_{\text{dir}} = \left(\frac{340}{340-5}\right) f$
$f_{\text{ind}} = \left(\frac{340}{340+5}\right) f$
$f_{\text{ind}} - f_{\text{dir}} = 5$
$\left\{\left(\frac{340}{340+5}\right)\left(\frac{340}{340+5}\right)\right\} f = 5$
$340\left\{\frac{10}{(300-5)(340+5)}\right\} = 5$
$f = \frac{340\times 5}{10}$
$f = 170\, Hz$

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---

26. Answer: b

Explanation:

Velocity of wave on string
$V = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{8}{5} \times 1000} = 40 m/s$
Now, wavelength of wave $\lambda = \frac{v}{n} = \frac{40}{100} m$
Separation b/w successive nodes, $\frac{\lambda}{2} = \frac{20}{100} m$
$= 20\, cm$

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---

27. Answer: c

Explanation:

$\frac{dy}{dt} = \sqrt{\frac{gy\rho A}{\mu}}$
$\frac{dy}{dt} = \int \sqrt{gy}$
$\int \frac{dy}{\sqrt{y}} = \sqrt{g}dt$
$\frac{y^{-\frac{1}{2}+1}}{-\frac{1}{2}+1}|_0^l = \sqrt{g}t|_0^t$
$t = 2\sqrt{\frac{20}{10}} = 2\sqrt{2}\,\text{sec}$

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28. Answer: d

Explanation:

Number of beats, b is

$b = \frac{2V_o n}{V_s}$

$= \frac{2\times2\times800}{320} = 10$

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29. Answer: b

Explanation:

$\frac{nv}{2\ell} = 420$
$\frac{(n+1)v}{2\ell} = 490$
$\frac{v}{2\ell} = 70$
$\ell = \frac{v}{140} = \frac{1}{140}\sqrt{\frac{540}{6\times10^{-3}}} = \frac{1}{140}\sqrt{90 \times 10^3}$
$\ell = \frac{300}{140} = 2.142$

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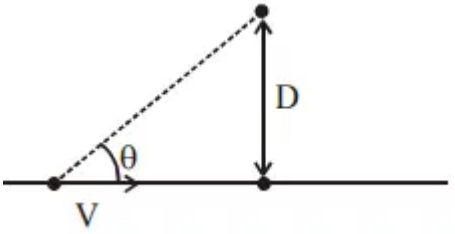
30. **Answer: d**

Explanation:



While approaching

$$\nu = \nu_0\left(\frac{c}{c-v\cos\theta}\right)$$

While receding

$$\nu = \nu_0\left(\frac{c}{c+v\cos\theta}\right)$$

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