Waves JEE Main PYQ - 2

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. A closed organ and an open organ tube filled by two different gases having the same bulk modulus but different densities ρ_1 and ρ_2, respectively. The frequency of the 9th harmonic of the closed tube is identical with the 4th harmonic of the open tube. If the length of the closed tube is 10 cm and the density ratio of the gases is $\rho_1 : \rho_2 = 1 : 16$, then the length of the open tube is: **(+4, -1)**

a. $\frac{20}{7}$ cm

b. $\frac{15}{7}$ cm

c. $\frac{20}{9}$ cm

d. $\frac{15}{9}$ cm

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2. A sonometer wire of resonating length 90 cm has a fundamental frequency of 400 Hz when kept under some tension. The resonating length of the wire with fundamental frequency of 600 Hz under same tension ________ cm. **(+4, -1)**

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3. A plane progressive wave is given by $y = 2\cos 2\pi(330t - x)\,\mathrm{m}$. The frequency of the wave is: **(+4, -1)**

a. 165 Hz

b. 330 Hz

c. 660 Hz

d. 340 Hz

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4. The equation of a stationary wave is: **(+4, -1)**

$$y = 2a\sin\left(\frac{2\pi nt}{\lambda}\right)\cos\left(\frac{2\pi x}{\lambda}\right)$$

Which of the following is NOT correct:

a. The dimensions of nt is $[L]$

b. The dimensions of n is $[LT^{-1}]$

c. The dimensions of n/λ is $[T]$

d. The dimensions of x is $[L]$

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5. Two waves of intensity ratio $1:9$ cross each other at a point. The resultant intensities at the point, when (a) Waves are incoherent is I_1 (b) Waves are coherent is I_2 and differ in phase by $60°$ If $\frac{I_1}{I_2} = \frac{10}{x}$ then $x =$ _____. **(+4, -1)**

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6. The fundamental frequency of a closed organ pipe is equal to the first overtone frequency of an open organ pipe. If length of the open pipe is 60 cm, the length of the closed pipe will be : **(+4, -1)**

a. 60 cm

b. 45 cm

c. 30 cm

d. 15 cm

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7. A closed organ pipe 150 cm long gives 7 beats per second with an open organ pipe of length 350 cm, both vibrating in fundamental mode. The velocity of sound is _________ m/s. **(+4, -1)**

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8. A beam of light consisting of two wavelengths 7000 Å and 5500 Å is used to obtain interference pattern in Young's double slit experiment. The distance between the slits is 2.5 mm and the distance between the plane of slits and the screen is 150 cm. The least distance from the central fringe, where the bright fringes due to both the wavelengths coincide, is n × 10^{-5} m. The value of n is_____. **(+4, -1)**

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9. Given below are two statement : one is labelled as Assertion A and the other is labelled as Reason R. **(+4, -1)**
Assertion A : EM waves used for optical communication have longer wavelengths than that of microwave, employed in Radar technology.
Reason R : Infrared EM waves are more energetic than microwaves, (used in Radar)
In the light of given statements, choose the correct answer from the options given below:

a. Both A and R true and R is the correct explanation of A

b. Both A and R true but R is NOT the correct explanation of A

c. A is true but R is false

d. A is false but R is true

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10. A proton and an α-particle are accelerated from rest by 2V and 4V potentials, respectively. The ratio of their de-Broglie wavelength is **(+4, -1)**

a. 2:1

b. 4:1

c. 8:1

d. 16:1

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11. A message signal of frequency 3kHz is used to modulate a carrier signal of frequency 1.5 MHz. The bandwidth of the amplitude modulated wave is **(+4, -1)**

a. 6 MHz

b. 3 MHz

c. 3 kHz

d. 6 kHz

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12. Given below are two statement : one is labelled as Assertion A and the other is labelled as Reason R. **(+4, -1)**
Assertion A : EM waves used for optical communication have longer wavelengths than that of microwave, employed in Radar technology.
Reason R : Infrared EM waves are more energetic than microwaves, (used in Radar)
In the light of given statements, choose the correct answer from the options given below:

a. Both A and R true and r is the correct explanation of A

b. Both A and R true but R is NOT the correct explanation of A

c. A is true but R is false

d. A is false but R is true

---

13. The difference between threshold wavelengths for two metal surfaces A and B having work function $\Phi_A = 9$ eV and $\Phi_B = 4.5$ eV in nm is: **(+4, -1)**
{Given, hc = 1242 eV nm}

a. 264

b. 540

c. 276

d. 138

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14. Given below are two statements: one is labelled as Assertion A and the other is labelled as Reason R **(+4, -1)**
Assertion A: The phase difference of two light waves change if they travel through different media having same thickness, but different indices of refraction.
Reason R: The wavelengths of waves are different in different media.
In the light of the above statements, choose the most appropriate answer from the options given below

a. Both A and R are correct and R is the correct explanation of A

b. Both A and R are correct but R is NOT the correct explanation of A

c. A is correct but R is not correct

d. A is not correct but R is correct

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15. A wave is given by the equation y= Asin{ π(330t-x) },then frequency of the wave is **(+4, -1)**

a. 330 Hz

b. 660 Hz

c. 165 Hz

d. $\frac{1}{330}$ Hz

16. The organ pipe having same length, one is open while the other is closed. Find ratio of 7th overtone of those organ pipes. (+4, -1)

a. $\frac{15}{16}$

b. $\frac{16}{15}$

c. $\frac{14}{15}$

d. $\frac{13}{14}$

17. A single slit of width a is illuminated by a monochromatic light of wavelength 600 nm. The value of 'a' for which first minimum appears at θ=30° on the screen will be : (+4, -1)

a. 0.6μm

b. 1.2μm

c. 1.8μm

d. 3μm

18. In an experiment with sonometer when a mass of 180 g is attached to the string, it vibrates with fundamental frequency of 30 Hz. When a mass m is attached, the string vibrates with fundamental frequency of 50 Hz. The value of m is ______g. (+4, -1)

19. A wire of density $8 \times 10^3 \ kg/m^3$ is stretched between two clamps 0.5 m apart. The extension developed in the wire is 3.2×10^{-4} m. If Y = $8 \times 10^{10} \ N/m^2$, the fundamental frequency of vibration in the wire will be ________Hz. (+4, -1)

20. If 917 Å be the lowest wavelength of Lyman series then the lowest wavelength of Balmer series will be _____ Å. **(+4, -1)**

21. A carrier wave of amplitude 15 V modulated by a sinusoidal base band signal of amplitude 3 V. The ratio of maximum amplitude to minimum amplitude in an amplitude modulated wave is **(+4, -1)**

a. $\frac{3}{2}$

b. 5

c. 1

d. 2

22. A guitar string of length 90 cm vibrates with a fundamental frequency of 120 Hz. The length of the string producing a fundamental frequency of 180 Hz will be _______ cm. **(+4, -1)**

23. The width of fringe is 2 mm on the screen in a double slits experiment for the light of wavelength of 400 nm. The width of the fringe for the light of wavelength 600 nm will be: **(+4, -1)**

a. 2mm

b. 3mm

c. 4mm

d. 1.33mm

24. **The power radiated from a linear antenna of length l is proportional to: (Given, λ = Wavelength of wave):** **(+4, -1)**

a. $\frac{l}{\lambda}$

b. $\frac{l}{\lambda^2}$

c. $\left(\frac{l}{\lambda}\right)^2$

d. $\frac{l^2}{\lambda}$

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25. The frequency of echo will be _______ Hz if the train blowing a whistle of frequency 320 Hz is moving with a velocity of 36 km/h towards a hill from which an echo is heard by the train driver. Velocity of sound in air is 330 m/s. **(+4, -1)**

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26. A wire of length 30 cm, stretched between rigid supports, has it's n^{th} and $(n+1)^{th}$ harmonics at 400 Hz and 450 Hz, respectively. If tension in the string is 2700 N, its linear mass density is _____ kg/m. **(+4, -1)**

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27. Two travelling waves of equal amplitudes and equal frequencies move in opposite directions along a string. They interfere to produce a stationary wave whose equation is given by $y = (10cos\ \pi x\ sin\frac{2\pi t}{T})$ cm. The amplitude of the particle at $x = \frac{4}{3}$ cm will be _______ cm. **(+4, -1)**

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28. A set of 20 tuning forks is arranged in a series of increasing frequencies. If each fork gives 4 beats with respect to the preceding fork and the frequency of the last fork is twice the frequency of the first, then the frequency of last fork is _______ Hz **(+4, -1)**

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

List - I		List - II	
A.	Television signal	i.	03 KHz
B.	Radio signal	ii.	20 KHz
C.	High Quality Music	iii.	02 MHz
D.	Human speech	iv.	06 MHz

Choose the correct answer from the options given below:

a. A-I, B-II, C-III, D-IV

b. A-IV, B-III, C-I, D-II

c. A-IV, B-III, C-II, D-I

d. A-I, B-II, C-IV, D-III

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30. A transverse wave is represented by $y = 2sin(\omega t – kx)\ cm$. The value of wavelength (in cm) for which the wave velocity becomes equal to the maximum particle velocity, will be **(+4, -1)**

a. 4π

b. 2π

c. π

d. 2

Answers

1. **Answer: c**

Explanation:

To solve this problem, we need to find the length of an open tube when the ninth harmonic of a closed tube matches the fourth harmonic of the open tube.

For a closed organ pipe (closed at one end), the formula for the frequency of the nth harmonic is:

$$f_n = \frac{nv_1}{4L_1}$$

where n is an odd integer, v_1 is the speed of sound in the gas inside the closed tube, and L_1 is the length of the closed tube.

For an open organ pipe, the formula for the frequency of the nth harmonic is:

$$f_n = \frac{nv_2}{2L_2}$$

where n is any integer, v_2 is the speed of sound in the gas inside the open tube, and L_2 is the length of the open tube.

Given: The ninth harmonic of the closed tube $(n = 9)$ matches the fourth harmonic of the open tube $(n = 4)$:

$$\frac{9v_1}{4\times10} = \frac{4v_2}{2L_2}$$

Simplifying that:

$$\frac{9v_1}{40} = \frac{4v_2}{2L_2}$$

$$\frac{9v_1}{40} = \frac{2v_2}{L_2}$$

$$L_2 = \frac{80v_2}{9v_1}$$

The speed of sound v in a medium is given by:

$$v = \sqrt{\frac{B}{\rho}}$$

where B is the bulk modulus, and ρ is the density of the gas. Given that the bulk modulus B is the same for both gases, the speed ratio is:

$$\frac{v_1}{v_2} = \sqrt{\frac{\rho_2}{\rho_1}}$$

Given the density ratio $\rho_1 : \rho_2 = 1 : 16$:

$$\frac{v_1}{v_2} = \sqrt{\frac{16}{1}} = 4$$

Substituting $\frac{v_1}{v_2} = 4$ into the equation for L_2:

$$L_2 = \frac{80 \times v_2}{9 \times 4 \times v_2} = \frac{80}{36} = \frac{20}{9}\,\text{cm}$$

Thus, the length of the open tube is $\frac{20}{9}\,\text{cm}$.

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2. **Answer: 60 - 60**

Explanation:

Given:
- Initial resonating length, $L = 90\,\text{cm}$
- Initial fundamental frequency, $f_0 = 400\,\text{Hz}$
- New fundamental frequency, $f' = 600\,\text{Hz}$

Step 1: Relation Between Frequency and Length
The fundamental frequency of a vibrating string is given by:

$$f_0 = \frac{v}{2L},$$

where:
- v is the wave speed,
- L is the length of the wire.
For the same tension, the wave speed v remains constant.

Step 2: Expressing New Length in Terms of Frequency
Let the new resonating length be L' for the frequency f'. The new fundamental frequency is given by:

$$f' = \frac{v}{2L'}.$$

Dividing the two equations:

$$\frac{f'}{f_0} = \frac{L}{L'}.$$

Rearranging to find L':

$$L' = L \times \frac{f_0}{f'}.$$

Step 3: Substituting the Given Values
Substituting the values:

$$L' = 90 \times \frac{400}{600}.$$

Simplifying:

$$L' = 90 \times \frac{2}{3} = 60\,\text{cm}.$$

Therefore, the new resonating length of the wire is $60\,\text{cm}$**.**

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3. **Answer: b**

Explanation:

To determine the frequency of the wave given by the equation $y = 2\cos 2\pi(330t - x)\,\mathrm{m}$, we need to analyze the equation and extract the relevant parameters of a wave.

The standard form of a plane progressive wave is:

$y = A\cos(2\pi ft - \frac{2\pi}{\lambda}x)$

Where:

- A is the amplitude of the wave.
- f is the frequency of the wave.
- λ is the wavelength of the wave.

Given the wave equation:

$y = 2\cos 2\pi(330t - x)\,\mathrm{m}$

By comparing this with the standard form, we can identify the term $2\pi ft$ in the given equation as $2\pi \times 330 \times t$. Hence, the frequency f is 330 Hz.

Therefore, the correct frequency of the wave is **330 Hz**.

This matches the given correct answer: **330 Hz**.

Thus, the correct option is **330 Hz**.

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4. **Answer: c**

Explanation:

Comparing the given equation with the standard equation for a standing wave:

$$\frac{2\pi nt}{\lambda} = \omega t, \quad \frac{2\pi x}{\lambda} = kx$$

where ω is the angular frequency and k is the wave number.

Analyzing the dimensions:

$$\left[\frac{n}{\lambda}\right] = [\omega] = [T^{-1}]$$

For the other terms:

$$[nt] = [\lambda] = [L], \quad [n] = [\lambda\omega] = [LT^{-1}], \quad [x] = [\lambda] = [L]$$

Conclusion:

Hence, the dimensions of n/λ are **[T]**.

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5. **Answer: 13 - 13**

Explanation:

For an incoherent wave:

The intensity I_1 is the sum of the individual intensities I_A and I_B:

$$I_1 = I_A + I_B \quad \Rightarrow \quad I_1 = I_0 + 9I_0 = 10I_0$$

For a coherent wave:

The intensity I_2 is given by the formula:

$$I_2 = I_A + I_B + 2\sqrt{I_A I_B}\cos(60^\circ)$$

Substituting the values and simplifying:

$$I_2 = I_0 + 9I_0 + 2\sqrt{I_0 I_0} \cdot \cos(60^\circ) = 13I_0$$

Finally, the ratio of the intensities I_1 and I_2 is:

$$\frac{I_1}{I_2} = \frac{10I_0}{13I_0} = \frac{10}{13}$$

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6. **Answer: d**

Explanation:

To solve this problem, we need to understand the relation between the frequencies of closed and open organ pipes.

1. The fundamental frequency of a closed organ pipe is given by $f_{\text{closed}} = \frac{v}{4L_{\text{closed}}}$ where v is the speed of sound in air and L_{closed} is the length of the closed pipe.
2. The first overtone (or second harmonic) frequency of an open organ pipe is $f_{\text{open}} = \frac{2v}{2L_{\text{open}}} = \frac{v}{L_{\text{open}}}$ where L_{open} is the length of the open pipe.
3. According to the problem statement, $f_{\text{closed}} = f_{\text{open}}$.
4. Plugging in the formulas into this equation, we have: $\frac{v}{4L_{\text{closed}}} = \frac{v}{L_{\text{open}}}$.
5. By cancelling v from both sides and solving for L_{closed}, we get: $4L_{\text{closed}} = L_{\text{open}}$ Which simplifies to: $L_{\text{closed}} = \frac{L_{\text{open}}}{4}$.
6. Given $L_{\text{open}} = 60 \text{ cm}$, plug this value into the equation: $L_{\text{closed}} = \frac{60}{4} = 15 \text{ cm}$.

Therefore, the length of the closed pipe is **15 cm**.

Hence, the correct answer is **15 cm**.

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7. Answer: 294 - 294

Explanation:

To find the velocity of sound using the given problem, we'll utilize the principles of sound waves in organ pipes. Since both pipes are in fundamental modes, we'll use the fundamental frequency formulas for open and closed pipes.

1. For a closed organ pipe:
   The fundamental frequency f_c is given by:
   $f_c = \frac{v}{4L_c}$
   where v is the velocity of sound, and $L_c = 150\,\text{cm} = 1.5\,\text{m}$ is the length of the closed pipe.
2. For an open organ pipe:
   The fundamental frequency f_o is given by:
   $f_o = \frac{v}{2L_o}$
   where $L_o = 350\,\text{cm} = 3.5\,\text{m}$ is the length of the open pipe.
3. Given the beat frequency is 7 beats per second:
   The beat frequency is the absolute difference between the two fundamental frequencies, $f_o - f_c = 7\,\text{Hz}$.
4. Express the equations for the frequencies:
   $f_c = \frac{v}{4 \times 1.5} = \frac{v}{6}$
   $f_o = \frac{v}{2 \times 3.5} = \frac{v}{7}$

5. Plug into the beat frequency equation:
   $\left|\frac{v}{7} - \frac{v}{6}\right| = 7$
6. Solve for v:
   $\left|\frac{6v-7v}{42}\right| = 7$
   $\left|\frac{-v}{42}\right| = 7$
   $\frac{v}{42} = 7$
   $v = 42 \times 7 = 294\,\mathrm{m/s}$

The calculated velocity of sound $v = 294\,\mathrm{m/s}$ is within the specified range (294, 294).

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8. Answer: 462 - 462

Explanation:

Let n_1 maxima of 7000 $\mathring{A}$ coincide with n_2 maxima of 5500 $\mathring{A}$. Therefore, $n_1\beta_1 = n_2\beta_2$,

$$\frac{n_1}{n_2} = \frac{\lambda_2}{\lambda_1} = \frac{5500}{7000} = \frac{11}{14}$$

Hence, the 11th maximum of 7000 $\mathring{A}$ coincides with the 14th maximum of 5500 $\mathring{A}$. To find the least distance from this,

$$y = n_1\beta_1 D/d$$

$$y = \frac{11 \times 7000 \times 10^{-10} \times 150 \times 10^{-2}}{2.5 \times 10^{-3}} = 462 \times 10^{-5}\,\mathrm{m}$$

Thus, $n = 462$

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9. Answer: d

Explanation:

The correct option is(D): A is false but R is true

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10. Answer: b

Explanation:

The correct option is(B): 4:1

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11. **Answer: d**

Explanation:

Step 1: Understanding the concept of bandwidth in amplitude modulation.
In Amplitude Modulation (AM), the bandwidth of the modulated signal is determined by the frequency of the message signal. The formula for the bandwidth of an AM signal is given by:

$$\text{Bandwidth of AM signal} = 2 \times f_{\text{message signal}}$$

Where $f_{\text{message signal}}$ is the frequency of the message signal being used to modulate the carrier wave. **Step 2: Applying the given values.**
From the problem, we are given that the message signal frequency is $f_{\text{message signal}} = 3\,\text{kHz}$. Now, using the formula for bandwidth:

$$\text{Bandwidth of AM signal} = 2 \times 3\,\text{kHz} = 6\,\text{kHz}$$

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12. **Answer: d**

Explanation:

Optical communication is performed in the frequency range of 1 THz to 1000 THz (from Microwave to UV). Therefore, the wavelength of EM waves used for optical communication is shorter than that of microwaves used in Radar. Hence, Assertion A is incorrect. On the other hand, Reason R is true because infrared waves have higher frequency and energy compared to microwaves. Thus, Assertion A is false but Reason R is true. Therefore, the correct answer is $\boxed{1}$.

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13. **Answer: d**

Explanation:

The threshold wavelength ($\lambda_{\text{threshold}}$) for a metal surface is related to its work function (ϕ) by the equation:

$$\lambda_{\text{threshold}} = \frac{hc}{\phi}$$

where:

- h is Planck's constant,
- c is the speed of light,
- ϕ is the work function of the metal.

Given:

$$hc = 1242\,\text{eV nm}$$

$$\phi_A = 9\,\text{eV}$$

$$\phi_B = 4.5\,\text{eV}$$

Step 1: Calculate Threshold Wavelengths for Both Metals

For Metal A:

$$\lambda_{\text{threshold},A} = \frac{1242\,\text{eV nm}}{9\,\text{eV}} = 138\,\text{nm}$$

For Metal B:

$$\lambda_{\text{threshold},B} = \frac{1242\,\text{eV nm}}{4.5\,\text{eV}} = 276\,\text{nm}$$

Step 2: Determine the Difference Between Threshold Wavelengths

$$\Delta\lambda = \lambda_{\text{threshold},B} - \lambda_{\text{threshold},A} = 276\,\text{nm} - 138\,\text{nm} = 138\,\text{nm}$$

Therefore, the difference between the threshold wavelengths for metal surfaces A and B is 138 nm, which corresponds to option (4).

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14. **Answer: a**

Explanation:

As we know the speed of light in a medium:

$$v = \frac{c}{\mu} \quad \text{or} \quad f\lambda = \frac{c}{\mu}$$

Therefore, $\lambda \propto \frac{1}{\mu}$.
When light travels through two different mediums, their phase difference will change:

$$\Delta Q = \frac{2\pi}{\lambda}$$

Thus, statement R is the correct explanation of A.

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15. **Answer: c**

Explanation:

The Correct answer is option is (C) : 165 Hz

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16. **Answer: b**

Explanation:

The Correct answer is option is (B) : $\frac{16}{15}$

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17. **Answer: b**

Explanation:

Understanding the Problem

We are given the condition for the first minimum in single-slit diffraction and need to find the slit width (a).

Solution

1. **Condition for First Minimum:**

The condition for the first minimum in single-slit diffraction is:

$a \sin\theta = \lambda$

where:

- a is the slit width
- θ is the angle of the minimum
- λ is the wavelength of light

2. **Substitute Values:**

Given $\theta = 30^\circ$ and $\lambda = 600\,\text{nm} = 600 \times 10^{-9}\,\text{m}$, we have:

$a \sin(30^\circ) = 600 \times 10^{-9}\,\text{m}$

3. **Solve for Slit Width (a):**

We know $\sin(30^\circ) = \frac{1}{2}$.

Substituting:

$a \left(\frac{1}{2}\right) = 600 \times 10^{-9}\,\text{m}$

Solving for a:

$a = 2 \times 600 \times 10^{-9}\,\text{m} = 1200 \times 10^{-9}\,\text{m}$

4. **Convert to Micrometers:**

$a = 1200\,\text{nm} = 1.2\,\mu\text{m}$

Final Answer

The slit width is $1.2\,\mu\text{m}$.

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18. Answer: 500 - 500

Explanation:

The fundamental frequency of a vibrating string is given by:

$$f = \frac{1}{2L}\sqrt{\frac{T}{\mu}},$$

where f is the frequency, L is the length of the string, T is the tension in the string, and μ is the linear mass density. The ratio of frequencies for the two cases is:

$$\frac{f_2}{f_1} = \sqrt{\frac{T_2}{T_1}},$$

where $T_1 = 180g$ and $T_2 = mg$. Substitute $f_2 = 50\,\text{Hz}$, $f_1 = 30\,\text{Hz}$:

$$\frac{50}{30} = \sqrt{\frac{mg}{180g}}.$$

Simplify:

$$\left(\frac{50}{30}\right)^2 = \frac{m}{180}.$$

$$\frac{25}{9} = \frac{m}{180}.$$

Solve for m:

$$m = \frac{25}{9} \cdot 180 = 500\,\text{g}.$$

Thus, the value of m is $\boxed{500\,\text{g}}$.

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19. **Answer: 80 - 80**

Explanation:

Step 1: Formula for Frequency

The frequency of a vibrating string is given by:

$$f = \frac{1}{2\ell}\sqrt{\frac{T}{\mu}},$$

where:

- ℓ: Length of the string
- T: Tension in the string
- μ: Linear mass density of the string.

Step 2: Substitute Tension in Terms of Young's Modulus

The tension T can be expressed in terms of Young's modulus (Y) as:

$$T = Y \cdot A \cdot \frac{\Delta \ell}{\ell},$$

where:

- Y: Young's modulus
- A: Cross-sectional area of the string
- $\Delta \ell$: Extension of the string
- ℓ: Original length of the string.

Substitute T into the frequency formula:

$$f = \frac{1}{2\ell}\sqrt{\frac{Y \cdot A \cdot \Delta \ell}{\ell \cdot \mu}}.$$

Step 3: Substitute the Given Values

Substitute the numerical values:

- $\ell = 0.5\,\mathrm{m}$
- $Y = 8 \times 10^{10}\,\mathrm{Pa}$
- $A = 3.2 \times 10^{-4}\,\mathrm{m}^2$
- $\mu = 8 \times 10^{-3}\,\mathrm{kg/m}$
- $\Delta \ell = 0.5\,\mathrm{m}.$

Substitute into the formula:

$$f = \frac{1}{2 \cdot 0.5}\sqrt{\frac{8 \times 10^{10} \cdot 3.2 \times 10^{-4} \cdot 0.5}{0.5 \cdot 8 \times 10^{-3}}}.$$

Step 4: Simplify the Expression

Simplify the terms inside the square root:

$$f = 1 \cdot \sqrt{\frac{8 \times 10^{10} \cdot 3.2 \times 10^{-4} \cdot 0.5}{4 \times 10^{-3}}}.$$

$$f = \sqrt{\frac{1.28 \times 10^{8}}{4 \times 10^{-3}}}.$$

$$f = \sqrt{3.2 \times 10^{10}}.$$

Simplify further:

$$f = 80\,\text{Hz}.$$

Final Answer:

The frequency of the vibrating string is $f = 80\,\text{Hz}$.

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20. Answer: 3668 - 3668

Explanation:

For the Lyman series, the lowest wavelength corresponds to the transition from $n = \infty$ to $n = 1$, and the wavelength is given as 917 Å.
For the Balmer series, the lowest wavelength corresponds to the transition from $n = \infty$ to $n = 2$.
The energy E_0 for the Lyman series is related to the wavelength λ_0 by:

$$E_0 = \frac{hc}{\lambda_0}$$

For Lyman, $\lambda_0 = 917\,\text{Å}$, so:

$$E_0 = \frac{hc}{917\,\text{Å}}$$

For the Balmer series, the energy is related by:

$$\frac{E_0}{4} = \frac{hc}{\lambda}$$

where λ is the wavelength of the Balmer series. Substituting the energy of the Lyman series:

$$\frac{hc}{4 \times 917\,\text{Å}} = \frac{hc}{\lambda}$$

Thus, the wavelength for the Balmer series is:

$$\lambda = 917 \times 4 = 3668\,\text{Å}$$

Therefore, the lowest wavelength of the Balmer series is 3668 Å.

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21. Answer: a

Explanation:

Calculation of Amplitude Modulation Parameters:

Step 1: Formula for Maximum and Minimum Amplitude

The maximum amplitude (A_{max}) and minimum amplitude (A_{min}) are given by:

- $A_{\text{max}} = A_c + A_m$
- $A_{\text{min}} = A_c - A_m$

Where:

- A_c: Carrier amplitude
- A_m: Modulating signal amplitude

Step 2: Substitute the Given Values

Given $A_c = 15\,\text{V}$ and $A_m = 3\,\text{V}$:

$$A_{\text{max}} = 15 + 3 = 18\,\text{V}$$

$$A_{\text{min}} = 15 - 3 = 12\,\text{V}$$

Step 3: Ratio of Maximum to Minimum Amplitude

The ratio is calculated as:

$$\frac{A_{\text{max}}}{A_{\text{min}}} = \frac{18}{12} = \frac{3}{2}$$

Conclusion:

The ratio of maximum amplitude to minimum amplitude is $\frac{3}{2}$.

---

22. **Answer: 60 - 60**

Explanation:

The fundamental frequency (f) of a vibrating string is given by:

$$f = \frac{v}{2L},$$

where: \item f is the frequency, \item v is the wave velocity, \item L is the length of the string.

Step 1: Relation between frequencies and lengths. For the initial string length (L) and frequency $(f_1 = 120\,\text{Hz})$:

$$f_1 = \frac{v}{2L}.$$

For the new string length (L') and frequency $(f_2 = 180\,\text{Hz})$:

$$f_2 = \frac{v}{2L'}.$$

Taking the ratio of the two frequencies:

$$\frac{f_2}{f_1} = \frac{L}{L'}.$$

Substitute $f_1 = 120\,\text{Hz}$ and $f_2 = 180\,\text{Hz}$:

$$\frac{180}{120} = \frac{L}{L'}.$$

Simplify:

$$\frac{3}{2} = \frac{L}{L'}.$$

Rearrange to solve for L':

$$L' = \frac{2}{3}L.$$

Step 2: Substitute the initial length. Given $L = 90\,\text{cm}$:

$$L' = \frac{2}{3} \cdot 90 = 60\,\text{cm}.$$

Final Answer: The new string length is:

$$\boxed{60\,\text{cm}}.$$

23. Answer: b

Explanation:

The fringe width (β) in a double-slit experiment is given by:

$$\beta = \frac{\lambda D}{d},$$

where: - λ is the wavelength of the light, - D is the distance between the slits and the screen, - d is the separation between the slits.

Step 1: Relation between fringe widths. Since D and d are constant, the fringe width β is directly proportional to λ:

$$\beta \propto \lambda.$$

Step 2: Calculate the new fringe width. Let the initial fringe width (β_1) correspond to $\lambda_1 = 400\,\text{nm}$ and the new fringe width (β_2) correspond to $\lambda_2 = 600\,\text{nm}$. Then:

$$\frac{\beta_2}{\beta_1} = \frac{\lambda_2}{\lambda_1}.$$

Substituting $\beta_1 = 2\,\text{mm}$, $\lambda_1 = 400\,\text{nm}$, and $\lambda_2 = 600\,\text{nm}$:

$$\frac{\beta_2}{2} = \frac{600}{400} \implies \beta_2 = 2 \cdot 1.5 = 3\,\text{mm}.$$

Final Answer: The fringe width for $\lambda = 600\,\text{nm}$ is:

$$\boxed{3\,\text{mm}}.$$

---

24. Answer: c

Explanation:

The power radiated by a linear antenna is proportional to the square of the current and the square of the antenna's length. Additionally, the radiated power depends inversely on the square of the wavelength of the electromagnetic wave. Thus, the proportionality relation is:

$$P \propto \left(\frac{l}{\lambda}\right)^2.$$

Final Answer: The power radiated from a linear antenna is proportional to:

$$\boxed{\left(\frac{l}{\lambda}\right)^2}.$$

---

25. Answer: 340 - 340

Explanation:

To solve this problem, we apply the Doppler effect formula for sound, which relates the observed frequency to the source frequency, taking into account the velocities of the source, observer, and the medium.

First, we convert the train's velocity into meters per second (m/s):

Velocity of train (v_s) = 36 km/h = 36 × (1000 m / 3600 s) = 10 m/s

The formula for the frequency of the echo heard by the train driver is given by:

$f_{echo} = f_0 \times [(v + v_0) / (v - v_s)]$

where:
f_0 = original frequency = 320 Hz,
v = speed of sound = 330 m/s,
v_0 = observer's velocity, since the train and observer are the same, $v_0 = v_s$ = 10 m/s,

Substitute the values into the formula:

$f_{echo} = 320 \times [(330 + 10) / (330 - 10)]$

$f_{echo} = 320 \times [(340) / (320)]$

Calculate the value:

$f_{echo} = 320 \times 1.0625 = 340$ Hz

Thus, the frequency of the echo heard by the train driver is 340 Hz, which falls within the expected range of 340 to 340 Hz. The calculation confirms that the computed frequency matches the expected value in the given range.

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

26. **Answer: 3 - 3**

Explanation:

The correct answer is 3

$\frac{v}{2l} = 50\ Hz$

$\Rightarrow T = [100 \times (\frac{30}{100})]^2 \times \mu$

$\Rightarrow \mu = \frac{2700}{900} = 3$

Therefore , linear mass density is 3 kg/m.

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---

27. **Answer: 5 - 5**

Explanation:

$A = |10cos(\pi x)$

At $x = \frac{4}{3}$

$A = |10cos(\pi \times \frac{4}{3})|$

$A = |10\ \ cos(240^o)|$

$A = |10 \times \frac{-1}{2})|$

$A = |-5\ cm|$

Therefore, amplitude = $5\ cm$.

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28. Answer: 152 - 152

Explanation:

The correct answer is 152 Hz
$f_1 = f$, $f_2 = f + 4$
$f_3 = f + 2 \times 4$, $f_4 = f + 3 \times 4$
$f_{20} = f + 19 \times 4$
$= f + (19 \times 4) = 2 \times f$
$f = 76$ Hz.
Frequency of last tuning forks = 2f
= 152 Hz

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---

29. Answer: c

Explanation:

The correct answer is (C) : A-IV, B-III, C-II, D-I
Television signal ⇒ 6 MHz
Radio signal ⇒ 2 MHz
High Quality music ⇒ 20 kHz
Human speech ⇒ 3 kHz

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---

30. Answer: a

Explanation:

The value of wavelength :

$\Rightarrow k = \frac{1}{A}$ $\left[\frac{\omega}{k} = A\omega\right]$

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

$\Rightarrow \frac{2\pi}{\lambda} = \frac{1}{2}\ cm$ $[\lambda = Wavelength]$

$\Rightarrow\ \lambda = 4\pi\ cm$

Hence, the correct option is (A): 4π

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