Waves and Oscillations JEE Main PYQ - 2

Total Time: 1 Hour **Total Marks:** 100

Instructions

Instructions

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 and Oscillations

1. If the length of the pendulum in pendulum clock increases by 0.1%, then the error in time per day is : **(+4, -1)**

a. 86.4 s

b. 8.64 s

c. 43.2 s

d. 4.32 s

2. **(+4, -1)**

A block of a mass $2\,kg$ is attached with two identical springs of spring constant $20\,N/m$ each The block is placed on a frictionless surface and the ends of the springs are attached to rigid supports (see figure) When the mass is displaced from its equilibrium position, it executes a simple harmonic motion The time period of oscillation is $\frac{\pi}{\sqrt{x}}$ in SI unit The value of x is

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3. Two bodies A and B of equal mass are suspended from two massless springs of spring constant k_1 and k_2, respectively. If the bodies oscillate vertically such that their amplitudes are equal, the ratio of the maximum velocity of A to the maximum velocity of B is: **(+4, -1)**

a. $\frac{k_1}{k_2}$

b. $\frac{k_2}{k_1}$

c. $\sqrt{\frac{k_2}{k_1}}$

d. $\sqrt{\frac{k_1}{k_2}}$

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4. **Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).** (+4, -1)
Assertion (A): Time period of a simple pendulum is longer at the top of a mountain than that at the base of the mountain.
Reason (R): Time period of a simple pendulum decreases with increasing value of acceleration due to gravity and vice-versa. In the light of the above statements.
choose the most appropriate answer from the options given below:

a. Both (A) and (R) are true but (R) is not the correct explanation of (A)

b. (A) is false but (R) is true

c. Both (A) and (R) are true and (R) is the correct explanation of (A)

d. (A) is true but (R) is false

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5. A particle is doing simple harmonic motion of amplitude 0.06 m and time period 3.14 s. The maximum velocity of the particle is _______ cm/s. (+4, -1)

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6. An object of mass $0.2\,\mathrm{kg}$ executes simple harmonic motion along the x-axis with a frequency of $\left(\frac{25}{\pi}\right)\,\mathrm{Hz}$. At the position $x = 0.04\,\mathrm{m}$, the object has kinetic energy $0.5\,\mathrm{J}$ and potential energy $0.4\,\mathrm{J}$. The amplitude of oscillation is $\ldots\ \mathrm{cm}$. (+4, -1)

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7. A particle performs simple harmonic motion with amplitude A. Its speed is increased to three times at an instant when its displacement is $\frac{2A}{3}$. The new amplitude of motion is $\frac{nA}{3}$. The value of n is _____. (+4, -1)

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8. A tuning fork resonates with a sonometer wire of length 1 m stretched with a tension of 6 N. When the tension in the wire is changed to 54 N, the same tuning fork produces 12 beats per second with it. The frequency of the tuning fork is _______ Hz. (+4, -1)

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9. A particle executes simple harmonic motion with an amplitude of 4 cm. At the mean position, the velocity of the particle is 10 cm/s. The distance of the particle from the mean position when its speed becomes 5 cm/s is $\sqrt{\alpha}$ cm, where α = ______ (+4, -1)

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10. A simple harmonic oscillator has an amplitude A and a time period of 6π seconds. Assuming the oscillation starts from its mean position, the time required by it to travel from $x = A$ to $x = \frac{\sqrt{3}}{2}A$ will be $\frac{\pi}{x}$ seconds, where $x =$ ____________. **(+4, -1)**

11. A compass needle of oscillation magnetometer oscillates 20 times per minute at a place P of dip 30°. The number of oscillations per minute become 10 at another place Q of 60° dip. The ratio of the total magnetic field at the two places respectively is $\frac{4}{\sqrt{x}}$ The value of x is **(+4, -1)**

12. The energy of an electromagnetic wave contained in a small volume oscillates with **(+4, -1)**

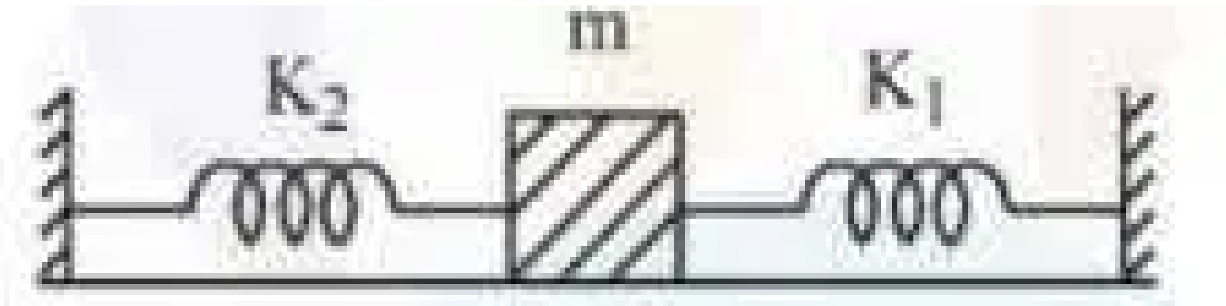
a. zero frequency

b. half the frequency of the wave

c. double the frequency of the wave

d. the frequency of the wave

13. A mass m is attached to two springs as shown in the figure. The spring constants of the two springs are K_1 and K_2. For the frictionless surface, the time period of oscillation of mass m is: **(+4, -1)**



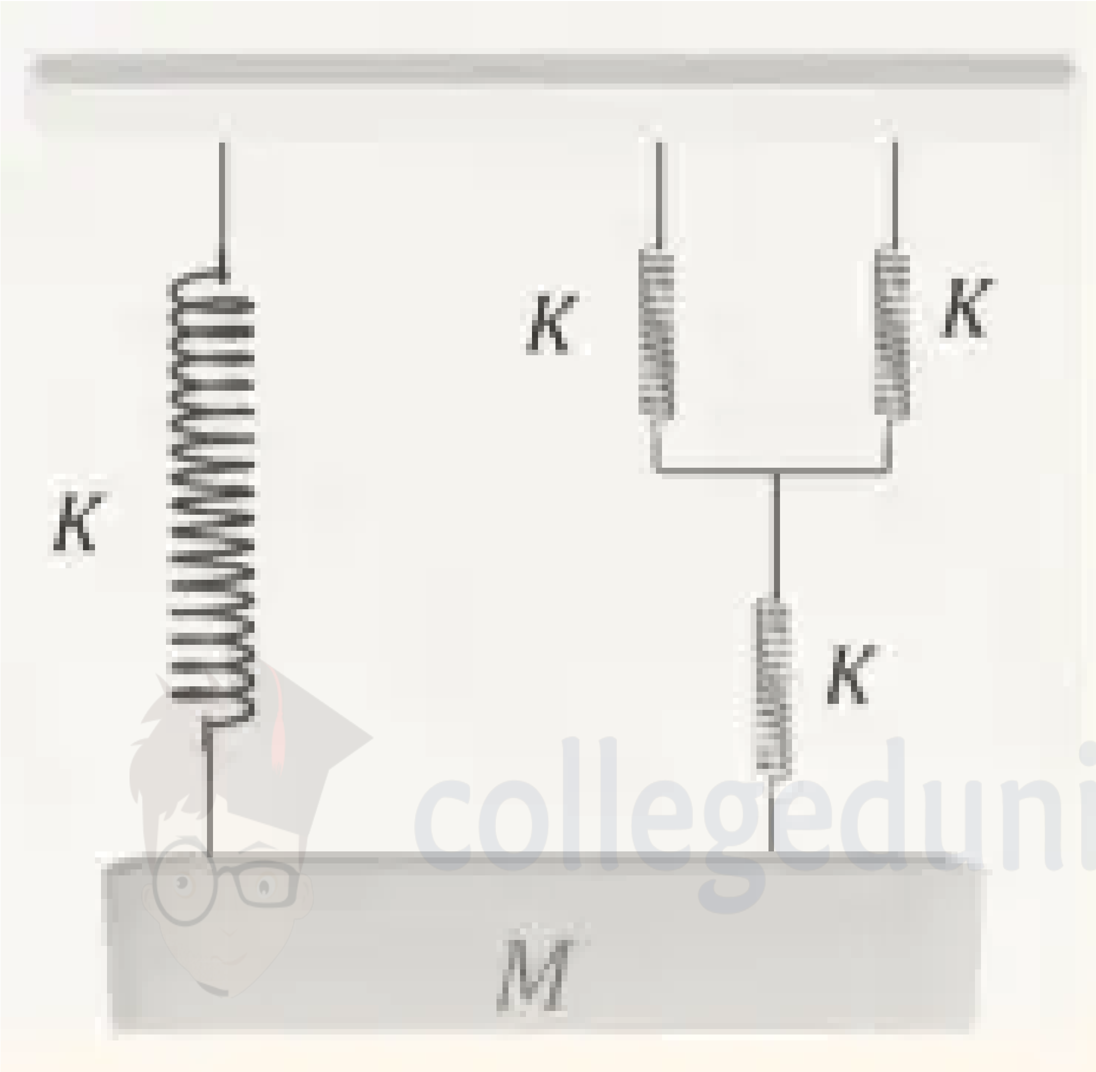
a. $2\pi\sqrt{\frac{m}{K_1-K_2}}$

b. $\frac{1}{2\pi}\sqrt{\frac{K_1-K_2}{m}}$

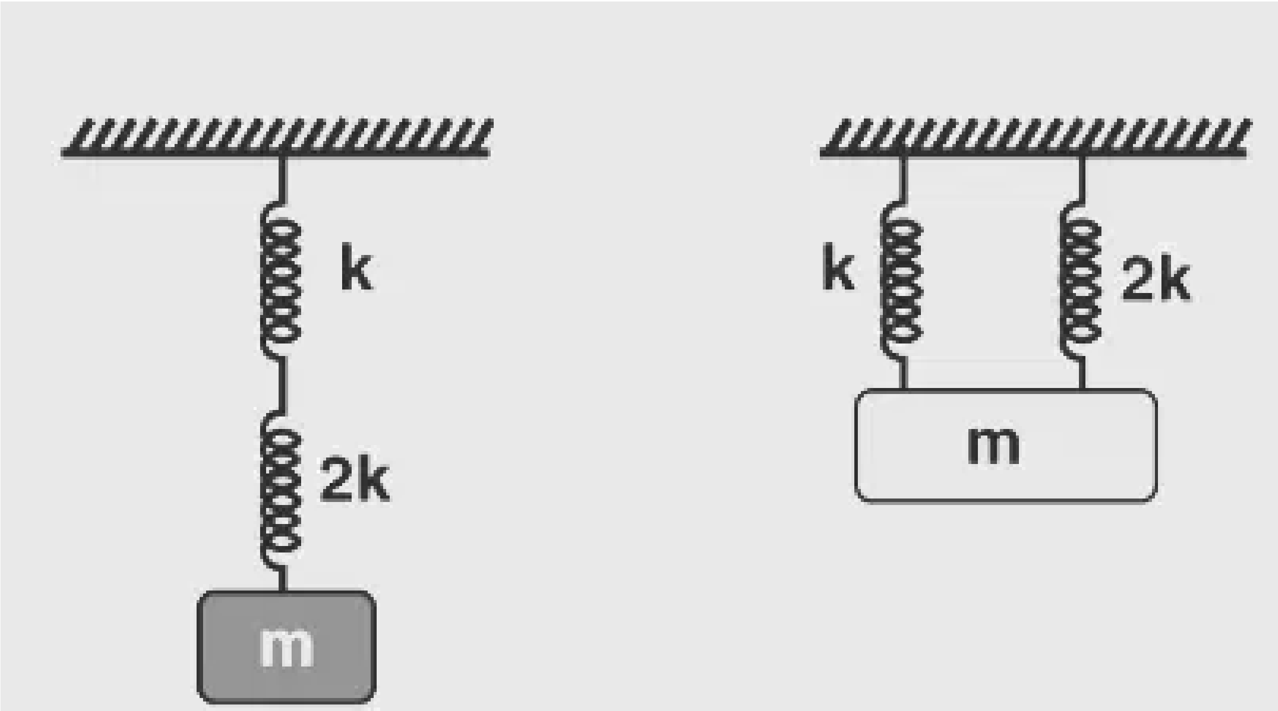
c. $\frac{1}{2\pi}\sqrt{\frac{K_1+K_2}{m}}$

d. $2\pi\sqrt{\frac{m}{K_1+K_2}}$

14. The period of oscillation of system shown below is $\pi\sqrt{\left(\frac{\alpha M}{5K}\right)}$ then α is **(+4, -1)**



15. As per given figures, two springs of spring constants k and 2k are connected to mass m. If the period of oscillation in figure (a)is 3s, then the period of oscillation in figure (b) will be $\sqrt{x}$ s. The value of x is _______ **(+4, -1)**



16. A pendulum of length $2\ m$ consists of a wooden bob of mass $50\ g$. A bullet of mass $75\ g$ is fired towards the stationary bob with a speed v. The bullet emerges out of the bob with a speed $\frac{v}{3}$ and the bob just completes the vertical circle. The value of v is ________ ms^{-1}. (if $g = 10\ m/s^2$). **(+4, -1)**

17. Assume there are two identical simple pendulum. Clock -1 is placed on the earth and Clock-2 is placed on a space station located at a height h above the earth surface. Clock-1 and Clock-2 operate at time periods $4s$ and $6s$ respectively. Then the value of h is -
(consider radius of earth $R_E = 6400km$ and g on earth $10m/s^2$) **(+4, -1)**

a. 1200 km

b. 1600 km

c. 3200 km

d. 4800 km

18. A pendulum is suspended by a string of length 250 cm. The mass of the bob of the pendulum is 200 g. The bob is pulled aside until the string is at 60° with vertical, as shown in the figure. After releasing the bob, the maximum velocity **(+4, -1)**

attained by the bob will be ___ ms^{-1}. (if $g = 10\ m/s^2$)

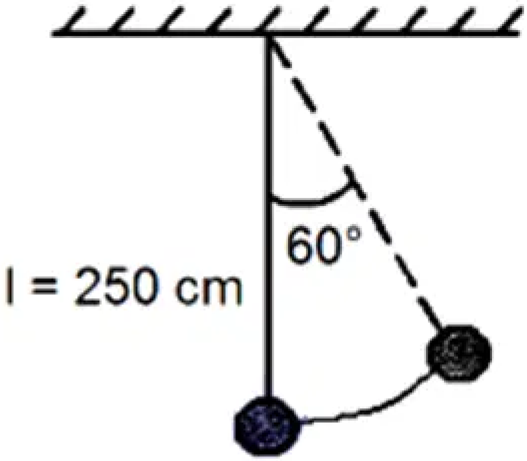


Fig. Oscillations

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19. When a car is approaching the observer, the frequency of horn is 100 Hz. After passing the observer, it is 50 Hz. If the observer moves with the car, the frequency will be $\frac{x}{3}$ Hz, where x = _____ . **(+4, -1)**

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20. A $0.5\ kg$ block moving at a speed of $12\ ms^{-1}$ compresses a spring through a distance 30 cm when its speed is halved. The spring constant of the spring will be _____ Nm^{-1}. **(+4, -1)**

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21. Two identical positive charges Q each are fixed at a distance of $2a$ apart from each other. Another point charge q_0 with mass m is placed at midpoint between two fixed charges. For a small displacement along the line joining the fixed charges, the charge q_0 executes SHM. The time period of oscillation of charge q_0 will be **(+4, -1)**

a. $\sqrt{\frac{4\pi^3\varepsilon 0rna^3}{q0Q}}$

b. $\sqrt{\frac{qoQ}{4\pi^3\varepsilon rna^3}}$

c. $\sqrt{\frac{2\pi^2\varepsilon_0 rna^3}{q0Q}}$

d. $\sqrt{\frac{8\pi^3\varepsilon_0 rna^3}{q0Q}}$

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22. A radio can tune to any station in 6 MHz to 10 MHz band. The value of corresponding wavelength bandwidth will be **(+4, -1)**

a. 4 m

b. 20 m

c. 30 m

d. 50 m

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23. In figure (A), mass '2 m' is fixed on mass 'm', which is attached to two springs of spring constant k. In figure (B), mass 'm' is attached to two springs of spring constant 'k' and '2k'. If mass 'm' in (A) and in (B) are displaced by distance' x' horizontally and then released, then time period T1 and T2 corresponding to (A) and (B) respectively follow the relation. **(+4, -1)**

a. $\frac{T_1}{T_2} = \frac{3}{\sqrt{2}}$

b. $\frac{T_1}{T_2} = \sqrt{\frac{3}{2}}$

c. $\frac{T_1}{T_2} = \sqrt{\frac{2}{3}}$

d. $\frac{T_1}{T_2} = \frac{\sqrt{2}}{3}$

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24. The positive feedback is required by an amplifier to act an oscillator. The feedback here means: **(+4, -1)**

a. External input is necessary to sustain ac signal in output

b. A portion of the output power is returned back to the input

c. Feedback can be achieved by LR network

d. The base-collector junction must be forward biased

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25. The displacement of simple harmonic oscillator after 3 seconds starting from its mean position is equal to half of its amplitude. The time period of harmonic motion is : **(+4, -1)**

a. 6 s

b. 8 s

c. 12 s

d. 36 s

Answers

1. Answer: c

Explanation:

Step 1: Understanding the Question:
The length of a pendulum clock increases, which will change its time period. We need to find the total error in time (time lost or gained) over a period of one day.
Step 2: Key Formula or Approach:
The time period (T) of a simple pendulum is given by $T = 2\pi\sqrt{\frac{L}{g}}$.
For small changes, the fractional change in the time period can be found using error analysis:

$$\frac{\Delta T}{T} = \frac{1}{2}\frac{\Delta L}{L}$$

The total error in time (Δt) in a day is this fractional change multiplied by the total seconds in a day.
Step 3: Detailed Explanation:
Given that the length (L) increases by 0.1%, the fractional change in length is:

$$\frac{\Delta L}{L} = 0.1$$

Now, we calculate the fractional change in the time period (T):

$$\frac{\Delta T}{T} = \frac{1}{2}\frac{\Delta L}{L} = \frac{1}{2} \times 0.001 = 0.0005$$

Since the length increases, the time period also increases (ΔT is positive). This means the clock runs slower and loses time.
The total number of seconds in one day is:

$$t = 24\,\text{hours} \times 60\,\text{minutes/hour} \times 60\,\text{seconds/minute} = 86400\,\text{s}$$

The total error in time per day (Δt) is:

$$\Delta t = \left(\frac{\Delta T}{T}\right) \times t = 0.0005 \times 86400\,\text{s}$$

$$\Delta t = \frac{1}{2000} \times 86400\,\text{s} = \frac{864}{20}\,\text{s} = \frac{86.4}{2}\,\text{s} = 43.2\,\text{s}$$

Step 4: Final Answer:
The error in time per day is 43.2 seconds. The clock will lose 43.2 seconds. This corresponds to option (C).

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2. Answer: 40 - 40

Explanation:

The kinetic energy is related to velocity as:

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

Substitute the given values ($m = 2\,\text{kg},\ \text{KE} = 10000\,\text{J}$):

$$\frac{1}{2} \cdot 2 \cdot v^2 = 10000$$

$$v^2 = 10000, \quad v = 100\,\text{m/s}$$

The acceleration is found using:

$$v = u + at$$

Since the body starts from rest ($u = 0$) and reaches $v = 100\,\text{m/s}$ in $t = 5\,\text{s}$:

$$100 = 0 + a \cdot 5 \implies a = \frac{100}{5} = 20\,\text{m/s}^2$$

The force acting on the body is:

$$F = m \cdot a = 2 \cdot 20 = 40\,\text{N}$$

Concepts:

1. Oscillations:

Oscillation is a process of repeating variations of any quantity or measure from its equilibrium value in time . Another definition of oscillation is a periodic variation of a matter between two values or about its central value.

The term vibration is used to describe the mechanical oscillations of an object. However, oscillations also occur in dynamic systems or more accurately in every field of science. Even our heartbeats also creates oscillations. Meanwhile, objects that move to and fro from its equilibrium position are known as oscillators.

Read More: Simple Harmonic Motion

Oscillation- Examples

The tides in the sea and the movement of a simple pendulum of the clock are some of the most common examples of oscillations. Some of examples of oscillations are vibrations caused by the guitar strings or the other instruments having strings are also and etc. The movements caused by oscillations are known as oscillating movements. For example, oscillating movements in a sine wave or a spring when it moves up and down.

The maximum distance covered while taking oscillations is known as the amplitude. The time taken to complete one cycle is known as the time period of the oscillation. The number of oscillating cycles completed in one second is referred to as the frequency which is the reciprocal of the time period.

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3. Answer: d

Explanation:

For a spring-mass system undergoing simple harmonic motion, the maximum velocity is given by:

$$v_{\max} = A\omega$$

where A is the amplitude, and ω is the angular frequency. The angular frequency ω is related to the spring constant and mass by:

$$\omega = \sqrt{\frac{k}{m}}$$

Given that the amplitudes of both bodies are equal, we can write the ratio of the maximum velocities for bodies A and B as:

$$\frac{v_A}{v_B} = \frac{A\omega_A}{A\omega_B} = \frac{\omega_A}{\omega_B} = \sqrt{\frac{k_1}{k_2}}$$

Thus, the ratio of the maximum velocity of A to that of B is $\sqrt{\frac{k_1}{k_2}}$.

4. **Answer: a**

Explanation:

To solve the problem, let's analyze the given statements:

- **Assertion (A):** The time period of a simple pendulum is longer at the top of a mountain than at the base of the mountain.
- **Reason (R):** The time period of a simple pendulum decreases with increasing value of acceleration due to gravity and vice-versa.

The formula for the time period (T) of a simple pendulum is:
$T = 2\pi\sqrt{(L/g)}$
where L is the length of the pendulum and g is the acceleration due to gravity. From this formula, we see that the time period is inversely related to the square root of g. As the altitude increases, like at the top of a mountain, the value of g decreases slightly because of the increase in distance from the center of the Earth. This leads to a longer time period (T) at the mountain top compared to the base. Thus, **Assertion (A)** is true.
The **Reason (R)** correctly states that the time period decreases with an increase in g, which is mathematically accurate. However, while this reason is true, it does not specifically explain why the time period is longer at a mountain top. This is due to the decrease in g at higher altitudes, which is only indirectly related to the reason given. Therefore, the correct answer is: Both (A) and (R) are true but (R) is not the correct explanation of (A).

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5. **Answer: 12 - 12**

Explanation:

We know:

$$v_{\max} = \omega A \quad \text{at mean position}$$

$$\omega = \frac{2\pi}{T} \quad \text{and} \quad v_{\max} = \frac{2\pi}{T} \times A$$

$$v_{\max} = \frac{2\pi}{3.14} \times 0.06 = 0.12\,\text{m/s}$$

$$v_{\max} = 12\,\text{cm/s}$$

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6. Answer: 6 - 6

Explanation:

The total mechanical energy E in simple harmonic motion (SHM) is the sum of kinetic energy (KE) and potential energy (PE). Given $KE = 0.5\,\text{J}$ and $PE = 0.4\,\text{J}$, we have:

$$E = KE + PE = 0.5 + 0.4 = 0.9\,\text{J}$$

The total mechanical energy in SHM is also given by:

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

Where $m = 0.2\,\text{kg}$ is the mass, ω is the angular frequency, and A is the amplitude. The frequency f is given as $\frac{25}{\pi}\,\text{Hz}$. Therefore, the angular frequency ω is:

$$\omega = 2\pi f = 2\pi\left(\frac{25}{\pi}\right) = 50\,\text{rad/s}$$

Substitute the values into the energy equation:

$$0.9 = \frac{1}{2}\cdot 0.2 \cdot 50^2 \cdot A^2$$

Solve for A^2:

$$0.9 = 0.1 \cdot 2500 \cdot A^2$$

$$0.9 = 250 \cdot A^2$$

Divide both sides by 250:

$$A^2 = \frac{0.9}{250}$$

$$A^2 = 0.0036$$

Take the square root to find A:

$$A = \sqrt{0.0036} = 0.06\,\text{m}$$

Convert to centimeters:

$$A = 0.06 \times 100 = 6\,\text{cm}$$

The computed amplitude is 6 cm, which falls within the given range of 6,6.

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7. **Answer: 7 - 7**

Explanation:

To solve this problem, we begin by considering the properties of simple harmonic motion. For a particle performing simple harmonic motion with amplitude A, the velocity v at a displacement x is given by:

$$v = \omega\sqrt{A^2 - x^2}$$

where ω is the angular frequency. At $x = \frac{2A}{3}$, the initial speed v_1 is:

$$v_1 = \omega\sqrt{A^2 - \left(\frac{2A}{3}\right)^2} = \omega\sqrt{A^2 - \frac{4A^2}{9}} = \omega\sqrt{\frac{5A^2}{9}} = \omega\frac{\sqrt{5}A}{3}$$

When the speed triples, the new speed $v_2 = 3v_1$:

$$v_2 = 3 \times \omega\frac{\sqrt{5}A}{3} = \omega\sqrt{5}A$$

For the new amplitude $A' = \frac{nA}{3}$, we write the expression for the new speed:

$$v_2 = \omega\sqrt{A'^2 - x^2}$$

At $x = \frac{2A}{3}$, v_2 is also:

$$\omega\sqrt{A'^2 - \left(\frac{2A}{3}\right)^2} = \omega\sqrt{\left(\frac{nA}{3}\right)^2 - \frac{4A^2}{9}}$$

Equating the expressions for v_2, we have:

$$\omega\sqrt{5}A = \omega\sqrt{\frac{n^2A^2}{9} - \frac{4A^2}{9}} = \omega A\sqrt{\frac{n^2-4}{9}}$$

By canceling common terms and solving for n, we get:

$$\sqrt{5} = \frac{\sqrt{n^2-4}}{3}$$

$$\sqrt{5} \times 3 = \sqrt{n^2 - 4}$$

Squaring both sides, we obtain:

$$45 = n^2 - 4$$

$$n^2 = 49$$

So, $n = 7$ as n is positive. Thus, the value of n is **7**, which falls within the expected range of 7 to 7.

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8. **Answer: 6 - 6**

Explanation:

The frequency of vibration of a sonometer wire is given by:

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

Calculating for initial tension:

$f_1 = \frac{1}{2}\sqrt{\frac{6}{\mu}}$

Calculating for new tension:

$f_2 = \frac{1}{2}\sqrt{\frac{54}{\mu}}$

Given:

$f_2 - f_1 = 12$

Ratio of frequencies:

$\frac{f_1}{f_2} = \frac{1}{3}$

Substituting values:

$f_1 = 6\,\mathrm{Hz}$

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9. **Answer: 12 - 12**

Explanation:

At mean position:

$$v_{\max} = A\omega = 10 \Rightarrow \omega = \frac{10}{4} = \frac{5}{2}$$

Using the equation $v = \omega\sqrt{A^2 - x^2}$ and $v = 5$:

$$5 = \frac{5}{2}\sqrt{4^2 - x^2}$$

Solving,

$$\sqrt{A^2 - x^2} = 2 \Rightarrow x^2 = A^2 - 4 = 16 - 4 = 12$$

Thus, $x = \sqrt{12}$ and $\alpha = 12$.

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10. **Answer: 2 - 2**

Explanation:

The given relationship involves the angular frequency ω and time t of a simple harmonic oscillator:

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

We know the relationship between angular frequency and time period T:

$$\omega = \frac{2\pi}{T}.$$

Substituting $\omega = \frac{2\pi}{T}$ into the equation $\omega t = \frac{\pi}{6}$:

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

Simplify the equation to solve for t:

$$t = \frac{\pi}{2} = \frac{\pi}{x}.$$

Comparing $\frac{\pi}{2} = \frac{\pi}{x}$, we find:

$$x = 2.$$

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11. **Answer: 243 - 243**

Explanation:

Solution:

The frequency of oscillation of a compass needle in a magnetic field is given by:

$$f = \frac{1}{2\pi}\sqrt{\frac{MB_H}{I}}$$

where:

f is the frequency of oscillation

M is the magnetic moment of the needle

B_H is the horizontal component of the Earth's magnetic field

I is the moment of inertia of the needle

Since M and I are constant, we have:

$$f \propto \sqrt{B_H}$$

$$f^2 \propto B_H$$

Also, $B_H = B\cos\delta$, where B is the total magnetic field and δ is the dip angle. So, $f^2 \propto B\cos\delta$. Let $f_1 = 20$ oscillations/minute and $\delta_1 = 30^\circ$.
Let $f_2 = 30$ oscillations/minute and $\delta_2 = 60^\circ$. Then,

$$f_1^2 \propto B_1\cos\delta_1$$

$$f_2^2 \propto B_2\cos\delta_2$$

Therefore,

$$\frac{f_1^2}{f_2^2} = \frac{B_1\cos\delta_1}{B_2\cos\delta_2}$$

Substituting the given values:

$$\frac{20^2}{30^2} = \frac{B_1\cos 30^\circ}{B_2\cos 60^\circ}$$

$$\frac{400}{900} = \frac{B_1(\sqrt{3}/2)}{B_2(1/2)}$$

$$\frac{4}{9} = \frac{B_1}{B_2}\sqrt{3}$$

$$\frac{B_1}{B_2} = \frac{4}{9\sqrt{3}}$$

We are given that $\frac{B_1}{B_2} = \frac{4}{\sqrt{x}}$. Therefore,

$$\frac{4}{\sqrt{x}} = \frac{4}{9\sqrt{3}}$$

$$\sqrt{x} = 9\sqrt{3}$$

$$x = (9\sqrt{3})^2 = 81 \cdot 3 = 243$$

Thus, $x = 243$.

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12. **Answer: c**

Explanation:

Step 1: Formula for Energy Density

The energy density of the wave is given by:

$\text{Energy density} = \frac{1}{2}\varepsilon_0 E_{\text{net}}^2$

Substitute $E_{\text{net}} = E_0 \sin(\omega t - kx)$:

$$\text{Energy density} = \frac{1}{2}\varepsilon_0 E_0^2 \sin^2(\omega t - kx)$$

Step 2: Use the Trigonometric Identity

Using the trigonometric identity $\sin^2 x = \frac{1}{2}(1 - \cos 2x)$:

$$\sin^2(\omega t - kx) = \frac{1}{2}(1 - \cos(2\omega t - 2kx))$$

Substitute this into the energy density formula:

$$\text{Energy density} = \frac{1}{2}\varepsilon_0 E_0^2 \cdot \frac{1}{2}(1 - \cos(2\omega t - 2kx))$$

Simplify the expression:

$$\text{Energy density} = \frac{1}{4}\varepsilon_0 E_0^2(1 - \cos(2\omega t - 2kx))$$

Final Answer:

The energy density of the wave is:

$\frac{1}{4}\varepsilon_0 E_0^2(1 - \cos(2\omega t - 2kx))$

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13. **Answer: d**

Explanation:

Both the springs are in parallel.
$K_{eq} = K_1 + K_2$
$T = 2\pi\sqrt{\frac{m}{K_{eq}}} = 2\pi\sqrt{\frac{m}{K_1 + K_2}}$

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14. **Answer: 12 - 12**

Explanation:

The Correct Answer is : 12

Concepts:

1. Oscillations:

Oscillation is a process of repeating variations of any quantity or measure from its equilibrium value in time . Another definition of oscillation is a periodic variation of a matter between two values or about its central value.

The term vibration is used to describe the mechanical oscillations of an object. However, oscillations also occur in dynamic systems or more accurately in every field of science. Even our heartbeats also creates oscillations. Meanwhile, objects that move to and fro from its equilibrium position are known as oscillators.

Read More: Simple Harmonic Motion

Oscillation- Examples

The tides in the sea and the movement of a simple pendulum of the clock are some of the most common examples of oscillations. Some of examples of oscillations are vibrations caused by the guitar strings or the other instruments having strings are also and etc. The movements caused by oscillations are known as oscillating movements. For example, oscillating movements in a sine wave or a spring when it moves up and down.

The maximum distance covered while taking oscillations is known as the amplitude. The time taken to complete one cycle is known as the time period of the oscillation. The number of oscillating cycles completed in one second is referred to as the frequency which is the reciprocal of the time period.

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15. **Answer: 2 - 2**

Explanation:

For case (a),

$k_{eq} = \frac{2K}{3}$

For case (b),

$k_{eq} = 3k$

$\because T = 2\pi\sqrt{\frac{m}{k}}$

$\therefore \frac{T_a}{T_b} = \sqrt{\frac{K_b}{K_a}}$

$\frac{3}{T_b} = \sqrt{\frac{3K\times3}{2k}} = \frac{3}{\sqrt{2}}$

$T_b = \sqrt{2}$

$x = 2$

Concepts:

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16. Answer: 10 - 10

Explanation:

$v_{bob} = \sqrt{5gI}$

$v_{bob} = \sqrt{5 \times 10 \times 2}$

$v_{bob} = 10\ m/s$

By the law of Conservation of Momentum,

$\Rightarrow 75 \times v = 75 \times \frac{v}{3} + 50 \times 10$

$\Rightarrow 50v = 50 \times 10$

$\Rightarrow v = 10\ m/s$

So, the answer is $10\ m/s$.

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---

17. **Answer: c**

Explanation:

$t \propto \frac{1}{\sqrt{g}}$ and $g \propto \frac{1}{(R+h)^2}$ $\frac{t1}{t2}$ = $\sqrt{\frac{g^1}{g}}$ = $\sqrt{\frac{R^2}{(R+h)^2}}$ $\frac{t1}{t2}$ = $\frac{4}{6}$ = $\frac{R}{(R+h)}$

$\Rightarrow h = 3200km$

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18. Answer: 5 - 5

Explanation:

The correct answer is 5

$\frac{1}{2}mv^2 = mgl(1 - cos\theta)$

$\Rightarrow v = \sqrt{2gl\ (1 - cos\theta)}$

$= \sqrt{2\ \times 10\ \times 2.5\ \times \frac{1}{2}}$

= 5 m/s

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19. Answer: 200 - 200

Explanation:

$100 = v_0 \frac{v}{v - v_c}$

$50 = v_0 \frac{v}{v + v_c}$

$2 = \frac{v + v_c}{v - v_c}$

$2v – 2v_c = v + v_c$

$v_c = \frac{v}{3}$

$100 = v_0 \frac{v \times 3}{2v}$

$v_0 = \frac{200}{3} = \frac{x}{3}$

$\Rightarrow x = 200$

So, the answer is 200.

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20. **Answer: 600 - 600**

Explanation:

$\frac{1}{2}mv^2 = \frac{1}{2}kx^2 + \frac{1}{2}m(\frac{v}{2})^2$
$\frac{1}{2}mv^2 - \frac{1}{2}m(\frac{v}{2})^2 = \frac{1}{2}kx^2$
$\frac{3}{8}mV^2 = \frac{1}{2}kx^2$
$k = \frac{3}{4} \times \frac{1}{2} \times \frac{144}{9} \times 100$
$k = 600$
So, the answer is 600.

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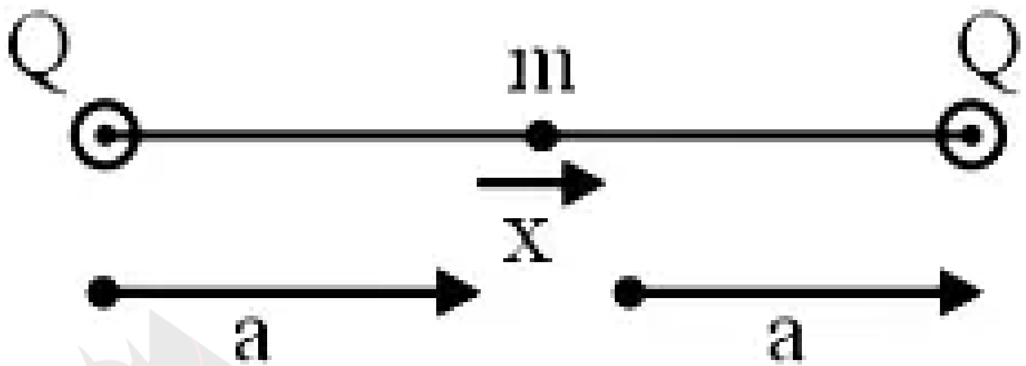
21. **Answer: a**

Explanation:

The correct option is(A): $\sqrt{\frac{4\pi^3\varepsilon 0rna^3}{q0Q}}$



(x << a) (a is acceleration)

$F_{net} = -(\frac{kq_oQ}{(a-x)} - \frac{kQq_o}{(a+x)^2})$

So, $T = 2\pi\sqrt{\frac{4\pi^3\varepsilon 0rna^3}{q0Q}}$

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---

22. Answer: b

Explanation:

$v_1 = 6 \times 10^6\ Hz$
$\lambda_1 = \frac{3\times10^8}{6\times10^6}$
$\lambda_1 = 50\ m$
$v_2 = 10 \times 10^6\ Hz$
$\lambda_2 = \frac{3\times10^8}{10\times10^6}$
$\lambda_2 = 30\ m$
The wavelength band with $= |\lambda_1 - \lambda_2| = 20\ m$

So, the correct option is (B): 20 m.

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23. **Answer: a**

Explanation:

Both the springs are in parallel combination in both the diagrams so
T_1=2π$2\pi\sqrt{\frac{3m}{2}}$k and T_2=2π $\sqrt{\frac{M}{3k}}$
So, $\frac{T_1}{T_2} = \frac{3}{\sqrt{2}}$

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---

24. **Answer: b**

Explanation:

The correct answer is (B): A portion of the output power is returned back to the input

Explanation:

Feedback means a portion of the output power is fed to the inputs.
Positive feedback involves taking a fraction of the output signal and introducing it back into the input, often in phase with the input signal. This can result in a cumulative effect, where the signal keeps reinforcing itself, leading to sustained oscillations.

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25. Answer: d

Explanation:

Time taken by the harmonic oscillator to move from mean position to half of amplitude is

$\frac{T}{12}$

Then, $\frac{T}{12} = 3$

$T = 36\ sec$

Hence, the correct option is (D): $36\ sec$

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