Waves and Oscillations JEE Main PYQ - 3

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. Two massless springs with spring constant 2 k and 9 k, carry 50 g and 100 g masses at their free ends. These two masses oscillate vertically such that their maximum velocities are equal. Then, the ratio of their respective amplitude will be **(+4, -1)**

a. 1 : 2

b. 3 : 2

c. 3 : 1

d. 2 : 3

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2. When a particle executes simple Harmonicmotion, the nature of graph of velocity asfunction of displacement will be : **(+4, -1)**

a. Circular

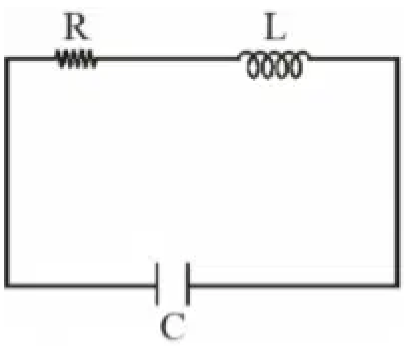
b. Ellipitical

c. Sinusoidal

d. Straight line

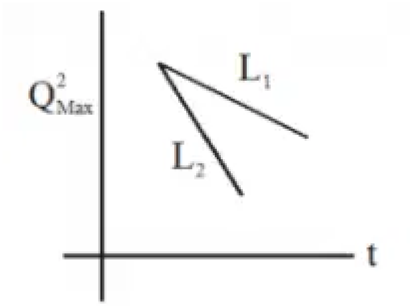
---

3. An LCR circuit is equivalent to a damped pendulum. In an LCR circuit, the capacitor is charged to $_0$ and then connected to the and as shown below. If a student plots graphs of the square of maximum charge on the capacitor with time (t) for two different values $_1$ and $_2$ ($_1$ > $_2$) of then which of the following represents this graph correctly? **(+4, -1)**

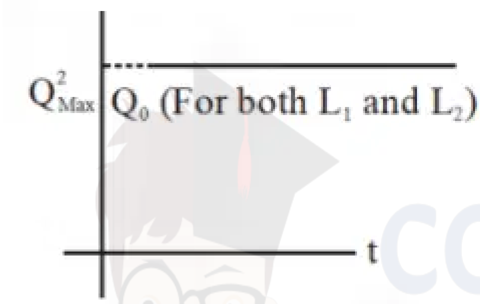


(plots are schematic and not drawn to scale)

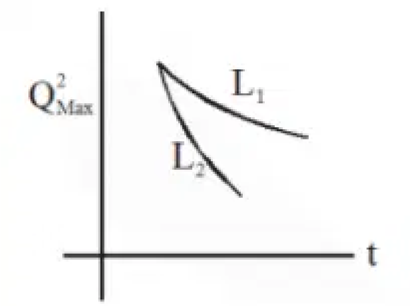
a. (A)



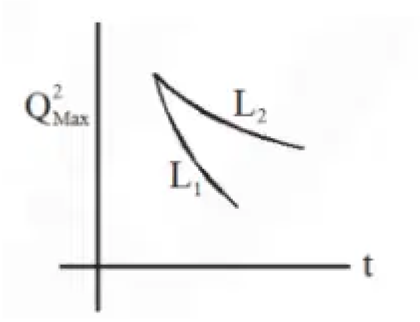
b. (B)



c. (C)

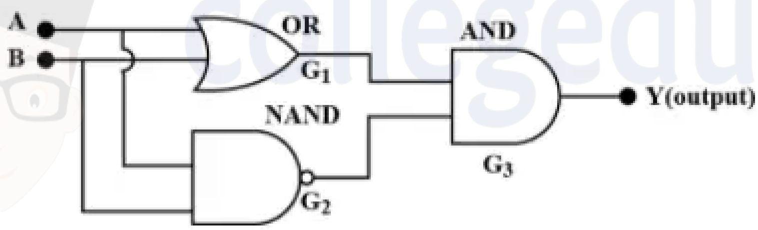


d. (D)



4. A long coaxial cable consists of two thin-walled conducting cylinders with an inner radius 2 and outer radius 8 . The inner cylinder carries a steady current 0.1 , and the outer cylinder provides the return path for that current. The current produces a magnetic field between the two cylinders. Find the energy stored in the magnetic field for length 5 of the cable. Express answer in (use ln2 = 0.7). **(+4, -1)**

5. The following logic gate circuit is equivalent to: **(+4, -1)**



a. (A) NAND gate

b. (B) OR gate

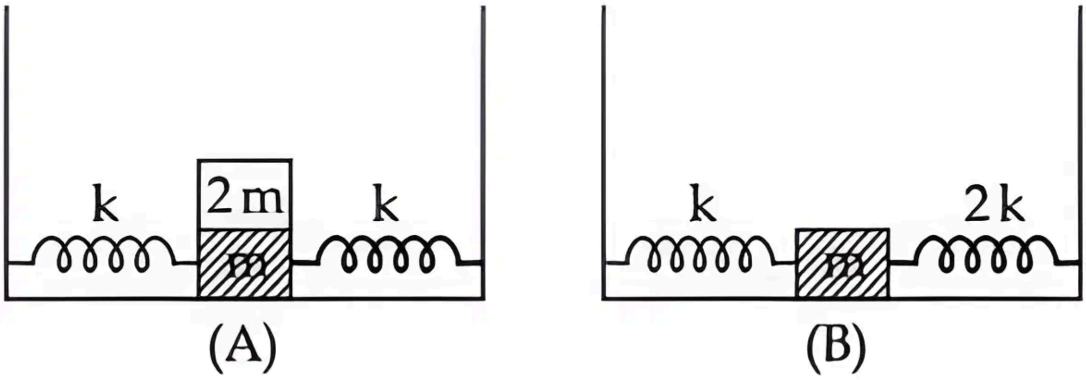
c. (C) XOR gate

d. (D) NOT gate

6. A galvanometer has a resistance of 96 Ω and it is desired to pass 4% of the total current through it. The value of shunt resistance is ____ Ω. **(+4, -1)**

7. In figure (A), mass ' $2m$ ' is fixed on mass ' m ' which is attached to two springs of spring constant k In figure (B), mass ' m ' is attached to two spring of spring constant ' k ' and ' $2k$ ' If mass ' m ' in (A) and (B) are displaced by **(+4, -1)**

distance ' x ' horizontally and then released, then time period T_1 and T_2 corresponding to (A) and (B) respectively follow the relation



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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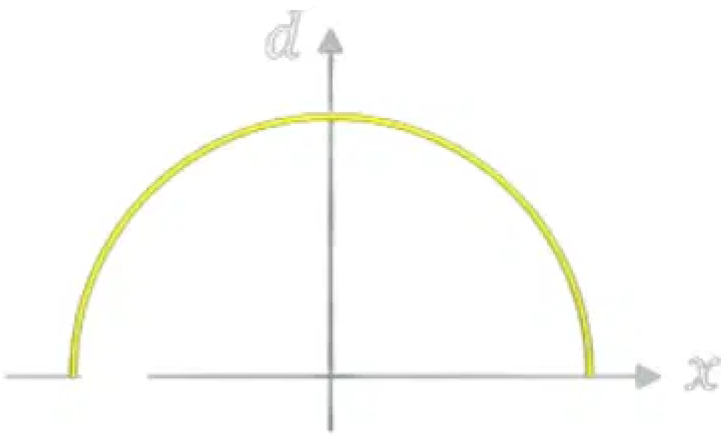
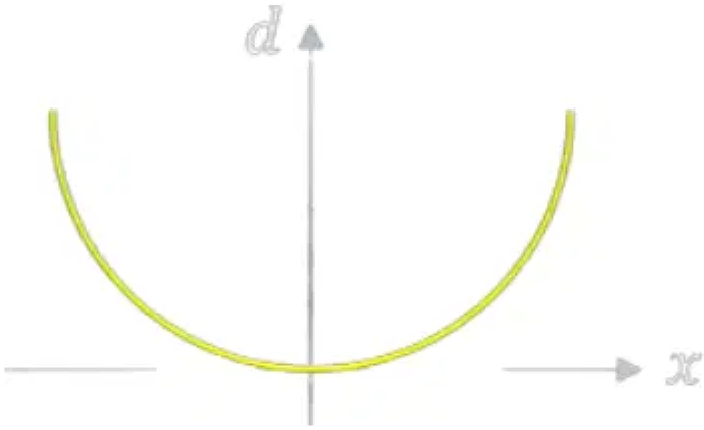
8. Select the correct graph showing the difference (d) between total energy and potential energy of a particle in linear SHM with position x of the particle (x = 0 is the mean position) **(+4, -1)**

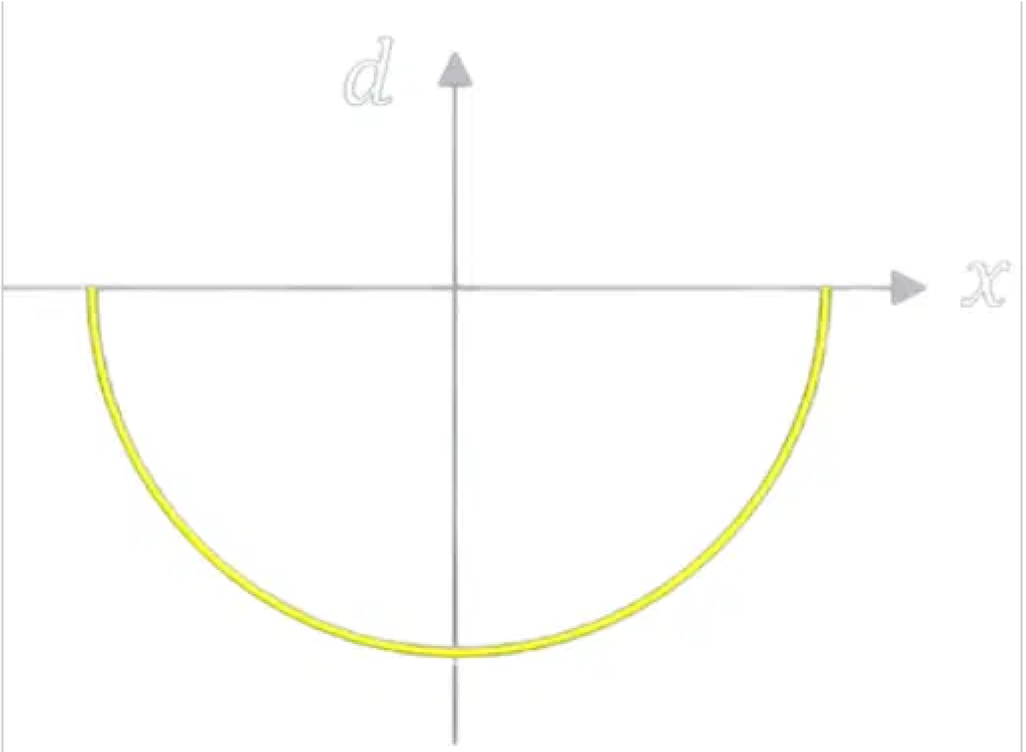


a.



b.

c.



d.

9. A particle is performing S.H.M whose distance from mean position varies as $x = Asin(wt)$. Find the position of the particle from the mean position, where kinetic energy and potential energy is equal. (+4, -1)

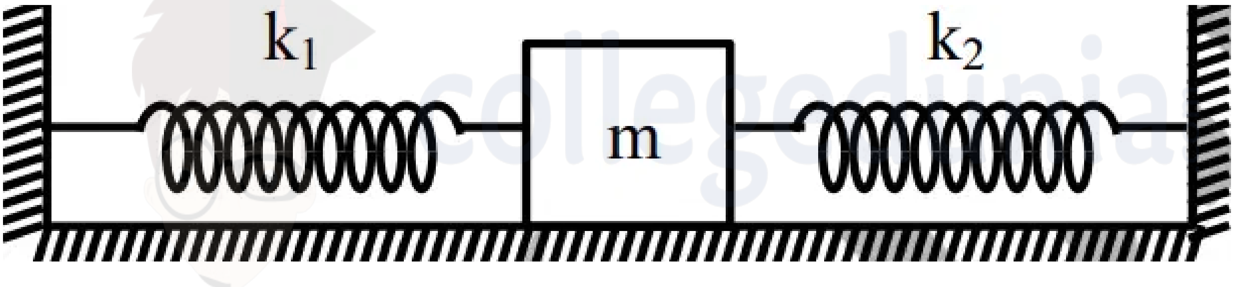
a. $\frac{A}{2}$

b. $\frac{A}{\sqrt{2}}$

c. $\frac{A}{2\sqrt{2}}$

d. $\frac{A}{4}$

10. Find period of oscillation if mass 'm' is displaced parallel to earth's surface & released? (+4, -1)



a. $2\pi\sqrt{\frac{k_1+k_2}{m}}$

b. $2\pi\sqrt{\frac{k_1k_2}{(m)k_1+k_2}}$

c. $2\pi\sqrt{\frac{m}{k_1+k_2}}$

d. $2\pi\sqrt{\frac{(m)k_1+k_2}{k_1k_2}}$

11. T is the time period of simple pendulum on the earth's surface Its time period becomes xT when taken to a height R (equal to earth's radius) above the earth's surface Then, the value of x will be: (+4, -1)

a. $\frac{1}{4}$

b. 4

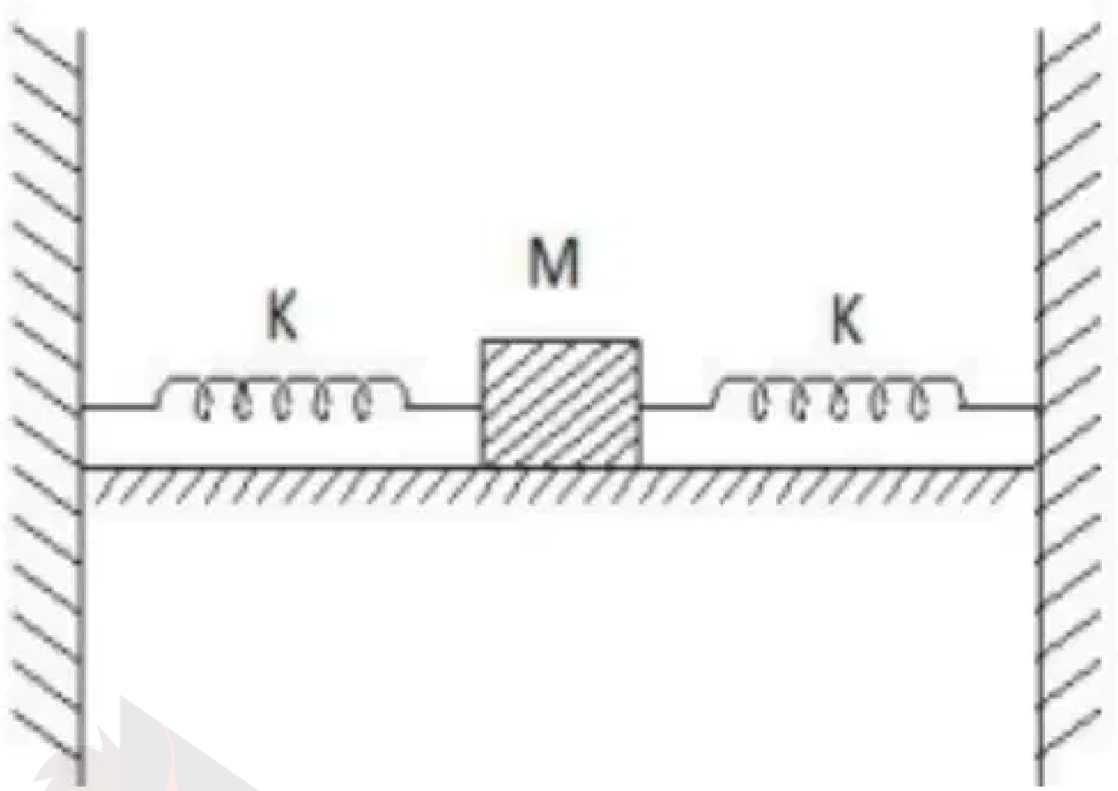
c. $\frac{1}{2}$

d. 2

12. 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 (+4, -1)

13. The general displacement of a simple harmonic oscillator is $x = A\sin\omega t$. Let T be its time period The slope of its potential energy (U) - time (t) curve will be maximum when $t = \frac{T}{\beta}$ The value of β is (+4, -1)

14. **In the figure given below, a block of mass $M = 490g$ placed on a frictionless table is connected with two springs having same spring constant $(K = 2Nm^{-1})$ If the block is horizontally displaced through ' X ' m then the number of complete oscillations it will make in 14π seconds will be** (+4, -1)



15. In an LC oscillator, if values of inductance and capacitance become twice and eight times, respectively, then the resonant frequency of oscillator becomes x times its initial resonant frequency ω_0 The value of x is: **(+4, -1)**

a. $1/4$

b. 4

c. 16

d. 1/16

16. In an LC oscillator, if values of inductance and capacitance become twice and eight times, respectively, then the resonant frequency of oscillator becomes x times its initial resonant frequency ω_0 The value of x is: **(+4, -1)**

a. $1/4$

b. 4

c. 16

d. 1/16

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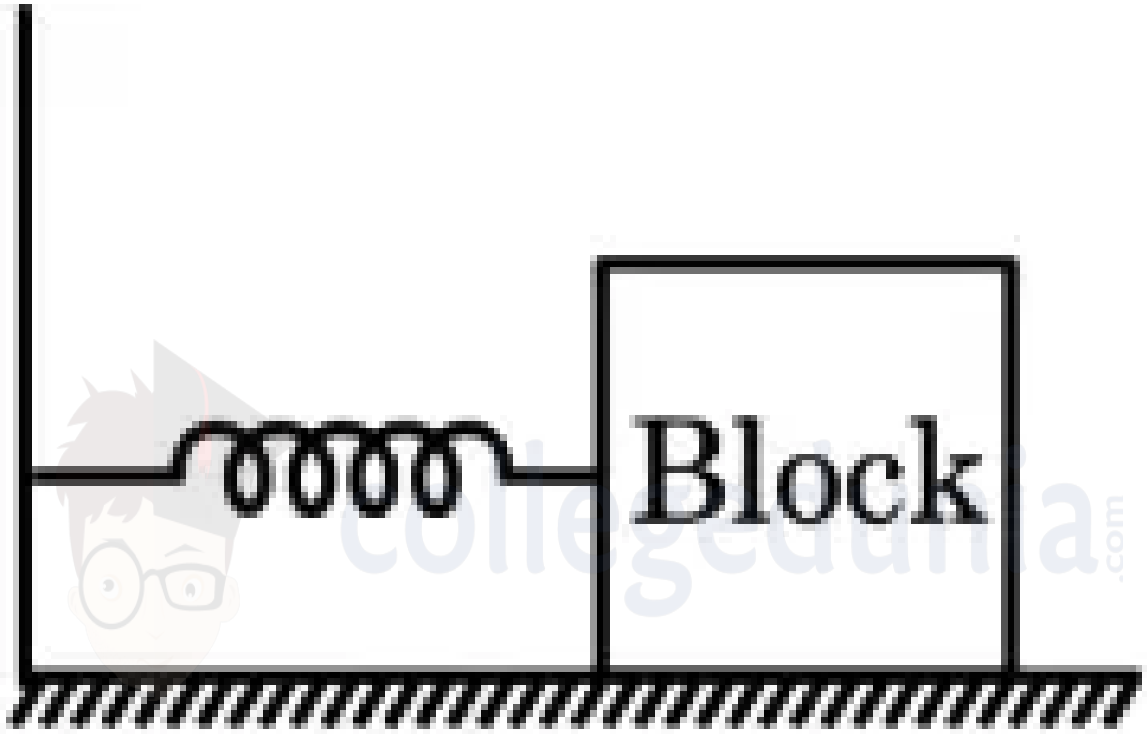
17. For a simple harmonic motion in a mass spring system shown, the surface is frictionless When the mass of the block is $1\,kg$, the angular frequency is ω_1 When the mass block is $2\,kg$ the angular frequency is ω_2 The ratio ω_2/ω_1 is **(+4, -1)**



a. $\sqrt{2}$

b. $\frac{1}{2}$

c. 2

d. $\frac{1}{\sqrt{2}}$

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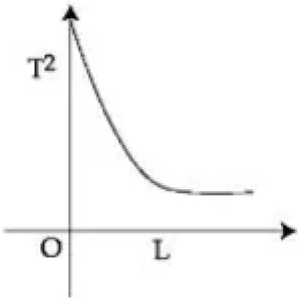
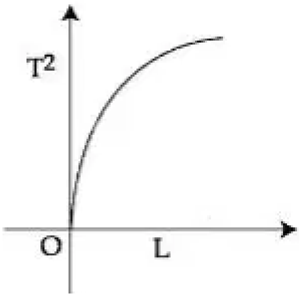
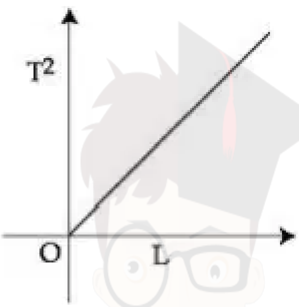
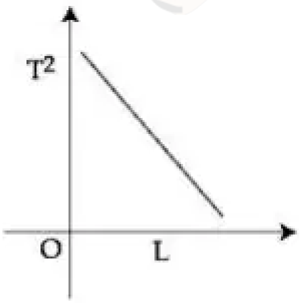
18. Choose the correct length (L) versus square of time period (T^2) graph for a simple pendulum executing simple harmonic motion **(+4, -1)**

a. 

b. 

c. 

d. 

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19. A spherical constant temperature heat source of radius $_1$ is at the center of a uniform solid sphere of radius $_2$. The rate at which heat is transferred through the surface of the sphere is proportional to: **(+4, -1)**

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20. The de Broglie wavelength of an electron accelerated to a potential of 400 is approximately: **(+4, -1)**

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21. A circular disc of radius 0.2 meter is placed in a uniform magnetic field of induction $\frac{1}{\pi}\left(\frac{Wb}{m^2}\right)$ in such a way that its axis makes an angle of 60 with B. The magnetic flux linked with the disc is: **(+4, -1)**

a. (A) 0.08 Wb

b. (B) 0.01 Wb

c. (C) 0.02 Wb

d. (D) 0.06 Wb

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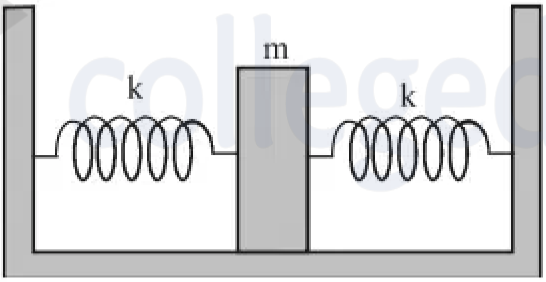
22. Two identical springs of spring constant k are attached to a block of mass m and to fixed supports as shown in Figure. Show that when the mass is displaced from its equilibrium position on either side, it executes a simple harmonic motion. The period of oscillation is: **(+4, -1)**



a. (A) 2 $\sqrt{\frac{}{2}}$

b. (B) $\sqrt{-}$

c. (C) 3 $\sqrt{\frac{}{3}}$

d. (D) None of the above

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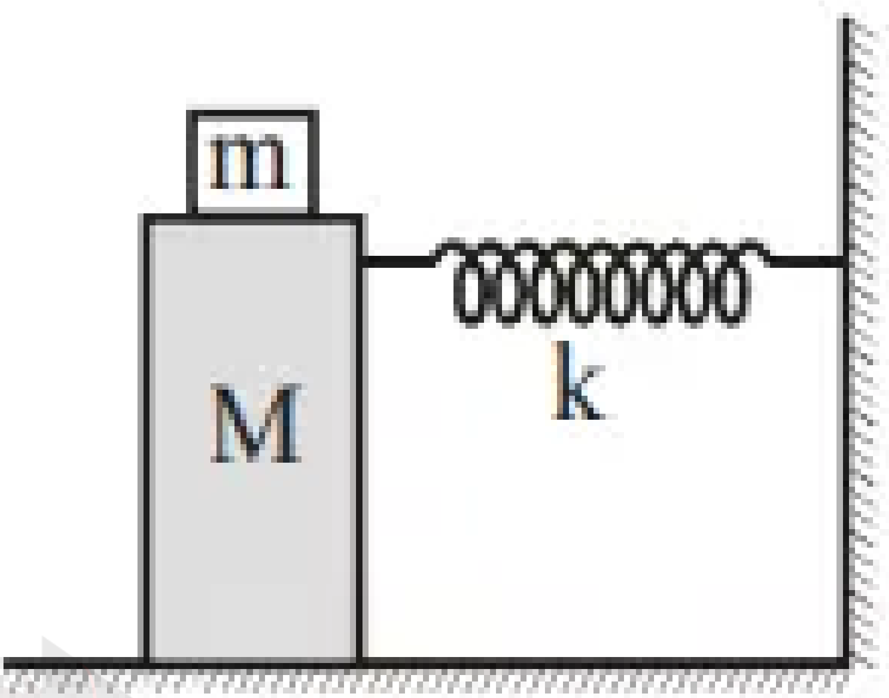
23. In the given figure, a mass M is attached to a horizontal spring which is fixed on one side to a rigid support. The spring constant of the spring is k. The mass oscillates on a frictionless surface with the time period T and amplitude A. When the mass is in an equilibrium position, as shown in the figure, another mass m is gently fixed upon it. The new amplitude of oscillation will be : **(+4, -1)**



a. $A\sqrt{\frac{M-m}{M}}$

b. $A\sqrt{\frac{M}{M+m}}$

c. $A\sqrt{\frac{M+m}{M}}$

d. $A\sqrt{\frac{M}{M-m}}$

---

24. A simple pendulum of length $1\,m$ is oscillating with an angular frequency $10\,rad/s$. The support of the pendulum starts oscillating up and down with a small angular frequency of $1\,rad/s$ and an amplitude of $10^{-2}\,m$. The relative change in the angular frequency of the pendulum is best given by : **(+4, -1)**

a. $10^{-3} rad/s$

b. $10^{-1} rad/s$

c. $1\,rad/s$

d. $10^{-5} rad/s$

---

25. A simple pendulum, made of a string of length l and a bob of mass m, is released from a small angle θ_0. It strikes a block of mass M, kept on a horizontal surface at its lowest point of oscillations, elastically. It bounces back and goes up to an angle θ_1. Then M is given by : **(+4, -1)**

a. $\frac{m}{2}\left(\frac{\theta_0-\theta_1}{\theta_0+\theta_1}\right)$

b. $\frac{m}{2}\left(\frac{\theta_0+\theta_1}{\theta_0-\theta_1}\right)$

c. $m\left(\frac{\theta_0+\theta_1}{\theta_0-\theta_1}\right)$

d. $m\left(\frac{\theta_0-\theta_1}{\theta_0+\theta_1}\right)$

Answers

1. **Answer: b**

Explanation:

$\omega_1 A_1 = \omega_2 A_2$

$\Rightarrow \frac{A_1}{A_2} = \frac{\omega_1}{\omega_2}$

$= \sqrt{\frac{k^2}{m^2}} \times \sqrt{\frac{m_1}{k_1}}$

$= \sqrt{\frac{9k}{100} \times \frac{50}{2k}}$

$= \frac{3}{2}$

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.

---

2. **Answer: b**

Explanation:

The correct option is(B): Ellipitical.

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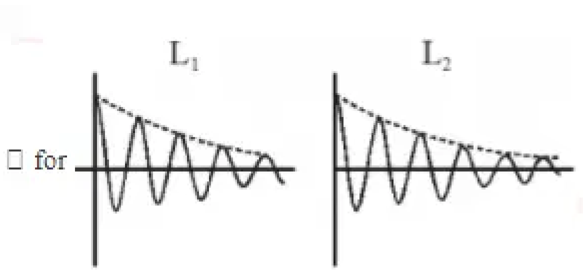
3. **Answer: c**

Explanation:

Explanation:
As damping is happening its amplitude would vary as The oscillations decay exponentially and will be proportional to e^{-} where depends inversely on L. So as inductance increases decay becomes slower for



Hence, the correct option is (C).

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4. **Answer: 7 - 7**

Explanation:

Explanation:
Total energy stored per unit volume $= \frac{2}{2 \ 0}$.Magnetic field at a distance from the central axis of cable is given by, $= \frac{0}{2}$ So, energy stored, $= \int \frac{2}{2} = \int \frac{2}{2 \ 0} 2$
$= \frac{0 \ 2}{4} \ln(-) = \frac{0}{4} \times 0.1^2 \times 5 \times \ln 4 = 7$ Hence, the correct answer is 7 .

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5. **Answer: c**

Explanation:

Explanation:
Input at OR gate ($_1$) are , so output will be, $_1 = +$ Input at NAND gate ($_2$) are , so output will be, $_2 = \bar{}$. Third gate $_3$ in AND gate,Input at $_3$ are $_1$ and $_2$ So, we can write output, $= (+) \bar{} = \bar{} + \bar{} + \bar{} + \bar{}$ Thus, we get:

= 0 + ‾ + ‾ + 0 = ‾ + ‾This expression is for XOR.Hence, the correct option is (C).

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6. **Answer: 4 - 4**

Explanation:

Explanation:
It is given that,The resistance of the galvanometer, Rg = 96Ω4% of the total current is passed through the galvanometer, i.e. Ig = 0.04 We have to find the value of shunt resistance.Let Rs be the shunt resistance. The shunt resistance is given by, $= \frac{}{-}$ $= \frac{0.04 \times 96\Omega}{- 0.04}$ $= \frac{0.04 \times 96\Omega}{0.96}$ = 4ΩHence, the correct answer is 4.

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7. **Answer: a**

Explanation:

The correct option is (A)

Concepts:

1. **Oscillations:**

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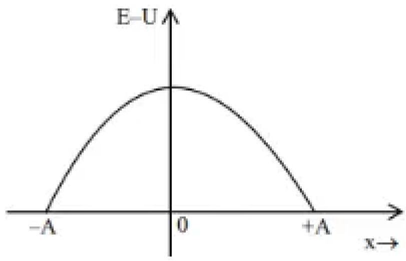
8. **Answer: a**

Explanation:

$$\text{Total energy in SHM} = E$$

$$E = K + U$$
$$E - U = K$$
$$E - U = \frac{1}{2} m\omega^2 \left(A^2 - x^2\right)$$



Concepts:

1. **Energy In Simple Harmonic Motion:**

We can note there involves a continuous interchange of potential and kinetic energy in a simple harmonic motion. The system that performs simple harmonic motion is called the harmonic oscillator.

Case 1: When the potential energy is zero, and the kinetic energy is a maximum at the equilibrium point where maximum displacement takes place.

Case 2: When the potential energy is maximum, and the kinetic energy is zero, at a maximum displacement point from the equilibrium point.

Case 3: The motion of the oscillating body has different values of potential and kinetic energy at other points.

---

9. Answer: b

Explanation:

For a particle in simple harmonic motion (SHM), the total energy E is the sum of kinetic energy (K.E.) and potential energy (P.E.), and is given by:

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

where M is the mass, ω is the angular frequency, and A is the amplitude. When the kinetic energy equals the potential energy:

$$\text{K.E.} = \text{P.E.}.$$

At any point in SHM, the kinetic energy is:

$$\text{K.E.} = \frac{1}{2}M\omega^2(A^2 - x^2),$$

and the potential energy is:

$$\text{P.E.} = \frac{1}{2}M\omega^2 x^2.$$

Setting $\text{K.E.} = \text{P.E.}$:

$$\frac{1}{2}M\omega^2(A^2 - x^2) = \frac{1}{2}M\omega^2 x^2.$$

Simplify:

$$A^2 - x^2 = x^2.$$

Rearrange:

$$2x^2 = A^2.$$

Solve for x:

$$x^2 = \frac{A^2}{2}.$$

$$x = \pm\frac{A}{\sqrt{2}}.$$

Thus, the distance from the mean position when the kinetic energy equals the potential energy is $\boxed{\frac{1}{\sqrt{2}}A}$.

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1. Energy In Simple Harmonic Motion:

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Case 3: The motion of the oscillating body has different values of potential and kinetic energy at other points.

---

10. Answer: c

Explanation:

$k_{eq} = k_1 + k_2$ (As the spring are parallel)
$T = 2\pi\sqrt{\frac{m}{k_{eq}}} = 2\pi\sqrt{\frac{m}{k_1+k_2}}$

So, the correct answer is (C): $2\pi\sqrt{\frac{m}{k_1+k_2}}$

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11. Answer: d

Explanation:

At surface of earth time period

$T = 2\pi\sqrt{\frac{\ell}{g}}$

At height $h = R$

$g' = \frac{g}{\left(1+\frac{h}{R}\right)^2} = \frac{g}{4}$

$\therefore xT = 2\pi\sqrt{\frac{\ell}{(g/4)}}$

$\Rightarrow xT = 2 \times 2\pi\sqrt{\frac{\ell}{g}}$

$\Rightarrow xT = 2T \Rightarrow x = 2$

Concepts:

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---

12. Answer: 5 - 5

Explanation:

The equivalent spring constant for the system is given by:

$$k_{\text{eq}} = k_1 + k_2 = 20 + 20 = 40\,\text{N/m}.$$

The angular frequency ω for the block-mass system is:

$$\omega = \sqrt{\frac{k_{eq}}{m}} = \sqrt{\frac{40}{2}} = \sqrt{20}\,\text{rad/s}.$$

The time period of oscillation T is:

$$T = \frac{2\pi}{\omega} = \frac{2\pi}{\sqrt{20}} = \frac{\pi}{\sqrt{5}}\,\text{s}.$$

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

$$x = 5.$$

Concepts:

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13. **Answer: 8 - 8**

Explanation:

The correct answer is 8

$x = A\sin(\omega t)$

$U_{(x)} = \frac{1}{2}kx^2$

$\frac{dU}{dt} = \frac{1}{2}k2x\frac{dx}{dt}$

$= kA^2\omega \sin\omega t \cos\omega t \times \frac{2}{2}$

$\left(\frac{dU}{dt}\right)_{\max} = \frac{kA^2\omega}{2}(\sin 2\omega t)_{\max}$

$2\omega t = \frac{\pi}{2} \Rightarrow t = \frac{\pi}{4}\omega = \frac{T}{8} \Rightarrow \beta = 8$

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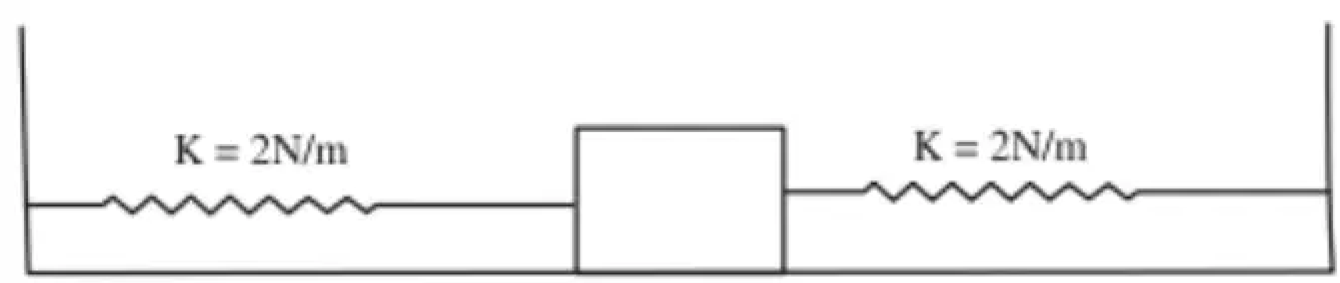
14. Answer: 20 - 20

Explanation:

The correct answer is 20.



Keff $= K + K$ as both springs are in use in parallel

$= 2k$

$= 2 \times 2 = 4N/m$

$m = 490\, gm$

$= 0.49\, kg$

$T = 2\pi\sqrt{\frac{m}{Keff}} = 2\pi\sqrt{\frac{0.49kg}{4}}$

$= 2\pi\sqrt{\frac{49}{400}} = 2\pi\frac{7}{20} = \frac{7\pi}{10}$

No. of oscillation in the 14π is

$N = \frac{\text{time}}{T} = \frac{14\pi}{7\pi/10} = 20$

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---

15. **Answer: a**

Explanation:

1. The resonant frequency of an LC circuit is given by:

$$\omega_0 = \frac{1}{\sqrt{LC}}.$$

2. When $L \to 2L$ and $C \to 8C$, the new resonant frequency is:

$$\omega = \frac{1}{\sqrt{2L \cdot 8C}} = \frac{1}{\sqrt{16LC}} = \frac{1}{4}\omega_0.$$

Thus, the value of x is $1/4$.

The resonant frequency of an LC oscillator decreases as the inductance and capacitance increase, since $\omega_0 \propto 1/\sqrt{LC}$.

Concepts:

1. Alternating Current:

An alternating current can be defined as a current that changes its magnitude and polarity at regular intervals of time. It can also be defined as an electrical current that repeatedly changes or reverses its direction opposite to that of Direct Current or DC which always flows in a single direction as shown below.

Alternating Current Production

Alternating current can be produced or generated by using devices that are known as alternators. However, alternating current can also be produced by different methods where many circuits are used. One of the most common or simple ways of generating AC is by using a basic single coil AC generator which consists of two-pole magnets and a single loop of wire having a rectangular shape.

Application of Alternating Current

AC is the form of current that are mostly used in different appliances. Some of the examples of alternating current include audio signal, radio signal, etc. An alternating current has a wide advantage over DC as AC is able to transmit power over large distances without great loss of energy.

---

16. **Answer: a**

Explanation:

The resonance frequency of LC oscillations circuit is

$?_0 = \frac{1}{\sqrt{LC}}$

$L \ ? \ 2L$

$C \ ? \ 8C$

$? = \frac{1}{\sqrt{2L�8C}} = \frac{1}{4\sqrt{LC}}$

$? = \frac{?_0}{4}$

So $x = \frac{1}{4}$

Concepts:

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---

17. **Answer: d**

Explanation:

The correct answer is (D) : $\frac{1}{\sqrt{2}}$

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

$\frac{\omega_2}{\omega_1} = \sqrt{\frac{m_1}{m_2}} = \sqrt{\frac{1}{2}}$

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---

18. **Answer: c**

Explanation:

Step 1: Recall the Formula for the Time Period of a Simple Pendulum

The time period (T) of a simple pendulum is given by:

$$T = 2\pi\sqrt{\frac{\ell}{g}}$$

where ℓ is the length of the pendulum and g is the acceleration due to gravity.

Step 2: Find the Relationship between T^2 and ℓ

Squaring both sides of the equation, we get:

$$T^2 = 4\pi^2\frac{\ell}{g}$$

Since $4\pi^2$ and g are constants, we can write:

$$T^2 \propto \ell$$

This indicates a linear relationship between T^2 and ℓ.

Step 3: Determine the Correct Graph

The graph of T^2 versus L should be a straight line passing through the origin, representing a direct proportionality.

Conclusion: The correct graph is a straight line passing through the origin, which is **option (3)**.

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---

19. **Answer: 2 - 2**

Explanation:

Explanation:
The rate H at which heat is transferred through the slab is,(a) directly proportional to the area ( ) available.(b) inversely proportional to the thickness of the slab Δ .(c) directly proportional to the temperature difference Δ .So, = Δ / Δ Where is the proportionality constant and is called thermal conductivity of the material.From above we know that, the rate H at which heat is transferred through the slab is directly proportional to the area ( ) available.Area of solid sphere is defined as, $= 4\ ^2$ Here is the radius of sphere.So, the area $_1$ of uniform small solid sphere having radius $_1$ will be, $_1 = 4\ _1^2$ And, the area $_2$ of uniform large solid sphere having radius $_2$ will be, $_2 = 4\ _2^2$ Thus the area from which heat is transferred through the surface of the sphere will be the difference of area of uniform large solid sphere $_2$ and small solid sphere $_1$.So, $= _2 - _1 = 4\ _2^2 - 4\ _1^2 = 4\ (\ _2^2 - \ _1^2)$Since the rate at which heat is transferred through the slab is directly proportional to the area (A) available, therefore the rate at which heat is transferred through the surface of the sphere is proportional to $_2^2 - \ _1^2$.Hence, the correct answer is $_2^2 - \ _1^2$.

---

20. Answer: 0.06 - 0.06

Explanation:

Given that: Potential ( ) = 400 Charge on an electron ( ) = 1.6×10^{-19} Mass of an electron ( ) = 9.1×10^{-31} Planck constant ( ) = 6.63×10^{-34} $= \frac{}{\sqrt{2}}$
$= \frac{6.63 \times 10^{-34}}{\sqrt{2 \times 9.1 \times 10^{-31} \times 1.6 \times 10^{-19} \times 400}} = 0.06 \times 10^{-9}$ $= 0.06$ Hence, the correct answer is '0.06'.

---

21. Answer: c

Explanation:

Explanation:
In the given problem,The radius of the circular disc is 0.2 meter.The uniform magnetic field of induction is $\frac{1}{}(Wbm^{-2})$The axis of the disc is inclined to the magnetic field with an angle of 60 .We need to find the magnetic flux linked with the disc.For this, we have a formula, which gives magnetic flux linked with it: = BAcos ... ... (1) Where, indicates magnetic flux linked with the disc.B indicates magnetic field.A

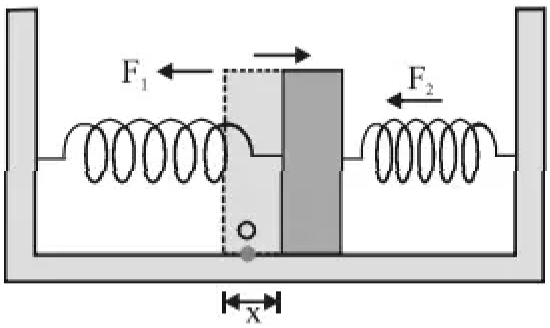
indicates the area of the disc. indicates the inclination of the axis of the disc to the magnetic field.In the formula, we use the cosine component of the magnetic field, because we need to find the magnetic flux, i.e., it means we need to find the total number of magnetic field lines which passes through the given area. The component which lies along the axis of the disc is always the cosine component.The radius of the circular disc is 0.2 meter.We can calculate its area, given by the formula: = ^{2} = $\times (0.2)^2$ m^2 Now, substituting the required values in the equation (1), we get: = BAcos = $\frac{1}{}$ × $\times (0.2)^2 \times \cos 60$ = $0.04 \times \frac{1}{2}$ = 0.02 Wb
Hence, the correct option is (C).

---

22. Answer: a

Explanation:

Explanation:
Let the mass m be displaced by a small distance x to the right as shown in Figure. Under this situation, the spring on the left side gets elongated by a length equal to x and that on the right side gets compressed by the same length. The forces acting on the mass are then,



$_1$ = − (force exerted by the spring on the left side, trying to pull the mass towards the mean position) $_2$ = − (force exerted by the spring on the right side, trying to push the mass towards the mean position)The net force, , acting on the mass is then given by, = − 2 Thus, the force acting on the mass is proportional to the displacement and is directed towards the mean position; therefore, the motion executed by the mass is simple harmonic. The time period of oscillations is, = 2 $\sqrt{\frac{}{2}}$
Hence, the correct option is (A).

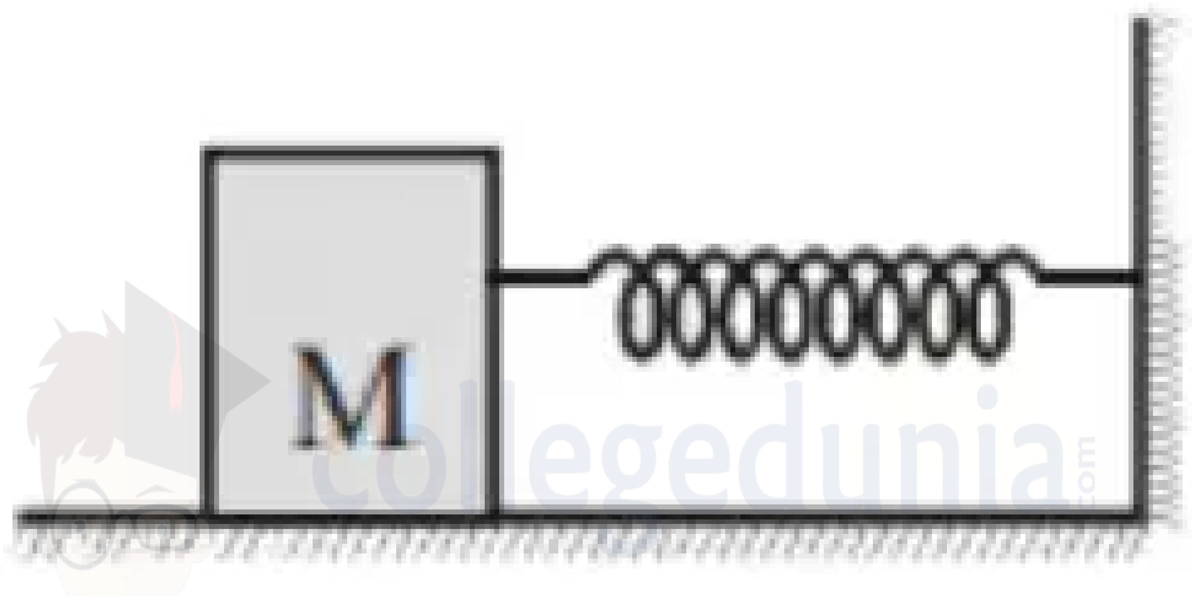
---

23. Answer: b

Explanation:

Let's determine the new amplitude of oscillation after another mass m is gently placed on the existing mass M at equilibrium.

Initially, the mass M attached to a spring with constant k oscillates with amplitude A. The time period of such a simple harmonic oscillator is given by:



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

When the mass is at equilibrium, and mass m is placed on it without any external force, the mass will continue oscillating but with a total mass of $M + m$.

The energy in the system initially (when mass M alone is oscillating) is:

$E_{\text{initial}} = \frac{1}{2}kA^2$

After adding the extra mass, the energy in the system when at maximum amplitude A' becomes:

$E_{\text{final}} = \frac{1}{2}kA'^2$

Since the total mechanical energy of the system is conserved (in the absence of external forces and damping):

$\frac{1}{2}kA^2 = \frac{1}{2}kA'^2$

Therefore, equating the expressions and solving for A':

$$A'^2 = A^2 \cdot \frac{M}{M+m}$$

$$A' = A\sqrt{\frac{M}{M+m}}$$

The new amplitude of oscillation is $A\sqrt{\frac{M}{M+m}}$, corresponding to the option:

$$A\sqrt{\frac{M}{M+m}}$$

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24. **Answer: a**

Explanation:

Angular frequency of pendulum

$\omega = \sqrt{\frac{g_{eff}}{\ell}}$

$\therefore \frac{\Delta\omega}{\omega} = \frac{1}{2}\frac{\Delta g_{eff}}{g_{eff}}$

$\Delta\omega = \frac{1}{2}\frac{\Delta g}{g} \times \omega$

[ω_s = angular frequency of support] $\Delta\omega = \frac{1}{2} \times \frac{2A\omega_s^2}{100} \times 100$

$\Delta\omega = 10^{-3}$ rad/sec.

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25. Answer: d

Explanation:

By momentum conservation

$m\sqrt{2g\ell}\left(1-\cos\theta_0\right) = MV_m - m\sqrt{2g1}\left(1-\cos\theta\right)$

$\Rightarrow m\sqrt{2g\ell}\left\{\sqrt{1-\cos\theta_0}+\sqrt{1-\cos\theta_1}\right\} = MV_m$

and $e = 1 = \frac{V_m+\sqrt{2g\ell(1-\cos\theta_1)}}{\sqrt{2g\ell(1-\cos\theta_0)}}$

$\sqrt{2g\ell}\left(\sqrt{1-\cos\theta_0}-\sqrt{1-\cos\theta_1}\right) = V_m$ ...(I)

$m\sqrt{2g\ell}\left(\sqrt{1-\cos\theta_0}+\sqrt{1-\cos\theta_0}\right) = MV_M$ ....(II)

Dividing

$\frac{\left(\sqrt{1-\cos\theta_0}+\sqrt{1-\cos\theta_1}\right)}{\left(\sqrt{1-\cos\theta_0}-\sqrt{1-\cos\theta_1}\right)} = \frac{M}{m}$

By componendo divided

$\frac{m-M}{m+M} = \frac{\sqrt{1-\cos\theta_1}}{\sqrt{1-\cos\theta_0}} = \frac{\sin\left(\frac{\theta_1}{2}\right)}{\sin\left(\frac{\theta_0}{2}\right)}$

$\Rightarrow \frac{M}{m} = \frac{\theta_0-\theta_1}{\theta_0+\theta_1} \Rightarrow M = \frac{\theta_0-\theta_1}{\theta_0+\theta_1}$

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