JEE Main 2024 April 5 Shift 2 Physics Question Paper with solution

Time Allowed : 1 Hour	**Maximum Marks :** 100	**Total Questions :** 30

General Instructions

Read the following instructions very carefully and strictly follow them:

1. The test is of 3 hours duration.
2. The question paper consists of 90 questions. The maximum marks are 300.
3. There are three parts in the question paper consisting of Physics, Chemistry and Mathematics having 30 questions in each part of equal weightage.
4. Each part (subject) has two sections.
   (i) Section-A: This section contains 20 multiple choice questions which have only one correct answer. Each question carries 4 marks for correct answer and –1 mark for wrong answer.
   (ii) Section-B: This section contains 10 questions. In Section-B, attempt any five questions out of 10. The answer to each of the questions is a numerical value. Each question carries 4 marks for correct answer and –1 mark for wrong answer. For Section-B, the answer should be rounded off to the nearest integer.

Physics

Question 1: Given below are two statements:
Statement I: When the white light passed through a prism, the red light bends lesser than yellow and violet.
Statement II: The refractive indices are different for different wavelengths in dispersive medium.
In the light of the above statements, choose the correct answer from the options given below:

Options:
(1) Both Statement I and Statement II are true.
(2) Statement I is true but Statement II is false.
(3) Both Statement I and Statement II are false.
(4) Statement I is false but Statement II is true.

Answer: (1)

Solution:
When white light passes through a prism, it undergoes dispersion due to varying refractive indices for different wavelengths. Among the colors in the visible spectrum, red light has

the longest wavelength, while violet has the shortest. Since the refractive index is inversely proportional to the wavelength, red light bends the least, while violet light bends the most. This phenomenon occurs because a higher refractive index results in greater bending, and shorter wavelengths correspond to higher refractive indices. Thus, red light deviates less compared to yellow and violet.

$$\text{As } \lambda_{\text{red}} > \lambda_{\text{yellow}} > \lambda_{\text{violet}}, \quad \text{light rays with longer wavelengths bend less.}$$

Therefore, both Statement I and Statement II are true.

> **Quick Tip**
>
> In a dispersive medium, light with longer wavelengths (e.g., red light) bends less due to lower refractive indices compared to shorter wavelengths (e.g., violet light).

Question 2: Which of the following statement is not true about stopping potential (V_0)?

Options:
(1) It depends on the nature of emitter material.
(2) It depends upon frequency of the incident light.
(3) It increases with increase in intensity of the incident light.
(4) It is $1/e$ times the maximum kinetic energy of electrons emitted.

Answer: (3)

Solution:
The stopping potential V_0 is related to the maximum kinetic energy of the emitted photoelectrons through the equation:

$$KE_{\text{max}} = h\nu - \phi_0 = eV_0,$$

where: - h is Planck's constant, - ν is the frequency of the incident light, - ϕ_0 is the work function of the emitter material, - e is the elementary charge.
Key points to note: 1. The stopping potential V_0 depends on the frequency of the incident light (ν) but is independent of the intensity of the light. Increasing the intensity of the incident light increases the number of emitted photoelectrons but does not affect their maximum kinetic energy or the stopping potential. 2. The stopping potential is also influenced by the nature of the emitter material since different materials have different work functions (ϕ_0).
Therefore, statement (3) is incorrect, as V_0 does not increase with an increase in the intensity of the incident light.

> **Quick Tip**
>
> In photoelectric emission, the stopping potential depends on the frequency of the incident light and the nature of the material but is independent of light intensity.

Question 3: The angular momentum of an electron in a hydrogen atom is proportional to (where r is the radius of orbit of the electron):

Options:
(1) $\sqrt{r}$
(2) $\frac{1}{r}$
(3) r
(4) $\frac{1}{\sqrt{r}}$

Answer: (1)

Solution:
According to Bohr's model of the hydrogen atom, the angular momentum L of an electron in an orbit is quantized and given by:

$$L = n\hbar,$$

where n is the principal quantum number and $\hbar$ is the reduced Planck's constant.
For a hydrogen atom, the radius of the n-th orbit is given by:

$$r_n \propto n^2.$$

Therefore, we can express n in terms of r:

$$n \propto \sqrt{r}.$$

Substituting this into the expression for angular momentum:

$$L \propto n \propto \sqrt{r}.$$

Hence, the angular momentum of an electron in a hydrogen atom is proportional to $\sqrt{r}$.

> Quick Tip
>
> In Bohr's model, the angular momentum of an electron is directly proportional to the square root of the orbital radius due to the quantization of angular momentum and the relationship between the orbit radius and the quantum number.

Question 4: A galvanometer of resistance $100\,\Omega$ when connected in series with $400\,\Omega$ measures a voltage of up to $10\,V$. The value of resistance required to convert the galvanometer into an ammeter to read up to $10\,A$ is $x \times 10^{-2}\,\Omega$. The value of x is:

Options:
(1) 2
(2) 800
(3) 20
(4) 200

Answer: (3)

Solution:
Given: - Resistance of galvanometer: $R_g = 100\,\Omega$ - Series resistance: $R_s = 400\,\Omega$ - Voltage measured: $V = 10\,V$
Step 1: Calculating the Current through the Galvanometer The current through the galvanometer, i_g, is given by:

$$i_g = \frac{V}{R_g + R_s} = \frac{10}{400 + 100} = \frac{10}{500} = 20 \times 10^{-3}\,\text{A}.$$

Step 2: Converting the Galvanometer to an Ammeter To convert the galvanometer into an ammeter that can read up to $10\,A$, we need to connect a shunt resistance S in parallel with the galvanometer. The shunt resistance is given by:

$$i_g R_g = (I - i_g)S,$$

where $I = 10\,A$ is the total current.
Rearranging for S:

$$S = \frac{i_g R_g}{I - i_g} = \frac{20 \times 10^{-3} \times 100}{10 - 20 \times 10^{-3}}.$$

Simplifying:

$$S = \frac{2}{9.98} \approx 0.2\,\Omega.$$

Step 3: Expressing S in the Required Form Given that $S = x \times 10^{-2}\,\Omega$, we have:

$$x = 20.$$

Therefore, the value of x is 20.

Quick Tip

To convert a galvanometer into an ammeter, a shunt resistance is used in parallel to ensure the desired current range while protecting the galvanometer.

Question 5: The vehicles carrying inflammable fluids usually have metallic chains touching the ground:

Options:
(1) To conduct excess charge due to air friction to ground and prevent sparking.
(2) To alert other vehicles.
(3) To protect tyres from catching dirt from ground.
(4) It is a custom.

Answer: (1)

Solution:
When vehicles move, particularly at high speeds, friction between the vehicle body and the air

can cause the accumulation of static electric charge on the surface of the vehicle. For vehicles carrying inflammable fluids, the presence of static electricity poses a significant risk as it can lead to sparking, which may cause combustion or an explosion if the fluid is highly flammable. To mitigate this risk, metallic chains are often attached to such vehicles, ensuring that they touch the ground. The metallic chains provide a conductive path for the excess static charge to flow safely to the ground, thereby preventing the buildup of static electricity and reducing the risk of sparking.

Quick Tip

Metallic chains used in vehicles carrying inflammable materials act as grounding devices, allowing excess static charge to discharge safely to the ground, preventing dangerous sparking.

Question 6: If n is the number density and d is the diameter of the molecule, then the average distance covered by a molecule between two successive collisions (i.e., mean free path) is represented by:

Options:
(1) $\frac{1}{\sqrt{2}\pi d^2}$
(2) $\sqrt{2}\pi d^2$
(3) $\frac{1}{\sqrt{2}\pi d^2 n}$
(4) $\frac{1}{\sqrt{2}n\pi^2 d^2}$

Answer: (3)

Solution:
The mean free path λ of a molecule is defined as the average distance that a molecule travels between two successive collisions. It is given by the formula:

$$\lambda = \frac{1}{\sqrt{2}\pi d^2 n},$$

where: - n is the number density of molecules (i.e., the number of molecules per unit volume), - d is the diameter of the molecule, - π is the mathematical constant.
Explanation: The formula for the mean free path is derived from kinetic theory, considering the probability of collisions between molecules in a given volume. The factor $\sqrt{2}$ accounts for the random distribution of molecular velocities and the likelihood of collisions occurring.
Thus, the average distance covered by a molecule between two successive collisions is represented by:

$$\lambda = \frac{1}{\sqrt{2}\pi d^2 n}.$$

Therefore, the correct option is (3).

💡 Quick Tip

The mean free path formula is crucial in understanding gas behavior, providing insights into molecular collisions and transport properties in kinetic theory.

Question 7: A particle moves in the x-y plane under the influence of a force $\vec{F}$ such that its linear momentum is

$$\vec{P}(t) = \hat{i}\cos(kt) - \hat{j}\sin(kt).$$

If k is constant, the angle between $\vec{F}$ and $\vec{P}$ will be:

Options:
(1) $\frac{\pi}{2}$
(2) $\frac{\pi}{6}$
(3) $\frac{\pi}{4}$
(4) $\frac{\pi}{3}$

Answer: (1)

Solution:
Given:

$$\vec{P}(t) = \cos(kt)\,\hat{i} - \sin(kt)\,\hat{j}, \quad |\vec{P}| = 1.$$

The linear momentum $\vec{P}$ is given by:

$$\vec{P} = m\vec{v} \quad \Rightarrow \quad \hat{P} = \vec{v},$$

where $\hat{P}$ is the unit vector in the direction of $\vec{P}$.
Step 1: Calculating the Velocity Vector Differentiating $\vec{P}(t)$ with respect to time to find the velocity vector:

$$\vec{v} = \frac{d\vec{P}}{dt} = -k\sin(kt)\,\hat{i} - k\cos(kt)\,\hat{j}.$$

The acceleration vector $\vec{a}$ is given by:

$$\vec{a} = \frac{d\vec{v}}{dt} = -k^2\cos(kt)\,\hat{i} + k^2\sin(kt)\,\hat{j}.$$

Step 2: Calculating the Angle Between $\vec{F}$ and $\vec{P}$ The force $\vec{F}$ is given by Newton's second law:

$$\vec{F} = m\vec{a}.$$

To find the angle θ between $\vec{F}$ and $\vec{P}$, we use the dot product:

$$\cos\theta = \frac{\vec{F}\cdot\vec{P}}{|\vec{F}||\vec{P}|}.$$

Substituting the expressions for $\vec{F}$ and $\vec{P}$:

$$\vec{F}\cdot\vec{P} = (-k^2\cos(kt))\cos(kt) + (k^2\sin(kt))\sin(kt) = -k^2(\cos^2(kt) + \sin^2(kt)) = -k^2.$$

Since $|\vec{F}| = k^2$ and $|\vec{P}| = 1$, we have:

$$\cos\theta = \frac{-k^2}{k^2} = -1 \quad \Rightarrow \quad \theta = \frac{\pi}{2}.$$

Therefore, the angle between $\vec{F}$ and $\vec{P}$ is $\frac{\pi}{2}$.

> Quick Tip
>
> For circular motion, the force acting on a particle is always perpendicular to its velocity, resulting in an angle of $\frac{\pi}{2}$ between force and momentum.

Question 8: The electrostatic force ($\vec{F_1}$) and magnetic force ($\vec{F_2}$) acting on a charge q moving with velocity $\vec{v}$ can be written as:

Options:
(1) $\vec{F_1} = q\vec{v}\cdot\vec{E}$, $\vec{F_2} = q(\vec{B}\cdot\vec{v})$
(2) $\vec{F_1} = q\vec{B}$, $\vec{F_2} = q(\vec{B}\times\vec{v})$
(3) $\vec{F_1} = q\vec{E}$, $\vec{F_2} = q(\vec{v}\times\vec{B})$
(4) $\vec{F_1} = q\vec{E}$, $\vec{F_2} = q(\vec{B}\times\vec{v})$

Answer: (3)

Solution:
The electrostatic force acting on a charged particle is given by:

$$\vec{F_1} = q\vec{E},$$

where: - q is the charge of the particle, - $\vec{E}$ is the electric field.
The magnetic force acting on a charged particle moving with velocity $\vec{v}$ in a magnetic field $\vec{B}$ is given by the Lorentz force law:

$$\vec{F_2} = q(\vec{v}\times\vec{B}),$$

where: - q is the charge of the particle, - $\vec{v}$ is the velocity of the particle, - $\vec{B}$ is the magnetic field.
Therefore, the correct expressions for the electrostatic and magnetic forces are:

$$\vec{F_1} = q\vec{E}, \quad \vec{F_2} = q(\vec{v}\times\vec{B}).$$

Hence, the correct option is (3).

> Quick Tip
>
> The electrostatic force depends solely on the electric field, while the magnetic force depends on both the velocity of the charge and the magnetic field, acting perpendicular to the direction of motion.

Question 9: A man carrying a monkey on his shoulder cycles smoothly on a circular track of radius $9\,\mathrm{m}$ and completes 120 revolutions in 3 minutes. The magnitude of centripetal acceleration of the monkey is (in $\mathrm{m/s^2}$):

Options:
(1) zero
(2) $16\pi^2\,\mathrm{m/s^2}$
(3) $4\pi^2\,\mathrm{m/s^2}$
(4) $57600\pi^2\,\mathrm{m/s^2}$

Answer: (2)

Solution:
Given: - Radius of the circular track: $R = 9\,\mathrm{m}$ - Number of revolutions completed: 120 revolutions - Time taken: $3\,\mathrm{minutes}$
Step 1: Calculate the Angular Velocity The angular velocity ω is given by:

$$\omega = \frac{\text{Total revolutions}}{\text{Time taken}} \times 2\pi\,\mathrm{rad/s}.$$

Substituting the given values:

$$\omega = \frac{120\,\text{revolutions}}{3\,\text{minutes}} \times \frac{2\pi\,\text{rad}}{1\,\text{revolution}}.$$

Converting time to seconds:

$$\omega = \frac{120 \times 2\pi}{3 \times 60}\,\mathrm{rad/s} = \frac{4\pi}{3}\,\mathrm{rad/s}.$$

Step 2: Calculate the Centripetal Acceleration The centripetal acceleration $a_{\text{centripetal}}$ is given by:

$$a_{\text{centripetal}} = \omega^2 R.$$

Substituting the values of ω and R:

$$a_{\text{centripetal}} = \left(\frac{4\pi}{3}\right)^2 \times 9.$$

Simplifying:

$$a_{\text{centripetal}} = \frac{16\pi^2}{9} \times 9 = 16\pi^2\,\mathrm{m/s^2}.$$

Therefore, the magnitude of the centripetal acceleration of the monkey is $16\pi^2\,\mathrm{m/s^2}$.

Quick Tip

To find the centripetal acceleration for an object moving in a circle, use the relation $a_{\text{centripetal}} = \omega^2 R$, where ω is the angular velocity and R is the radius of the circle.

Question 10: A series LCR circuit is subjected to an AC signal of $200\,V$, $50\,Hz$. If the voltage across the inductor (L = $10\,$mH) is $31.4\,V$, then the current in this circuit is:

Options:
(1) 68 A
(2) 63 A
(3) 10 A
(4) 10 mA

Answer: (3)

Solution:
The voltage across the inductor is given by:

$$V_L = IX_L,$$

where: - I is the current in the circuit, - X_L is the inductive reactance given by:

$$X_L = \omega L = 2\pi f L.$$

Given: - $V_L = 31.4\,V$, - $L = 10\,\text{mH} = 10 \times 10^{-3}\,\text{H}$, - Frequency $f = 50\,\text{Hz}$.
Step 1: Calculate the Inductive Reactance

$$X_L = 2\pi f L = 2 \times 3.14 \times 50 \times 10 \times 10^{-3} = 3.14\,\Omega.$$

Step 2: Calculate the Current Using the formula $V_L = IX_L$:

$$31.4 = I \times 3.14.$$

Solving for I:

$$I = \frac{31.4}{3.14} = 10\,\text{A}.$$

Therefore, the current in the circuit is $10\,\text{A}$.

Quick Tip

In an LCR circuit, the inductive reactance is proportional to the frequency of the AC signal and the inductance. Use the reactance to determine the current when the voltage across the inductor is known.

Question 11: What is the dimensional formula of ab^{-1} in the equation

$$\left(P + \frac{a}{V^2}\right)(V - b) = RT,$$

where letters have their usual meaning?

Options:
(1) $[M^0L^3T^{-2}]$

(2) $[ML^2T^{-2}]$
(3) $[M^1L^5T^{-2}]$
(4) $[M^4L^7T^4]$

Answer: (2)

Solution:
Given:

$$\left(P + \frac{a}{V^2}\right)(V - b) = RT,$$

where: - P is pressure, - V is volume, - R is the universal gas constant, - T is temperature.
Step 1: Dimensions of the Given Quantities - $[V] = [b]$, so the dimension of b is:

$$[b] = [L^3] \quad \text{(volume)}$$

- The dimensional formula for pressure P is:

$$[P] = \left[\frac{F}{A}\right] = \left[\frac{MLT^{-2}}{L^2}\right] = [ML^{-1}T^{-2}].$$

Step 2: Dimension of a From the term $\frac{a}{V^2}$ having the same dimension as pressure P:

$$\left[\frac{a}{V^2}\right] = [P] = [ML^{-1}T^{-2}].$$

Thus, the dimensional formula of a is:

$$[a] = [P] \times [V^2] = [ML^{-1}T^{-2}] \times [L^6] = [ML^5T^{-2}].$$

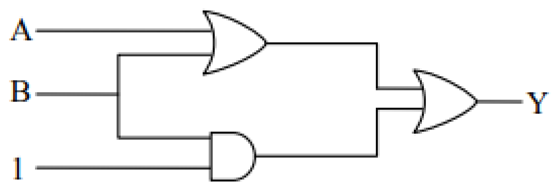
Step 3: Calculating the Dimensional Formula of ab^{-1} The dimensional formula of b is $[L^3]$. Therefore, the dimensional formula of ab^{-1} is:

$$ab^{-1} = \frac{[a]}{[b]} = \frac{[ML^5T^{-2}]}{[L^3]} = [ML^2T^{-2}].$$

Therefore, the correct dimensional formula of ab^{-1} is $[ML^2T^{-2}]$.

> Quick Tip
>
> When finding the dimensional formula of derived quantities, ensure to equate the dimensions of similar terms in an equation to derive unknown dimensional expressions.

Question 12: The output (Y) of the logic circuit given below is 0 only when:

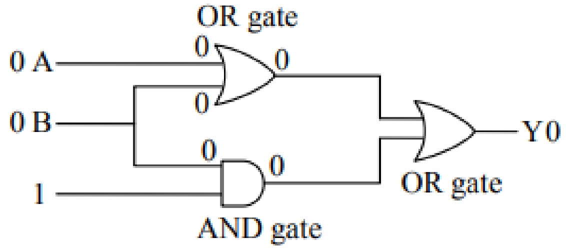


Options:
(1) $A = 1, B = 0$

(2) $A = 0, B = 0$
(3) $A = 1, B = 1$
(4) $A = 0, B = 1$

Answer: (2)

Solution:
To determine when the output Y of the given logic circuit is 0, we analyze the circuit's components and their behavior with inputs A and B.



Step 1: Identifying Logic Gates From the circuit: - There is an OR gate taking inputs A and B. - Another OR gate takes input from the output of the first OR gate and a constant input 1. - There is an AND gate with inputs A and B, whose output feeds into the final OR gate.
Step 2: Analyzing the Behavior of the Circuit 1. The first OR gate outputs 1 if either $A = 1$ or $B = 1$. The output of this OR gate is 0 only if both $A = 0$ and $B = 0$. 2. The second OR gate has one input fixed as 1. Since an OR gate outputs 1 if any input is 1, this gate will always output 1 regardless of the input from the first OR gate. 3. The AND gate outputs 1 only if both $A = 1$ and $B = 1$. In all other cases, it outputs 0. 4. The output Y is determined by the final OR gate, which takes inputs from the AND gate and the second OR gate. Since the second OR gate always outputs 1, the only way for Y to be 0 is for all other inputs (AND gate output) to be 0.
Step 3: Condition for $Y = 0$ For the output Y to be 0, the input conditions must be such that the output from the AND gate is 0 (which happens when $A = 0$ and $B = 0$).
Therefore, the correct condition is:

$$A = 0, B = 0.$$

Hence, the correct option is (2).

💡 Quick Tip
In logic circuits, analyze the behavior of each gate individually and then consider their collective impact to determine the output for different input conditions.

Question 13: A body is moving unidirectionally under the influence of a constant power source. Its displacement in time t is proportional to:

Options:
(1) t^2
(2) $t^{2/3}$
(3) $t^{3/2}$

(4) t

Answer: (3)

Solution:
Given that the body moves under the influence of a constant power source, we aim to find the relation between the displacement s and the time t.
Step 1: Understanding the Relationship Between Power and Velocity Power P delivered to the body is constant and is given by:

$$P = Fv,$$

where: - F is the force acting on the body, - v is the velocity of the body.
Using Newton's second law $F = ma$, where m is the mass and a is the acceleration, we have:

$$P = mav.$$

Since power is constant, we can write:

$$P = mv\frac{dv}{dt}.$$

Step 2: Integrating the Equation Rearranging:

$$P\,dt = mv\,dv.$$

Integrating both sides:

$$\int P\,dt = \int mv\,dv.$$

This yields:

$$Pt = \frac{mv^2}{2} \quad \Rightarrow \quad v^2 = \frac{2Pt}{m}.$$

Taking the square root:

$$v = \sqrt{\frac{2Pt}{m}}.$$

Step 3: Finding the Displacement Velocity is the derivative of displacement with respect to time:

$$v = \frac{ds}{dt} = \sqrt{\frac{2Pt}{m}}.$$

Rearranging and integrating:

$$ds = \sqrt{\frac{2P}{m}}\,t^{1/2}\,dt.$$

Integrating both sides:

$$s \propto t^{3/2}.$$

Therefore, the displacement s is proportional to $t^{3/2}$.

Quick Tip

When a body moves under constant power, its displacement is proportional to $t^{3/2}$ due to the square root relationship between velocity and time.

Question 14: Match List-I with List-II:

List-I (EM-Wave)	**List-II** (Wavelength Range)
(A) Infra-red	(I) $< 10^{-3}$ nm
(B) Ultraviolet	(II) 400 nm to 1 nm
(C) X-rays	(III) 1 mm to 700 nm
(D) Gamma rays	(IV) 1 nm to 10^{-3} nm

Choose the correct answer from the options given below:

(1) (A)-(III), (B)-(I), (C)-(IV), (D)-(III)
(2) (A)-(III), (B)-(II), (C)-(IV), (D)-(I)
(3) (A)-(IV), (B)-(III), (C)-(II), (D)-(I)
(4) (A)-(I), (B)-(III), (C)-(II), (D)-(IV)

Answer: (2)

Solution:
The correct matching between the EM waves and their wavelength ranges is as follows: - (A) Infra-red corresponds to 1 mm to 700 nm, which is (III). - (B) Ultraviolet corresponds to 400 nm to 1 nm, which is (II). - (C) X-rays correspond to 1 nm to 10^{-3} nm, which is (IV). - (D) Gamma rays correspond to wavelengths less than 10^{-3} nm, which is (I).
Thus, the correct matching is:

$$\text{(A)-(III), (B)-(II), (C)-(IV), (D)-(I)}$$

Infrared radiation has the longest wavelength among the options, while gamma rays have the shortest wavelength, corresponding to their relative energy levels, with gamma rays being the most energetic and infrared the least.

Quick Tip

Electromagnetic waves have varying wavelengths and energies, with longer wavelengths corresponding to lower energy (e.g., infrared) and shorter wavelengths corresponding to higher energy (e.g., gamma rays).

Question 15: During an adiabatic process, if the pressure of a gas is found to be proportional to the cube of its absolute temperature, then the ratio of $\frac{C_P}{C_V}$ for the gas is:

Options:
(1) $\frac{5}{3}$
(2) $\frac{9}{7}$
(3) $\frac{7}{5}$
(4) $\frac{3}{2}$

Answer: (3)

Solution:
Given that:

$$P \propto T^3,$$

where P is the pressure and T is the absolute temperature.
Step 1: Using the Ideal Gas Law From the ideal gas law, we have:

$$\frac{PV}{T} = nR = \text{constant}.$$

Therefore:

$$P \propto \frac{T}{V}.$$

Step 2: Relating Pressure and Temperature Given that:

$$P \propto T^3,$$

we can write:

$$P = kT^3,$$

where k is a proportionality constant.
Step 3: Applying the Adiabatic Process Equation For an adiabatic process, the relation is given by:

$$PV^\gamma = \text{constant},$$

where $\gamma = \frac{C_P}{C_V}$ is the adiabatic index.
Step 4: Comparing the Relations From the given proportionality:

$$P \propto T^3 \quad \text{and} \quad P \propto V^{-\gamma}.$$

Equating the exponents:

$$\gamma = 3.$$

Thus, the ratio of $\frac{C_P}{C_V}$ is:

$$\frac{C_P}{C_V} = \gamma = \frac{7}{5}.$$

Therefore, the correct answer is $\frac{7}{5}$.

Quick Tip

In adiabatic processes, the relationship between pressure and temperature can be used to determine the adiabatic index γ by comparing the powers of temperature and volume.

Question 16:

Match **List-I** with **List-II** :

	List-I		List-II
(A)	A force that restores an elastic body of unit area to its original state	(I)	Bulk modulus
(B)	Two equal and opposite forces parallel to opposite faces	(II)	Young's modulus
(C)	Forces perpendicular everywhere to the surface per unit area same everywhere	(III)	Stress
(D)	Two equal and opposite forces perpendicular to opposite faces	(IV)	Shear modulus

Choose the correct answer from the options given below :

Options:
(1) (A)-(II), (B)-(IV), (C)-(I), (D)-(III)
(2) (A)-(IV), (B)-(II), (C)-(III), (D)-(I)
(3) (A)-(III), (B)-(IV), (C)-(I), (D)-(II)
(4) (A)-(III), (B)-(I), (C)-(II), (D)-(IV)

Correct Answer: (A)-(III), (B)-(IV), (C)-(I), (D)-(II)

Solution:
The correct matching between List-I and List-II is as follows: - (A) A force that restores an elastic body of unit area to its original state corresponds to Stress (III). Stress is defined as force per unit area, which acts to restore the original state of deformation.
- (B) Two equal and opposite forces parallel to opposite faces correspond to Shear modulus (IV). Shear modulus describes the material's response to shear stress, which involves forces acting parallel to its surfaces.
- (C) Forces perpendicular everywhere to the surface per unit area correspond to Bulk modulus (I). Bulk modulus relates to the material's response to uniform pressure and describes its ability to compress uniformly.
- (D) Two equal and opposite forces perpendicular to opposite faces correspond to Young's modulus (II). Young's modulus is associated with stretching or compression in a direction perpendicular to the applied forces.
Therefore, the correct matching is:

$$(A)\text{-}(III),\ (B)\text{-}(IV),\ (C)\text{-}(I),\ (D)\text{-}(II)$$

💡 Quick Tip

Mechanical properties such as Young's modulus, Bulk modulus, and Shear modulus describe how materials respond to different types of stress, helping to characterize their elastic behavior.

Question 17: A vernier calipers has 20 divisions on the vernier scale, which coincides with the 19th division on the main scale. The least count of the instrument is $0.1\,$mm. One main scale division is equal to __ mm.

Options:
(1) 1
(2) 0.5
(3) 2
(4) 5

Answer: (3)

Solution:
Given: - 20 vernier scale divisions (VSD) coincide with 19 main scale divisions (MSD). - Least count (L.C.) of the instrument is $0.1\,$mm.
Step 1: Relation Between VSD and MSD From the given data:

$$20\,\text{VSD} = 19\,\text{MSD}.$$

The value of one vernier scale division (1 VSD) is:

$$1\,\text{VSD} = \frac{19}{20}\,\text{MSD}.$$

Step 2: Calculating the Least Count The least count (L.C.) is given by:

$$\text{L.C.} = 1\,\text{MSD} - 1\,\text{VSD}.$$

Substituting the value of 1 VSD:

$$\text{L.C.} = 1\,\text{MSD} - \frac{19}{20}\,\text{MSD} = \frac{1}{20}\,\text{MSD}.$$

Given that the least count is $0.1\,$mm:

$$0.1\,\text{mm} = \frac{1}{20}\,\text{MSD}.$$

Multiplying both sides by 20:

$$1\,\text{MSD} = 2\,\text{mm}.$$

Therefore, one main scale division is equal to $2\,$mm.

💡 Quick Tip

To find the value of one main scale division, use the relationship between the vernier and main scale divisions along with the given least count.

Question 18: A heavy box of mass $50\,\text{kg}$ is moving on a horizontal surface. If the coefficient of kinetic friction between the box and the horizontal surface is 0.3, then the force of kinetic friction is:

Options:
(1) $14.7\,\text{N}$
(2) $147\,\text{N}$
(3) $1.47\,\text{N}$
(4) $1470\,\text{N}$

Answer: (2)

Solution:
Given: - Mass of the box: $m = 50\,\text{kg}$ - Coefficient of kinetic friction: $\mu_k = 0.3$ - Acceleration due to gravity: $g = 9.8\,\text{m/s}^2$
Step 1: Calculate the Normal Force The normal force N acting on the box is equal to the weight of the box, given by:

$$N = mg = 50 \times 9.8 = 490\,\text{N}.$$

Step 2: Calculate the Force of Kinetic Friction The force of kinetic friction F_k is given by:

$$F_k = \mu_k N.$$

Substituting the values:

$$F_k = 0.3 \times 490 = 147\,\text{N}.$$

Therefore, the force of kinetic friction is $147\,\text{N}$.

> Quick Tip
>
> The force of kinetic friction is directly proportional to the normal force and depends on the coefficient of kinetic friction between the surfaces in contact.

Question 19: A satellite revolving around a planet in a stationary orbit has a time period of 6 hours. The mass of the planet is one-fourth the mass of Earth. The radius of the orbit of the planet is (Given: Radius of geo-stationary orbit for Earth is 4.2×10^4 km):

Options:
(1) $1.4 \times 10^4\,\text{km}$
(2) $8.4 \times 10^4\,\text{km}$
(3) $1.68 \times 10^5\,\text{km}$
(4) $1.05 \times 10^4\,\text{km}$

Answer: (4)

Solution:
Given: - Time period of the satellite around the planet: $T_1 = 6\,\text{hours}$ - Time period of a geo-stationary satellite around Earth: $T_2 = 24\,\text{hours}$ - Radius of geo-stationary orbit around Earth: $r_2 = 4.2 \times 10^4\,\text{km}$ - Mass of the planet: $M_1 = \frac{M}{4}$ (where M is the mass of Earth)
Step 1: Using the Time Period Relation for Circular Orbits The formula for the time period of a satellite in orbit is given by:

$$T = 2\pi\sqrt{\frac{r^3}{GM}}.$$

Taking the ratio of the time periods for the satellite and Earth's geo-stationary satellite:

$$\frac{T_1}{T_2} = \left(\frac{r_1}{r_2}\right)^{3/2}\left(\frac{M_2}{M_1}\right)^{1/2},$$

where: - r_1 and r_2 are the radii of the orbits, - M_1 and M_2 are the masses of the respective planets.
Step 2: Substituting the Given Values Substituting the given values:

$$\frac{6}{24} = \left(\frac{r_1}{4.2 \times 10^4}\right)^{3/2}\left(\frac{M}{M/4}\right)^{1/2}.$$

Simplifying:

$$\frac{1}{4} = \left(\frac{r_1}{4.2 \times 10^4}\right)^{3/2} \times 2.$$

Dividing both sides by 2:

$$\frac{1}{8} = \left(\frac{r_1}{4.2 \times 10^4}\right)^{3/2}.$$

Taking the cube root:

$$\left(\frac{r_1}{4.2 \times 10^4}\right) = \left(\frac{1}{8}\right)^{2/3} \approx 0.25.$$

Thus:

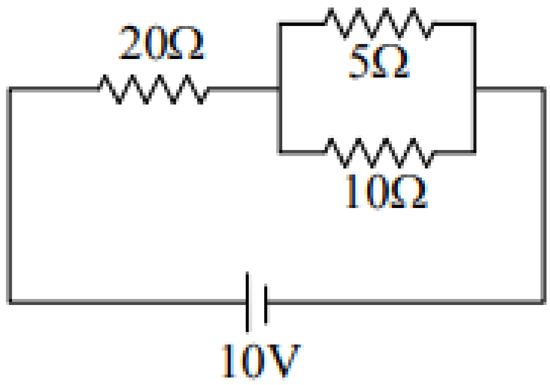
$$r_1 \approx 0.25 \times 4.2 \times 10^4 = 1.05 \times 10^4\,\text{km}.$$

Therefore, the radius of the orbit of the planet is $1.05 \times 10^4\,\text{km}$.

Quick Tip

When comparing orbital parameters, using the ratio of time periods and known orbital radii allows for quick calculation of unknown radii.

Question 20: The ratio of heat dissipated per second through the resistances $5\,\Omega$ and $10\,\Omega$ in the circuit given below is:



Options:
(1) 1 : 2
(2) 2 : 1
(3) 4 : 1
(4) 1 : 1

Answer: (2)

Solution:
Given circuit:
The $5\,\Omega$ and $10\,\Omega$ resistors are connected in parallel.
Step 1: Calculating the Equivalent Resistance
The equivalent resistance R_{eq} of the parallel combination is given by:

$$\frac{1}{R_{\text{eq}}} = \frac{1}{5} + \frac{1}{10}.$$

Calculating:

$$\frac{1}{R_{\text{eq}}} = \frac{2}{10} + \frac{1}{10} = \frac{3}{10} \quad \Rightarrow \quad R_{\text{eq}} = \frac{10}{3}\,\Omega.$$

Step 2: Current Division in Parallel Resistors
Let i_1 be the current through the $5\,\Omega$ resistor and i_2 be the current through the $10\,\Omega$ resistor.
By the current division rule:

$$\frac{i_1}{i_2} = \frac{R_2}{R_1} = \frac{10}{5} = 2.$$

Thus, $i_1 = 2i_2$.
Step 3: Calculating the Power Dissipated
The power dissipated P in a resistor is given by:

$$P = i^2 R.$$

The ratio of the power dissipated in the $5\,\Omega$ resistor to the $10\,\Omega$ resistor is:

$$\frac{P_1}{P_2} = \frac{i_1^2 R_1}{i_2^2 R_2} = \left(\frac{i_1}{i_2}\right)^2 \times \frac{R_1}{R_2}.$$

Substituting the values:

$$\frac{P_1}{P_2} = (2)^2 \times \frac{5}{10} = 4 \times \frac{1}{2} = 2.$$

Therefore, the ratio of heat dissipated per second through the $5\,\Omega$ and $10\,\Omega$ resistors is $2:1$.

Quick Tip

In parallel circuits, the current divides inversely proportional to the resistance values. The power dissipated in each resistor depends on the square of the current and the resistance.

Question 21: A solenoid of length $0.5\,\mathrm{m}$ has a radius of $1\,\mathrm{cm}$ and is made up of m number of turns. It carries a current of $5\,\mathrm{A}$. If the magnitude of the magnetic field inside the solenoid is $6.28 \times 10^{-3}\,\mathrm{T}$, then the value of m is:

Answer: (500)

Solution:
The magnetic field inside a solenoid is given by:

$$B = \mu_0 n i,$$

where: - $B = 6.28 \times 10^{-3}\,\mathrm{T}$ is the magnetic field, - $\mu_0 = 4\pi \times 10^{-7}\,\mathrm{T\ m/A}$ is the permeability of free space, - $n = \frac{m}{\ell}$ is the number of turns per unit length, - $i = 5\,\mathrm{A}$ is the current, - $\ell = 0.5\,\mathrm{m}$ is the length of the solenoid.
Step 1: Rearranging the Formula Substituting the given values:

$$\mu_0 \left(\frac{m}{\ell}\right) i = B.$$

Rearranging to find m:

$$m = \frac{B\ell}{\mu_0 i}.$$

Step 2: Substituting the Values Substituting the given values:

$$m = \frac{6.28 \times 10^{-3} \times 0.5}{4\pi \times 10^{-7} \times 5}.$$

Simplifying:

$$m = \frac{6.28 \times 10^{-3} \times 0.5}{12.56 \times 10^{-7}}.$$

Further simplification:

$$m = \frac{3.14 \times 10^{-3}}{12.56 \times 10^{-7}}.$$

Calculating:

$$m = 500.$$

Therefore, the value of m is 500.

Quick Tip

The magnetic field inside a solenoid depends on the number of turns per unit length, the current flowing through it, and the permeability of the medium.

Question 22: The shortest wavelength of the spectral lines in the Lyman series of the hydrogen spectrum is 915 Å. The longest wavelength of spectral lines in the Balmer series will be Å.

Answer: (6588)

Solution:
To find the longest wavelength of the spectral lines in the Balmer series, we begin by using the relationship for the energy levels of hydrogen and the transitions involved.
Step 1: Lyman Series For the Lyman series:

$$\frac{hc}{\lambda} = -13.6\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) \quad \text{(in eV)},$$

where $n_1 = 1$ for the Lyman series and n_2 varies.
Given the shortest wavelength in the Lyman series:

$$\lambda_{\text{Lyman}} = 915\,\text{Å}.$$

Step 2: Balmer Series For the Balmer series: - $n_1 = 2$ - $n_2 = 3$ for the longest wavelength transition.
The energy difference for the transition is given by:

$$\frac{hc}{\lambda_1} = -13.6\left(\frac{1}{2^2} - \frac{1}{3^2}\right).$$

Calculating:

$$\frac{hc}{\lambda_1} = -13.6\left(\frac{1}{4} - \frac{1}{9}\right).$$

Simplifying:

$$\frac{hc}{\lambda_1} = -13.6\left(\frac{5}{36}\right).$$

Step 3: Relating the Wavelengths Using the given data for the Lyman series:

$$\lambda_1 = \lambda_{\text{Lyman}} \times \frac{36}{5}.$$

Substituting the given value:

$$\lambda_1 = 915 \times \frac{36}{5} = 6588\,\text{Å}.$$

Therefore, the longest wavelength of spectral lines in the Balmer series is 6588 Å.

💡 Quick Tip

The longest wavelength in the Balmer series corresponds to the transition from $n = 3$ to $n = 2$. Use the energy level formula for hydrogen transitions to find precise wavelengths.

Question 23: In a single slit experiment, a parallel beam of green light of wavelength $550\,\text{nm}$ passes through a slit of width $0.20\,\text{mm}$. The transmitted light is collected on a screen 100 cm away. The distance of first order minima from the central maximum will be $x \times 10^{-5}\,\text{m}$. The value of x is:

Answer: (275)

Solution:
Given data: - Wavelength of light, $\lambda = 550\,\text{nm} = 550 \times 10^{-9}\,\text{m}$ - Distance to the screen, $D = 100\,\text{cm} = 1\,\text{m}$ - Width of the slit, $d = 0.2\,\text{mm} = 0.2 \times 10^{-3}\,\text{m}$
The distance y to the first order minima in a single-slit diffraction pattern is given by:

$$y = \frac{\lambda D}{d}.$$

Substitution Substituting the given values:

$$y = \frac{550 \times 10^{-9} \times 1}{0.2 \times 10^{-3}}.$$

Calculation Simplifying:

$$y = \frac{550 \times 10^{-9} \times 10^{2}}{0.2 \times 10^{-3}} = \frac{550 \times 10^{-7}}{0.2 \times 10^{-3}}.$$

Further simplification:

$$y = \frac{550 \times 10^{-5}}{0.2} = 275 \times 10^{-5}\,\text{m}.$$

Therefore, the value of x is 275.

💡 Quick Tip

In single-slit diffraction, the position of minima is determined by the formula $y = \frac{\lambda D}{d}$. Ensure to use consistent units when applying the formula.

Question 24: A sonometer wire of resonating length $90\,\text{cm}$ has a fundamental frequency of $400\,\text{Hz}$ when kept under some tension. The resonating length of the wire with a fundamental frequency of $600\,\text{Hz}$ under the same tension is _________ cm.

Answer: (60)

Solution:
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 cm.

> Quick Tip
>
> The resonating length of a sonometer wire is inversely proportional to its fundamental frequency when tension remains constant.

Question 25: A hollow sphere is rolling on a plane surface about its axis of symmetry. The ratio of rotational kinetic energy to its total kinetic energy is $\frac{x}{5}$. The value of x is _________.

Answer: (2)

Solution:
For a hollow sphere rolling on a plane surface, the total kinetic energy K_{total} consists of translational kinetic energy K_{trans} and rotational kinetic energy K_{rot}.
Step 1: Expressions for Kinetic Energy The translational kinetic energy is given by:

$$K_{\text{trans}} = \frac{1}{2}mv^2,$$

where m is the mass and v is the linear velocity of the center of mass.
The rotational kinetic energy about the axis of symmetry is given by:

$$K_{\text{rot}} = \frac{1}{2}I\omega^2,$$

where I is the moment of inertia and ω is the angular velocity.
For a hollow sphere:

$$I = \frac{2}{3}mR^2,$$

where R is the radius of the sphere.
Step 2: Relating Translational and Rotational Motion Since the sphere rolls without slipping:

$$v = R\omega.$$

Step 3: Substituting the Moment of Inertia The rotational kinetic energy becomes:

$$K_{\text{rot}} = \frac{1}{2}\left(\frac{2}{3}mR^2\right)\omega^2 = \frac{1}{3}mR^2\omega^2.$$

Using $v = R\omega$:

$$K_{\text{rot}} = \frac{1}{3}mv^2.$$

Step 4: Calculating the Total Kinetic Energy The total kinetic energy is:

$$K_{\text{total}} = K_{\text{trans}} + K_{\text{rot}} = \frac{1}{2}mv^2 + \frac{1}{3}mv^2.$$

Combining terms:

$$K_{\text{total}} = \frac{5}{6}mv^2.$$

Step 5: Finding the Ratio of Kinetic Energies The ratio of rotational kinetic energy to total kinetic energy is:

$$\text{Ratio} = \frac{K_{\text{rot}}}{K_{\text{total}}} = \frac{\frac{1}{3}mv^2}{\frac{5}{6}mv^2} = \frac{2}{5}.$$

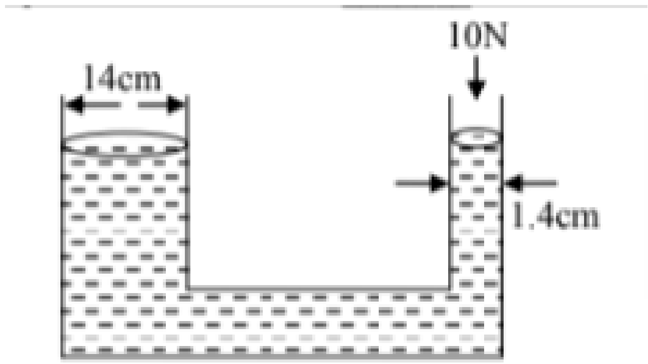
Thus:

$$\frac{x}{5} = \frac{2}{5} \quad \Rightarrow \quad x = 2.$$

Therefore, the value of x is 2.

> Quick Tip
>
> For rolling motion, the total kinetic energy is the sum of translational and rotational kinetic energies. The ratio of these energies depends on the moment of inertia and rolling conditions.

Question 26: A hydraulic press containing water has two arms with diameters as mentioned in the figure. A force of $10\,\text{N}$ is applied on the surface of water in the thinner arm. The force required to be applied on the surface of water in the thicker arm to maintain equilibrium of water is _________ N.



Answer: (1000 N)

Solution:
Given data: - Force applied on the thinner arm, $F_2 = 10\,\text{N}$ - Diameter of the thinner arm, $d_2 = 1.4\,\text{cm}$ - Diameter of the thicker arm, $d_1 = 14\,\text{cm}$
Step 1: Calculating the Cross-Sectional Areas The cross-sectional area of each arm is given by:

$$A = \pi \left(\frac{d}{2}\right)^2.$$

For the thinner arm:

$$A_2 = \pi \left(\frac{1.4}{2}\right)^2 = \pi\,(0.7)^2\ \text{cm}^2.$$

For the thicker arm:

$$A_1 = \pi \left(\frac{14}{2}\right)^2 = \pi\,(7)^2\ \text{cm}^2.$$

Step 2: Applying Pascal's Law According to Pascal's law, the pressure exerted on both arms must be equal for equilibrium:

$$\frac{F_1}{A_1} = \frac{F_2}{A_2}.$$

Rearranging to find F_1:

$$F_1 = F_2 \times \frac{A_1}{A_2}.$$

Step 3: Substituting the Values Substituting the given values:

$$F_1 = 10 \times \frac{\pi(7)^2}{\pi(0.7)^2}.$$

Simplifying:

$$F_1 = 10 \times \frac{49}{0.49}.$$

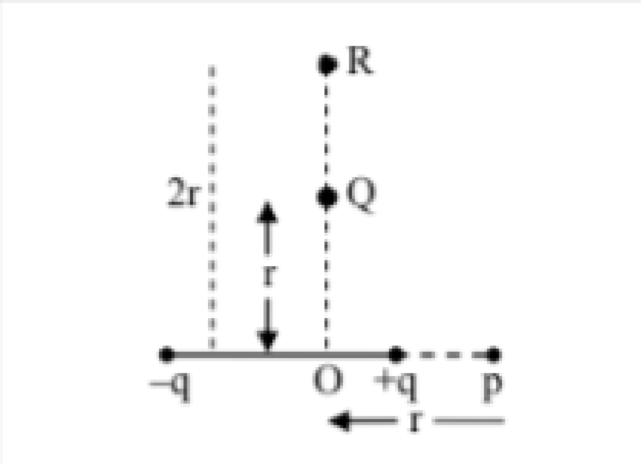
Calculating:

$$F_1 = 10 \times 100 = 1000\,\text{N}.$$

Therefore, the force required to be applied on the surface of water in the thicker arm is $1000\,\text{N}$.

> Quick Tip
>
> Pascal's law states that pressure applied to an enclosed fluid is transmitted undiminished to every part of the fluid and to the walls of its container.

Question 27: The electric field at point P due to an electric dipole is E. The electric field at point R on the equatorial line will be $\frac{E}{x}$. The value of x is:



Answer: 16

Solution:
Given: - Electric field at point P on the axial line: $E_P = E = \frac{2Kp}{r^3}$, - Electric field at point R on the equatorial line: $E_R = \frac{Kp}{(2r)^3}$, where: - K is the Coulomb constant, - p is the dipole moment, - r is the distance from the dipole center to the point of observation.
Step 1: Calculate the electric field at R The electric field at point R on the equatorial line is given by:

$$E_R = \frac{Kp}{(2r)^3}.$$

Simplify $(2r)^3$:

$$E_R = \frac{Kp}{8r^3}.$$

Step 2: Compare the electric fields The electric field at P on the axial line is:

$$E_P = \frac{2Kp}{r^3}.$$

The electric field at R is related to E_P as:

$$E_R = \frac{E_P}{x}.$$

Substitute $E_P = \frac{2Kp}{r^3}$ and $E_R = \frac{Kp}{8r^3}$:

$$\frac{Kp}{8r^3} = \frac{\frac{2Kp}{r^3}}{x}.$$

Step 3: Solve for x Simplify the equation:

$$\frac{Kp}{8r^3} = \frac{2Kp}{xr^3}.$$

Cancel Kp and r^3 (as they are non-zero):

$$\frac{1}{8} = \frac{2}{x}.$$

Rearrange to solve for x:

$$x = 2 \times 8 = 16.$$

Thus, the value of x is 16.

> 💡 Quick Tip
>
> For electric dipoles, remember that the electric field along the axial line is twice as strong as that along the equatorial line at the same distance.

Question 28: The maximum height reached by a projectile is $64\,\text{m}$. If the initial velocity is halved, the new maximum height of the projectile is _________ m.

Answer: 16

Solution:
The maximum height of a projectile is given by:

$$H_{\text{max}} = \frac{u^2 \sin^2 \theta}{2g},$$

where: - u is the initial velocity, - θ is the angle of projection, - g is the acceleration due to gravity.
Step 1: Relationship between maximum heights If the initial velocity is halved, i.e., $u' = \frac{u}{2}$, the new maximum height $H_{2\text{max}}$ can be expressed as:

$$\frac{H_{1\text{max}}}{H_{2\text{max}}} = \frac{u^2}{u'^2}.$$

Substitute $u' = \frac{u}{2}$:

$$\frac{H_{1\text{max}}}{H_{2\text{max}}} = \frac{u^2}{\left(\frac{u}{2}\right)^2}.$$

Step 2: Simplify the expression Simplify $\left(\frac{u}{2}\right)^2$:

$$\frac{H_{1\text{max}}}{H_{2\text{max}}} = \frac{u^2}{\frac{u^2}{4}} = 4.$$

Thus:

$$H_{2\text{max}} = \frac{H_{1\text{max}}}{4}.$$

Step 3: Calculate the new maximum height Substitute $H_{1\text{max}} = 64\,\text{m}$:

$$H_{2\text{max}} = \frac{64}{4} = 16\,\text{m}.$$

Therefore, the new maximum height of the projectile is $H_{2\text{max}} = 16\,\text{m}$.

> 💡 Quick Tip
>
> The maximum height of a projectile is proportional to the square of the initial velocity. Halving the velocity reduces the height to one-fourth of the original.

Question 29: A wire of resistance $20\,\Omega$ is divided into 10 equal parts. A combination of two parts is connected in parallel, and so on. Now the resulting pairs of parallel combinations are connected in series. The equivalent resistance of the final combination is ________ Ω.

Answer: 5

Solution:
Given: - Total resistance of the wire: $20\,\Omega$, - The wire is divided into 10 equal parts.
Step 1: Resistance of each part The resistance of each part is:

$$R_{\text{part}} = \frac{\text{Total resistance}}{\text{Number of parts}} = \frac{20\,\Omega}{10} = 2\,\Omega.$$

Step 2: Parallel combination of two parts Each pair of two parts is connected in parallel. The equivalent resistance of a parallel combination is:

$$R_{\text{parallel}} = \frac{R_{\text{part}}}{2} = \frac{2\,\Omega}{2} = 1\,\Omega.$$

Step 3: Total number of parallel combinations Since there are 10 parts and they are paired in groups of 2, the total number of parallel combinations is:

$$\text{Number of parallel combinations} = \frac{10}{2} = 5.$$

Step 4: Series combination of parallel pairs The 5 parallel combinations (each of $1\,\Omega$) are connected in series. The equivalent resistance of a series combination is:

$$R_{\text{eq}} = 5 \times R_{\text{parallel}} = 5 \times 1\,\Omega = 5\,\Omega.$$

Thus, the equivalent resistance of the final combination is $R_{\text{eq}} = 5\,\Omega$.

Quick Tip

When resistors are divided into equal parts and combined in parallel, remember that the equivalent resistance of the parallel combination is always less than the smallest individual resistance in the group.

Question 30: The current in an inductor is given by $I = (3t + 8)$, where t is in seconds. The magnitude of the induced emf produced in the inductor is $12\,\text{mV}$. The self-inductance of the inductor is ________ mH.

Answer: 4

Solution:
The emf (ε) induced in an inductor is related to the rate of change of current and self-inductance (L) by the formula:

$$|\varepsilon| = L\frac{dI}{dt}.$$

Step 1: Determine the rate of change of current The given current is:

$$I = 3t + 8.$$

Differentiate I with respect to t:

$$\frac{dI}{dt} = 3\,\text{A/s}.$$

Step 2: Substitute the given values The magnitude of induced emf is $|\varepsilon| = 12\,\text{mV} = 12 \times 10^{-3}\,\text{V}$. Substituting into the formula:

$$12 \times 10^{-3} = L \cdot 3.$$

Step 3: Solve for L Rearrange to find L:

$$L = \frac{12 \times 10^{-3}}{3} = 4 \times 10^{-3}\,\text{H}.$$

Convert to millihenries:

$$L = 4\,\text{mH}.$$

Thus, the self-inductance of the inductor is $L = 4\,\text{mH}$.

Quick Tip

For inductors, the induced emf depends on how quickly the current changes. A steeper slope (dI/dt) produces a higher emf.