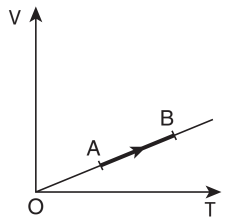
NEET 2018 – Solved Physics Paper

1. The volume (V) of a monatomic gas varies with its temperature (T) as shown in the graph. The ratio of work done by the gas, to the heat absorbed by it, when it undergoes a change from state A to state B, is



(1) $\frac{1}{3}$ (2) $\frac{2}{3}$

(3) $\frac{2}{5}$ (4) $\frac{2}{7}$

Solution

We know that $dQ = mc_P dT$ for isobaric process and work done $dW = PdV = nRdT$. Taking ratio of dQ and dW, we get

$$\frac{dW}{dQ} = \frac{nRdT}{nC_P dT} = \frac{R}{C_P} \quad (1)$$

Now, $C_P - C_V = R$. Dividing by C_P, we get

$$1 - \frac{C_V}{C_P} = \frac{R}{C_P} \quad (2)$$

Therefore, substituting Eq. (2) in Eq. (1), we get

$$\frac{dW}{dQ} = 1 - \frac{C_V}{C_P}$$

Now, we know $\frac{C_P}{C_V} = \gamma$. Therefore,

$$\frac{dW}{dQ} = 1 - \frac{1}{\gamma}$$

For monatomic gas, $\gamma = \frac{5}{3}$. Therefore,

$$\frac{dW}{dQ} = 1 - \frac{3}{5} = \frac{2}{5}$$

Answer (3)

2. The fundamental frequency in an open organ pipe is equal to the third harmonic of a closed organ pipe. If the length of the closed organ pipe is 20 cm, the length of the open organ pipe is

(1) 12.5 cm (2) 8 cm

(3) 13.2 cm (4) 16 cm

Solution

Given: Fundamental frequency of an open organ pipe = Third harmonic of closed organ pipe

Now, fundamental frequency of open organ pipe $= \frac{v}{2l}$, where l is length of open organ pipe.

Third harmonic of closed organ pipe $= \frac{3v}{4l}$, where l is length of closed organ pipe. Therefore,

$$\frac{v}{2l} = \frac{3v}{4l} \quad \frac{1}{2l} = \frac{3}{4l} \quad l = \frac{4l}{3 \times 2} = \frac{2l}{3}$$

Given: $l = 20\ \text{cm}$, therefore,

$$l = \frac{2 \times 20}{3} = 13.33\ \text{cm} \approx 13.2\ \text{cm}$$

Answer (3)

3. At what temperature will the rms speed of oxygen molecules become just sufficient for escaping from the Earth's atmosphere?

(Given: Mass of oxygen molecule (m) = 2.76×10^{-26} kg, Boltzmann's constant $k_B = 1.38 \times 10^{-23}\ \text{J K}^{-1}$)

(1) 5.016×10^4 K (2) 8.360×10^4 K

(3) 2.508×10^4 K (4) 1.254×10^4 K

Solution

The rms speed of oxygen, $v_{rms} = \sqrt{\frac{3k_BT}{m}}$; escape velocity $= 11200\ \text{m s}^{-1}$. Therefore,

$$v_{rms} = 1120\ \text{m s}^{-1} \quad \sqrt{\frac{3k_BT}{m}} = 11200\ \text{m s}^{-1}$$

On rearranging, we get

$$T = \frac{(11200\ \text{m/s})^2 \times m}{3k_B}$$

Substituting the values, we get

$$T = \frac{(11200\ \text{m s}^{-1})^2 \times 2.76 \times 10^{-26}\ \text{kg}}{3 \times 1.38 \times 10^{-23}\ \text{J K}^{-1}} = 8.360 \times 10^4\ \text{K}$$

Answer (2)

4. The efficiency of an ideal heat engine, working between the freezing point and boiling point of water, is

(1) 6.25% **(2)** 20%
(3) 26.8% **(4)** 12.5%

Solution

We know that the efficiency of an ideal heat engine is

$$\eta = \left(1 - \frac{T_2}{T_1}\right)$$

where T_1 is temperature of source and T_2 is temperature of sink.

Now, boiling point of water = 100 °C

$\Rightarrow$ T_1 = 100 °C = 373 K.

Freezing point of water = 0 °C $\Rightarrow$ T_2 = 0°C = 273 K.

Therefore, $\eta = \left(1 - \frac{273}{373}\right) = \frac{100}{373}$

Efficiency (in %) $= \frac{100}{373} \times 100 = 26.809\%$

Answer (3)

5. A carbon resistor of (47 ± 4.7) kΩ is to be marked with rings of different colours for its identification. The colour code sequence will be

(1) Yellow – Green – Violet – Gold
(2) Yellow – Violet – Orange – Silver
(3) Violet – Yellow – Orange –Silver
(4) Green – Orange – Violet – Gold

Solution

As per colour code: 4 → Yellow;
7 → Violet

Now, (47 ± 4.7) kΩ = $47 \times 10^3 \pm 10\%$

So, 10^3 → Orange

10% → Silver

Therefore, the sequence is

Yellow – Violet – Orange – Silver

Answer (2)

6. A set of 'n' equal resistors, of value 'R' each, are connected in series to a battery of emf 'E' and internal resistance 'R'. The current drawn is I. Now, the 'n' resistor are connected in parallel to the same battery. Then the current drawn from battery becomes $10I$. The value of 'n' is

(1) 20 **(2)** 11
(3) 10 **(4)** 9

Solution

For resistors connected in series, we have

$$R_{eq} = R + R + R + \ldots R = nR$$

By ohm's law: $V = 1R \Rightarrow I = \frac{V}{R} = \frac{E}{nR + R}$

Therefore, $$I = \frac{E}{nR + R} \qquad (1)$$

For resistors connected in parallel, we have

$$\frac{1}{R_{eq}} = \frac{1}{R} + \frac{1}{R} + \frac{1}{R} + \cdots \frac{1}{R} = \frac{n}{R}$$

Therefore, from $V = I'R' \Rightarrow I' = \frac{V}{R'}$ (2)

$$\Rightarrow 10I = \frac{E}{R/n + R} \qquad (2)$$

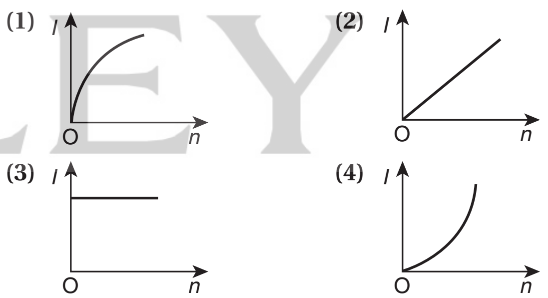
Substituting Eq. (1) in Eq. (2), we get

$$\frac{10E}{nR + R} = \frac{E}{R/n + R} \Rightarrow \frac{10}{(n+1)R} = \frac{1}{R\left(\frac{1}{n} + 1\right)}$$

$$\Rightarrow 10 = \frac{(n+1)R}{\left(\frac{1}{n} + 1\right)R} \Rightarrow 10 = \frac{(n+1)n}{(n+1)} \Rightarrow n = 10$$

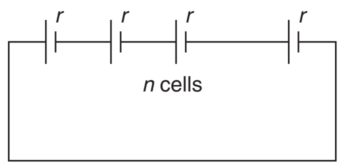
Answer (3)

7. A battery consists of a variable number 'n' of identical cells (having internal resistance 'r' each) which are connected in series. The terminals of the battery are short-circuited and the current I is measured. Which of the graphs shown the correct relationship between I and n?



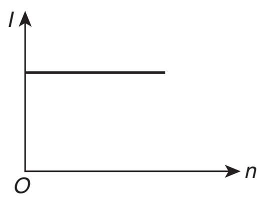
Solution

The circuit is shown below.



By Ohm's law: $V = IR \Rightarrow I = \frac{nE}{nr} = \frac{E}{r}$

Therefore, I is independent of n. Thus, the graph shown in option (3) is correct.



Answer (3)

8. Unpolarised light is incident from air on a plane surface of a material of refractive index 'μ'. At a particular angle of incidence 'i', it is found that the reflected and refracted rays are perpendicular to each other. Which of the following options is correct for this situation?

(1) $i = \sin^{-1}\left(\frac{1}{\mu}\right)$

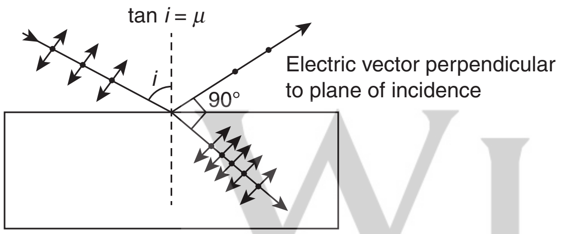
(2) Reflected light is polarised with its electric vector perpendicular to the plane of incidence

(3) Reflected light is polarised with its electric vector parallel to the plane of incidence

(4) $i = \tan^{-1}\left(\frac{1}{\mu}\right)$

Solution

Given that unpolarised light is incident from air on plane surface of a material of refractive index μ. At a particular angle of incidence 'i', the reflected and refracted rays are perpendicular to each other. This angle of incidence is Brewster angle and the reflected light is polarised with electric field vector perpendicular to the plane of incidence.



Answer (2)

9. In Young's double-slit experiment the separation d between the slits is 2 mm, the wavelength λ of the light used is 5896 Å and distance D between the screen and slits is 100 cm. It is found that the angular width of the fringes is 0.20°. To increase the fringe angular width to 0.21° (with same λ and D), the separation between the slits needs to be changed to

(1) 2.1 mm **(2)** 1.9 mm
(3) 1.8 mm **(4)** 1.7 mm

Solution

Fringe angular width $= \frac{\lambda D}{d}$; where D is the distance between screen and slits, d is separation between the slits and λ is wavelength.

Given λ and D are same for both cases. Therefore, $\beta \propto \frac{1}{\alpha}$.

Now, for $d_1 = 2$ mm, $\beta_1 = 0.20°$; for $d_2 = ?$, $\beta_2 = 0.21°$

Taking the ratio, we get

$$\frac{\beta_1}{\beta_2} = \frac{d_2}{d_1} \Rightarrow d_2 = \frac{\beta_1}{\beta_2} \times d_1$$

$$\Rightarrow d_2 = \frac{0.20}{0.21} \times 2\text{ mm} = 1.90\text{ mm}$$

Answer (2)

10. An astronomical refracting telescope will have large angular magnification and high angular resolution, when it has an objective lens of

(1) large focal length and large diameter.
(2) large focal length and small diameter.
(3) small focal length and large diameter.
(4) small focal length and small diameter.

Solution

For telescope:

Angular magnification $= \frac{\text{Focal length of objective lens}}{\text{Focal length of eyepiece}}$

Therefore, for large angular magnification focal length of objective should be large.

Also, angular resolution $= \frac{\text{Diameter}}{1.22\lambda}$

Therefore, for high-resolution diameter should be large. Thus, objective lens should have large focal length and large diameter in order to have large angular magnification and singular resolution.

Answer (1)

11. The ratio of kinetic energy to the total energy of an electron in a Bohr orbit of the hydrogen atom is

(1) 2 : – 1 **(2)** 1 : –1
(3) 1 : 1 **(4)** 1 : –2

Solution

Kinetic energy of an electron in a Bohr orbit of hydrogen atom is

$$\text{KE} = \frac{kZe^2}{2r_n}; \qquad \text{where } k = \frac{1}{4\pi\varepsilon_0}$$

Total energy of an electron in a Bohr orbit of hydrogen atom is

$$E = \frac{-kZe^2}{2r_n}; \qquad \text{where } k = \frac{1}{4\pi\varepsilon_0}$$

Therefore, total energy = –kinetic energy

Ratio of kinetic energy to total energy = 1 : –1

Answer (2)

12. An electron of mass m with an initial velocity $\vec{v} = v_0\hat{i}\,(v_0 > 0)$ enters an electric field $\vec{E} = -E_0\hat{i}\,(E_0 = \text{constant} > 0)$ at $t = 0$. If λ_0 is its de Broglie wavelength initially, then its de Broglie wavelength at time t is

(1) $\lambda_0 t$ **(2)** $\lambda_0\left(1 + \frac{eE_0}{mv_0}t\right)$

(3) $\frac{\lambda_0}{\left(1 + \frac{eE_0}{mv_0}t\right)}$ **(4)** λ_0

Solution

Given, initial velocity of electron $\vec{v} = v_0\hat{i}$; electric field $\vec{E} = -E_0\hat{i}$

Initially, de Broglie wavelength $= \lambda_0$

Therefore, the force on electron in electric field is

$$\vec{F} = q\vec{E} = -e(-E_0 i) = eE_0 i$$

Thus, acceleration of electron is $a = \frac{\vec{F}}{m} = \frac{eE_0\hat{i}}{m}$

Now, velocity at time t is $v = u + at$, therefore, $v = v_0\hat{i} + \frac{eE_0\hat{i}t}{m}$

Now, we know that

$$\lambda = \frac{h}{mv} = \frac{h}{m\left(v_0 + \frac{eE_0 t}{m}\right)} = \frac{h}{mv_0\left(1 + \frac{eE_0 t}{mv_0}\right)}$$

Here, $\frac{h}{mv_0} = \lambda_0$

Thus, $\lambda = \frac{\lambda_0}{\left(1 + \frac{eE_0 t}{mv_0}\right)}$

Answer (3)

13. For a radioactive material, half-life is 10 min. If initially there are 600 number of nuclei, the time taken (in min) for the disintegration of 450 nuclei is

(1) 30 **(2)** 10
(3) 20 **(4)** 15

Solution

Given, initial number of nuclei of radioactive material is

$$N_0 = 600$$

Number of nuclei disintegrated after t min $= N_d = 450$
Half-life, $T_{1/2} = 10$ min
Therefore, the number of nuclei remaining after t min is

$$N = 600 - 450 = 150$$

Now, we know that $\frac{N}{N_0} = \left(\frac{1}{2}\right)^{\alpha}$; where, $\alpha = t/T_{1/2}$

Therefore, $\frac{150}{600} = \left(\frac{1}{2}\right)^{t/10} \Rightarrow \frac{1}{4} = \left(\frac{1}{2}\right)^{t/10} \Rightarrow \left(\frac{1}{2}\right)^{2} = \left(\frac{1}{2}\right)^{-t/10}$

Equating powers, we get

$$2 = \frac{t}{10} \Rightarrow t = 20 \text{ min}$$

Answer (3)

14. When the light of frequency $2v_0$ (where, v_0 is threshold frequency), is incident on a metal plate, the maximum velocity of electrons emitted is v_1. When the frequency of the incident radiation is increased to $5v_0$, the maximum velocity of electrons emitted from the same plate is v_2. The ratio of v_1 to v_2 is

(1) 4 : 1 **(2)** 1 : 4
(3) 1 : 2 **(4)** 2 : 1

Solution

From photoelectric effect equation, we have

$$E = W_0 + \frac{1}{2}mv^2$$

Therefore, $2hv_0 = hv_0 + \frac{1}{2}mv_1^2 \Rightarrow \frac{1}{2}mv_1^2 = hv_0$ (1)

and $5hv_0 = hv_0 + \frac{1}{2}mv_2^2 \Rightarrow \frac{1}{2}mv_2^2 = 4hv_0$ (2)

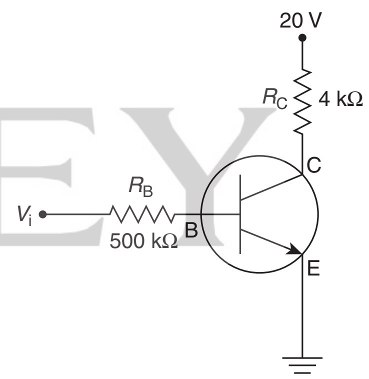
Dividing Eq. (1) by (2), we get

$$\frac{\frac{1}{2}mv_1^2}{\frac{1}{2}mv_2^2} = \frac{hv_0}{4hv_0} \Rightarrow \frac{v_1^2}{v_2^2} = \frac{1}{4} \Rightarrow \frac{v_1}{v_2} = \frac{1}{2}$$

Therefore, the ratio of v_1 to v_2 is 1 : 2.

Answer (3)

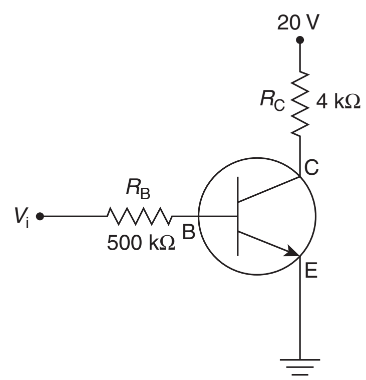
15. In the circuit shown in the figure, the input voltage V_i is 20 V, $V_{BE} = 0$ and $V_{CE} = 0$. The values of I_B, I_C and β are given by



(1) $I_B = 20$ μA, $I_C = 5$ mA, $\beta = 250$
(2) $I_B = 25$ μA, $I_C = 5$ mA, $\beta = 200$
(3) $I_B = 40$ μA, $I_C = 10$ mA, $\beta = 250$
(4) $I_B = 40$ μA, $I_C = 5$ mA, $\beta = 125$

Solution

Given: $V_i = 20$ V; $V_{BE} = 0$; $V_{CE} = 0$



We know that $V_i = I_C R_C + V_{CE}$

$$\Rightarrow I_C = \frac{V_i - V_{CE}}{R_C} = \frac{20-0}{4\,\text{k}\Omega} \Rightarrow I_C = \frac{20}{4\times 10^3} = 5\times 10^{-3}\,\text{A} = 5\,\text{mA}$$

Also, $V_i = I_B R_B + V_{BE}$

$$\Rightarrow I_B = \frac{V_i - V_{BE}}{R_B} = \frac{20-0}{500\,\text{k}\Omega} = \frac{20}{500\times 10^3} = 4\times 10^{-5}\,\text{A}$$

Therefore, $I_B = 40\times 10^{-6}\,\text{A} = 40\,\mu\text{A}$

Now $\beta = \frac{I_C}{I_B} = \frac{5\times 10^{-3}}{40\times 10^{-6}} = 125$

Therefore, $I_B = 40\,\mu\text{A}$, $I_C = 5\,\text{mA}$, $\beta = 125$

Answer (4)

16. In a *p-n* junction diode, change in temperature due to heating

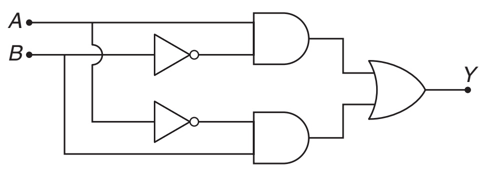
(1) does not affect resistance of *p-n* junction.
(2) affects only forward resistance.
(3) affects only reverse resistance.
(4) affects the overall *V–I* characteristics of *p-n* junction.

Solution

In *p-n* junction diode, change in temperature due to heating affects the overall *V-I* characteristics of *p-n* junction because on heating number of electron-hole pairs will increase due to which the current and resistance will change.

Answer (4)

17. In the combination of the following gates the output Y can be written in terms of inputs A and B as

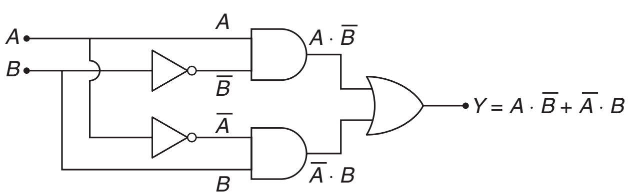


(1) $\overline{A\cdot B} + A\cdot B$ **(2)** $A\cdot\overline{B} + \overline{A}\cdot B$

(3) $\overline{A\cdot B}$ **(4)** $\overline{A+B}$

Solution

The given logic circuit is



Answer (2)

18. An EM wave is propagating in a medium with a velocity $\vec{V} = V\hat{i}$. The instantaneous oscillating electric field of this EM wave is along $+y$ axis. Then the direction of oscillating magnetic field of the EM wave will be along

(1) $-y$ direction **(2)** $+z$ direction
(3) $-z$ direction **(4)** $-x$ direction

Solution

We know that $\vec{v} = \vec{E}\times\vec{B}$. Given: $\vec{v} = v\hat{i}$; $\vec{E} = E\hat{j}$. Now, from vector analysis, we know that $\hat{i} = \hat{j}\times\hat{k}$, therefore, $\vec{B} = B\hat{k}$. Thus, the direction of oscillating magnetic field of em wave will be along $+z$ direction.

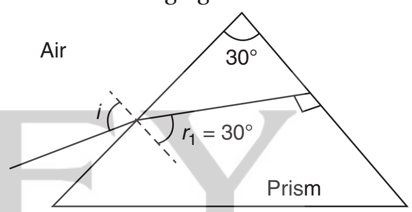
Answer (2)

19. The refractive index of the material of a prism is $\sqrt{2}$ and the angle of the prism is 30°. One of the two refracting surfaces of the prism is made a mirror inwards, by silver coating. A beam of monochromatic light entering the prism from the other face will retrace its path (after reflection from the silvered surface) if its angle of incidence on the prism is

(1) 30° **(2)** 45°
(3) 60° **(4)** zero

Solution

Consider the following figure:



From Snell's law, we have $\frac{\sin i}{\sin r} = \frac{\mu_{\text{prism}}}{\mu_{\text{air}}}$.

Therefore, $$\frac{\sin i}{\sin 30°} = \frac{\sqrt{2}}{1}$$

Therefore, $\sin i = \sqrt{2}\sin 30 \Rightarrow \sin i = \sqrt{2}\times\frac{1}{2} = \frac{1}{\sqrt{2}}$.

Thus, $i = 45°$

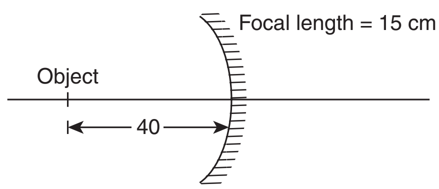
Answer (2)

20. An object is placed at a distance of 40 cm from a concave mirror of focal length 15 cm. If the object is displaced through a distance of 20 cm towards the mirror, the displacement of the image will be

(1) 30 cm towards the mirror.
(2) 36 cm away from the mirror.
(3) 30 cm away from the mirror.
(4) 36 cm towards the mirror.

Solution

Consider the following figure:

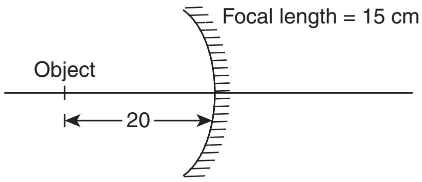


Using mirror formula, we have

$$\frac{1}{f}=\frac{1}{v}+\frac{1}{u}\Rightarrow\frac{1}{v}=\frac{1}{f}-\frac{1}{u}=\frac{1}{-15}-\frac{1}{-40}\Rightarrow\frac{1}{v}=\frac{-40+15}{40\times15}$$

$$\Rightarrow\frac{1}{v}=\frac{-25}{40\times15}\Rightarrow v=\frac{-40\times15}{25}=-24\text{ cm}$$

Now, if the object is displaced 20 cm towards the mirror, we have



$$\frac{1}{f}=\frac{1}{v}+\frac{1}{u}\Rightarrow\frac{1}{v}=\frac{1}{f}-\frac{1}{u}=\frac{1}{-15}-\frac{1}{-20}=\frac{-20+15}{15\times20}$$

Therefore, $v=\frac{-20\times15}{5}=-60\text{ cm}$

Therefore, displacement of image is $60-24=36$ cm away from the mirror.

Answer (2)

21. The magnetic potential energy stored in a certain inductor is 25 mJ, when the current in the inductor is 60 mA. This inductor is of inductance

(1) 1.389 H **(2)** 138.88 H
(3) 0.138 H **(4)** 13.89 H

Solution

Given, energy stored in inductor = 25 mJ;
Current in inductor = 60 mA

We know that potential energy stored in an inductor $=\frac{1}{2}LI^2$

$$\Rightarrow 25\text{ mJ}=\frac{1}{2}L(60\text{ mA})^2$$

$$\Rightarrow L=\frac{2\times25\text{ mJ}}{(60\text{ mA})^2}=\frac{2\times25\times10^{-3}}{60\times10^{-3}\times60\times10^{-3}}=\frac{500}{36}$$

$$\Rightarrow L=13.89\text{ H}$$

Answer (4)

22. An electron falls from rest through a vertical distance h in a uniform and vertically upward directed electric field E. The direction of electric field is now reversed, keeping its magnitude the same. A proton is allowed to fall from rest in it through the same vertical distance h. The time of fall of the electron, in comparison to the time of fall of the proton is

(1) 10 times greater. **(2)** 5 times greater.
(3) smaller. **(4)** equal.

Solution

Here, vertical distance, $s=h$; initial velocity, $u=0$; acceleration, $a=\frac{qE}{m}$

Using $s=ut+\frac{1}{2}at^2$, we have

$$h=0+\frac{1}{2}\left(\frac{qE}{m}\right)t^2\Rightarrow t^2=\frac{2mh}{qE}\Rightarrow t\propto m$$

Since $m_e<m_p \Rightarrow t_e<t_p$

Therefore, time of fall of electron is smaller in comparison to the time of fall of the proton.

Answer (3)

23. The electrostatic force between the metal plates of an isolated parallel-plate capacitor C having a charge Q and area A is

(1) proportional to the square root of the distance between the plates.
(2) linearly proportional to the distance between the plates.
(3) independent of the distance between the plates.
(4) inversely proportional to the distance between the plates.

Solution

Electrostatic force between metal plates is

$$F=\frac{Q\sigma}{2\varepsilon_0}=\frac{Q.Q}{2A\varepsilon_0}$$

(Because for parallel-plate capacitor having charge Q and area A, $\sigma=\frac{Q}{A}$)

Therefore, $F=\frac{Q^2}{2A\varepsilon_0}$

Thus, electrostatic force between the metal plates is independent of the distance between the plates.

Answer (3)

24. A tuning fork is used to produce resonance in a glass tube. The length of the air column in this tube can be adjusted by a variable piston. At room temperature of 27°C, two successive resonances are produced at 20 cm and 73 cm of column length. If the frequency of the tuning fork is 320 Hz, the velocity of sound in air at 27°C is

(1) 350 m s^{-1} **(2)** 339 m s^{-1}
(3) 330 m s^{-1} **(4)** 300 m s^{-1}

Solution

Since $L_2-L_1=\frac{\lambda}{2}$, we have

$$\nu\lambda=v\Rightarrow\lambda=\frac{v}{\nu}$$

Therefore, $L_2 - L_1 = \frac{v}{2\nu} \Rightarrow v = 2\nu(L_2 - L_1)$

Here, $L_2 = 73$ cm, $L_1 = 20$ cm, $\nu = 320$ Hz

Therefore, $v = 2 \times 320\ (73\text{ cm} - 20\text{ cm}) = 2 \times 320 \times 53\text{ cm s}^{-1}$

$v = 2 \times 320 \times 53 \times 10^{-2}\text{ m s}^{-1} = 339.2\text{ m s}^{-1}$

$v \approx 339\text{ m s}^{-1}$

Answer (2)

25. A pendulum is hung from the roof of a sufficiently high building and is moving freely to and fro like a simple harmonic oscillator. The acceleration of the bob of the pendulum is 20 m s^{-2} at a distance of 5 m from the mean position. The time period of oscillation is

(1) 2 s **(2)** π s
(3) 2π s **(4)** 1 s

Solution

We know that $a = -\omega^2 x$; where a is acceleration = 20 m s^{-2}; x is distance from mean position = 5 m; ω is angular frequency $= \frac{2\pi}{T}$. Therefore,

$$|a| = \omega^2 x \Rightarrow |a| = \left(\frac{2\pi}{T}\right)^2 x$$

$$\Rightarrow T^2 = \frac{(2\pi)^2 x}{|a|} \Rightarrow \frac{(2\pi)^2 \times 5}{20} \Rightarrow T^2 = \frac{4\pi^2 \times 5}{20} = \pi^2$$

Therefore, $T = \pi$.

Answer (2)

26. A metallic rod of mass per unit length 0.5 kg m^{-1} is lying horizontally on a smooth inclined plane which makes an angle of 30° with the horizontal. The rod is not allowed to slide down by flowing a current through it when a magnetic field of induction 0.25 T is acting on it in the vertical direction. The current flowing in the rod to keep it stationary is

(1) 14.76 A **(2)** 5.98 A
(3) 7.14 A **(4)** 11.32 A

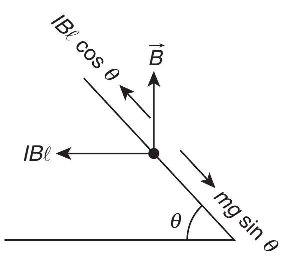
Solution

Given, $\frac{m}{l} = 0.5\text{ kg m}^{-1}$; $\theta = 30°$; $B = 0.25$ T

At equilibrium, $mg \sin\theta = IBl \cos\theta$

$$\Rightarrow I = \frac{mg\sin\theta}{Bl\cos\theta}$$

Therefore, $I = \frac{0.5 \times 9.8}{0.25} \frac{\sin 30°}{\cos 30°} = 11.32$ A



Answer (4)

27. A thin diamagnetic rod is placed vertically between the poles of an electromagnet. When the current in the electromagnet is switched on, then the diamagnetic rod is pushed up, out of the horizontal magnetic field. Hence, the rod gains gravitational potential energy. The work required to do this comes from

(1) the lattice structure of the material of the rod.
(2) the magnetic field.
(3) the current source.
(4) the induced electric field due to the changing magnetic field.

Solution

In an electromagnet, magnetic energy is obtained by current source. Energy of current source is converted into potential energy of the rod.

Answer (3)

28. An inductor 20 mH, a capacitor 100 μF and a resistor 50 Ω are connected in series across a source of emf, $V = 10 \sin 314\, t$. The power loss in the circuit is

(1) 2.74 W **(2)** 0.43 W
(3) 0.79W **(4)** 1.13W

Solution

Given, $L = 20$ mH; $C = 100$ μF; $R = 50$ Ω; $V = 10 \sin 314\, t$; $V_{\text{rms}} = 10$; $\omega = 314$

We know that Power $P = V_{\text{rms}} I_{\text{rms}} \cos\phi$;

$$I_{\text{rms}} = \frac{V_{\text{rms}}}{Z};\ \cos\phi = \frac{R}{Z}$$

Therefore, $$P = V_{\text{rms}} \frac{V_{\text{rms}}}{Z} \cdot \frac{R}{Z} = \frac{V_{\text{rms}}^2 R}{Z^2}$$

Now, $Z = \sqrt{(X_L - X_C)^2 + R^2}$; where $X_L = \omega L$ and $X_C = \frac{1}{\omega C}$

Therefore, $X_L = 314 \times 20 \times 10^{-3} = 6.28\ \Omega$

$$X_C = \frac{1}{\omega C} = \frac{1}{314 \times 100 \times 10^{-6}} = 31.84\ \Omega$$

$$Z = \sqrt{(6.28 - 31.84)^2 + 50^2} = 56\ \Omega$$

$$P = \frac{(10)^2 \times 50}{(56)^2} = 0.79\text{ W}$$

Answer (3)

29. Current sensitivity of a moving coil galvanometer is 5 div mA^{-1} and its voltage sensitivity (angular deflection per unit voltage applied) is 20 div V^{-1}. The resistance of the galvanometer is

(1) 250 Ω **(2)** 25 Ω
(3) 40 Ω **(4)** 500 Ω

Solution

Given, current sensitivity of a moving coil galvanometer = 5 div/mA $\Rightarrow I_s = 5/10^{-3}$

Voltage sensitivity, $V_s = 20$ div/V

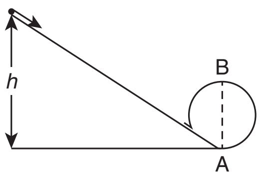
We know that current sensitivity $I_s = \frac{NBA}{C}$

Voltage sensitivity $V_s = \frac{NBA}{CR_s} = \frac{I_s}{R_s}$

Therefore, $R_s = \frac{I_s}{V_s} = \frac{5}{10^{-3}} \times \frac{1}{20} = \frac{5000}{20} = 250\,\Omega$

Answer (1)

30. A body initially at rest and sliding along a frictionless track from a height h (as shown in the figure) just completes a vertical circle of diameter AB = D. The height h is equal to



(1) $\frac{7}{5}D$ **(2)** D

(3) $\frac{3}{2}D$ **(4)** $\frac{5}{4}D$

Solution

According to conservation of energy, we have

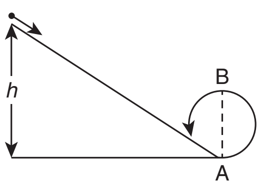
$$mgh = \frac{1}{2}mv^2 \Rightarrow gh = \frac{1}{2}v^2 \Rightarrow h = \frac{1}{2}\frac{v^2}{g}$$

Now to complete a vertical circle, $v = \sqrt{5gR}$. Therefore,

$$h = \frac{1}{2} \times \frac{5gR}{g} = \frac{5R}{2}$$

Given AB $= D \Rightarrow R = \frac{D}{2}$. Therefore,

$$h = \frac{5}{4}D$$



Answer (4)

31. Three objects, A: a solid sphere, B: a thin circular disc and C: a circular ring; each have the same mass M and radius R. They all spin with the same angular speed ω about their own symmetry axes. The amounts of work (W) required to bring them to rest, would satisfy the relation

(1) $W_B > W_A > W_C$ **(2)** $W_A > W_B > W_C$

(3) $W_C > W_B > W_A$ **(4)** $W_A > W_C > W_B$

Solution

Since work is $W = \Delta$K.E. (loss in kinetic energy), therefore,

$$W = \text{K.E.} = \frac{1}{2}I\omega^2 \Rightarrow W \propto I$$

Now, for solid sphere $I_A = \frac{2}{5}MR^2$

For thin circular disc $I_B = \frac{1}{2}MR^2$

For circular ring $I_C = MR^2$

Therefore, $I_C > I_B > I_A \Rightarrow W_C > W_B > W_A$

Answer (3)

32. A moving block having mass m, collides with another stationary block having mass $4m$. The lighter block comes to rest after collision. When the initial velocity of the lighter block is v, then the value of coefficient of restitution (e) will be

(1) 0.8 **(2)** 0.25

(3) 0.5 **(4)** 0.4

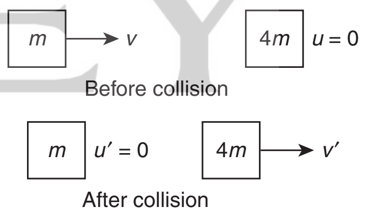
Solution

By law of conservation of linear momentum, we have

Momentum before collision = Momentum after collision

$$mv + 4m \times 0 = m \times 0 + 4mv'$$

$$mv = 4mv' \Rightarrow v = 4v' \quad (1)$$



Now, coefficient of restitution $e = \frac{\text{Velocity of separation}}{\text{Velocity of approach}}$

$$\Rightarrow e = \frac{v'}{v}$$

Using Eq. (1), we have

$$e = \frac{v'}{4v'} = \frac{1}{4} \Rightarrow e = 0.25$$

Answer (2)

33. Which one of the following statements is incorrect?

(1) Frictional force opposes the relative motion.

(2) Limiting value of static friction is directly proportional to normal reaction.

(3) Rolling friction is smaller than sliding friction.

(4) Coefficient of sliding friction has dimensions of length.

Solution

Coefficient of sliding friction has no dimensions:

$$F = \mu N \Rightarrow \mu = \frac{F}{N} = \frac{\text{MLT}^{-2}}{\text{MLT}^{-2}}$$

Therefore, $\mu = \text{M}^0\text{L}^0\text{T}^0$. **Answer (4)**

34. A toy car with charge q moves on a frictionless horizontal plane surface under the influence of a uniform electric field $\vec{E}$. Due to the force $q\vec{E}$, its velocity increases from 0 to 6 m s^{-1} in 1 s duration. At that instant the direction of the field is reversed? The car continues to move for two more seconds under the influence of this field. The average velocity and the average speed of the toy car between 0 to 3 s are, respectively,

(1) 1 m s^{-1}, 3.5 m s^{-1} **(2)** 1 m s^{-1}, 3 m s^{-1}
(3) 2 m s^{-1}, 4 m s^{-1} **(4)** 1.5 m s^{-1}, 3 m s^{-1}

Solution

Given, in 1 s duration, velocity increases from 0 to 6 m s^{-1}; in 1 s to 2 s duration, the car continues to move but velocity decreases from 6 to 0 m s^{-1}.
In 2 s to 3 s duration, the velocity increases from 0 m s^{-1} to –6 m s^{-1} in reverse direction.

Therefore, for $t = 0$ s to $t = 1$ s: $s_1 = \frac{1}{2} \times 6(1)^2 = 3$ m

For $t = 1$ s to $t = 2$ s: $s_2 = 6.1 - \frac{1}{2} \times 6 \times 1^2 = 3$ m

For $t = 2$ s to $t = 3$ s: $s_3 = 0 - \frac{1}{2} \times 6 \times 1^2 = -3$ m

Therefore, total displacement $= s_1 + s_2 + s_3 = 3 + 3 - 3 = 3$ m

$$\Rightarrow \text{Average velocity} = \frac{3}{3} = 1 \text{ m s}^{-1}$$

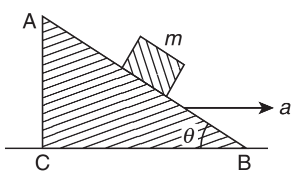
Total distance travelled = 9 m

$$\Rightarrow \text{Average speed} = \frac{9}{3} = 3 \text{ m s}^{-1}$$

Therefore, average velocity and average speed are 1 m s^{-1} and 3 m s^{-1}, respectively.

Answer (2)

35. A block of mass m is placed on a smooth inclined wedge ABC of inclination θ as shown in the figure. The wedge is given an acceleration 'a' towards the right. The relation between a and θ for the block to remain stationary on the wedge is



(1) $a = g \cos \theta$ **(2)** $a = \frac{g}{\sin\theta}$

(3) $a = \frac{g}{\text{cosec}\,\theta}$ **(4)** $a = g \tan \theta$

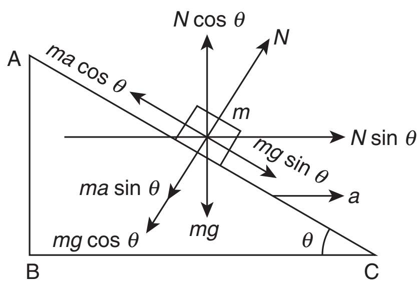
Solution

From the given diagram shown below, we have the following forces acting on the block

$$N \sin \theta = ma \quad (1)$$
$$N \cos \theta = mg \quad (2)$$

On dividing Eq. (1) by Eq. (2), we get

$$\frac{\sin\theta}{\cos\theta} = \frac{a}{g} \Rightarrow \tan\theta = \frac{a}{g} \Rightarrow a = g \tan\theta$$



Answer (4)

36. The moment of the force, $\vec{F} = 4\hat{i} + 5\hat{j} - 6\hat{k}$ at (2, 0, – 3), about the point (2, – 2, – 2), is given by

(1) $-7\hat{i} - 8\hat{j} - 4\hat{k}$ **(2)** $-4\hat{i} - \hat{j} - 8\hat{k}$

(3) $-8\hat{i} - 4\hat{j} - 7\hat{k}$ **(4)** $-7\hat{i} - 4\hat{j} - 8\hat{k}$

Solution

Given force is $\vec{F} = 4\hat{i} + 5\hat{j} - 6\hat{k}$. Now, the distance between the location of force and the given point is

$$\vec{r} = (2-2)\hat{i} + (0-(-2))\hat{j} + (-3-(-2))\hat{k} = 0\hat{i} + 2\hat{j} - \hat{k}$$

(2, –2, –2) ———————— (2, 0, –3)

Therefore, the moment of force is

$$\vec{\tau} = \vec{r} \times \vec{F} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 0 & 2 & -1 \\ 4 & 5 & -6 \end{vmatrix} \Rightarrow \hat{i}(-12+5) - \hat{j}(0+4) + \hat{k}(0-8)$$

Thus, moment of force $= -7\hat{i} - 4\hat{j} - 8\hat{k}$.

Answer (4)

37. A student measured the diameter of a small steel ball using a screw gauge of least count 0.001 cm. The main scale reading is 5 mm and zero of circular scale division coincides with 25 divisions above the reference level. If screw gauge has a zero error of –0.004 cm, the correct diameter of the ball is

(1) 0.053 cm **(2)** 0.525 cm
(3) 0.521 cm **(4)** 0.529 cm

Solution

Reading of screw gauge = MSR + VSR × LC + zero error
Where MSR is main scale reading = 5 mm
$= 5 \times 10^{-3}$ m = 0.5 cm
VSR is Vernier scale reading = 25 divisions
Least count (LC) = 0.001 cm
Zero error = 0.004 cm
Therefore, diameter of ball is
0.5 cm + 25 × 0.001 cm + 0.004 = 0.529 cm

Answer (4)

38. A solid sphere is rotating freely about its symmetry axis in free space. The radius of the sphere is increased keeping its mass same. Which of the following physical quantities would remain constant for the sphere?

(1) Rotational kinetic energy **(2)** Moment of inertia
(3) Angular velocity **(4)** Angular momentum

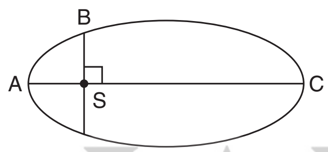
Solution

Here $\tau_{\text{out}} = 0 \Rightarrow \dfrac{dL}{dt} = 0$

Therefore, L is constant and hence its angular momentum remains constant.

Answer (4)

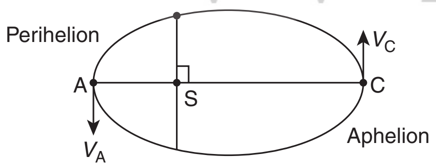
39. The kinetic energies of a planet in an elliptical orbit about the Sun, at positions A, B and C are K_A, K_B and K_C, respectively. AC is the major axis and SB is perpendicular to AC at the position of the Sun S as shown in the figure. Then



(1) $K_B < K_A < K_C$ **(2)** $K_A > K_B > K_C$
(3) $K_A < K_B < K_C$ **(4)** $K_B > K_A > K_C$

Solution

Here $v_A > v_B > v_C$.



Now, the kinetic energy $K = \dfrac{1}{2}mv^2 \Rightarrow K \propto v^2$. Therefore,

$$K_A > K_B > K_C$$

Answer (2)

40. If the mass of the Sun were ten times smaller and the universal gravitational constant were ten times larger in magnitude, which of the following is not correct?

(1) Time period of a simple pendulum on the Earth would decrease.
(2) Walking on the ground would become more difficult.
(3) Raindrops will fall faster.
(4) 'g' on the Earth will not change.

Solution

Given, if the mass of the Sun is 10 times smaller, that is, $M'_s = \dfrac{M_s}{10}$

Universal gravitational constant is 10 times larger in magnitude, that is, $G' = 10G$

Acceleration due to gravity g is given by $g = \dfrac{GM}{R}$; therefore, g increases. Hence, option (4) is incorrect.

Answer (4)

41. A solid sphere is in rolling motion. In rolling motion, a body possesses translational kinetic energy (K_t) as well as rotational kinetic energy (K_r) simultaneously. The ratio $K_t : (K_t + K_r)$ for the sphere is

(1) 10 : 7 **(2)** 5 : 7
(3) 7 : 10 **(4)** 2 : 5

Solution

Translational kinetic energy, $K_t = \dfrac{1}{2}mv^2$

Rotational kinetic energy, $K_r = \dfrac{1}{2}I\omega^2$

We know for solid sphere, moment of inertia is $I = \dfrac{2}{5}MR^2$

Also, $\omega = \dfrac{v}{R}$. Therefore,

$$K_r = \frac{1}{2}\left(\frac{2}{5}MR^2\right)\left(\frac{v}{R}\right)^2 = \frac{1}{5}Mv^2$$

Now, $K_r + K_t = \dfrac{1}{2}Mv^2 + \dfrac{1}{5}Mv^2 = \dfrac{7}{10}Mv^2$

Therefore, ratio $\dfrac{k_t}{k_t + k_r} = \dfrac{\frac{1}{2}Mv^2}{\frac{7}{2}Mv^2} = \dfrac{5}{7}$

Thus, $K_t : (K_t + K_r) = 5:7$

Answer (2)

42. A small sphere of radius 'r' falls from rest in a viscous liquid. As a result, heat is produced due to viscous force. The rate of production of heat when the sphere attains its terminal velocity, is proportional to

(1) r^5 **(2)** r^2
(3) r^3 **(4)** r^4

Solution

Rate of heat produced = Power obtained by viscous force
Now, the power obtained by viscous force = $6\pi\eta r v_T^2$; where η is the viscosity, r is the radius of sphere v_T is the terminal velocity.

Terminal velocity, $v_T = \dfrac{2r^2}{9\eta}(\rho - \sigma)g \Rightarrow v_T \propto r^2$

Therefore, power $\propto r \cdot (r^2)^2 \Rightarrow$ power $\propto r^5$.

Thus, rate of heat produced $\propto r^5$.

Answer (1)

43. The power radiated by a black body is P and it radiates maximum energy at wavelength, λ_0. If the temperature of the black body is now changed so that it radiates maximum energy at wavelength $\frac{3}{4}\lambda_0$, the power radiated by it becomes nP. The value of n is

(1) $\frac{256}{81}$ **(2)** $\frac{4}{3}$

(3) $\frac{3}{4}$ **(4)** $\frac{81}{256}$

Solution

Power radiated is $P = \sigma A T^4 \Rightarrow P \propto T^4$.

By Wein's law, $T \propto \frac{1}{\lambda_m} \Rightarrow P \propto \left(\frac{1}{\lambda_m}\right)^4$

Given, at wavelength λ_0, power radiated is P, that is,

$$P \propto \left(\frac{1}{\lambda_0}\right)^4 \qquad (1)$$

At wavelength $\frac{3}{4}\lambda_0$, power radiated in nP, that is,

$$nP \propto \left(\frac{1}{\frac{3}{4}\lambda_0}\right)^4 \qquad (2)$$

Taking ratio, $\frac{nP}{P} = \frac{\left(\frac{1}{3/4\lambda_0}\right)^4}{(1/\lambda_0)^4} \Rightarrow n = \left(\frac{\lambda_0}{\frac{3}{4}\lambda_0}\right)^4$

$\Rightarrow n = \left(\frac{4}{3}\right)^4 = \frac{256}{81}$

Answer (1)

44. Two wires are made of the same material and have the same volume. The first wire has cross-sectional area A and the second wire has cross-sectional area $3A$. If the length of the first wire is increased by Δl on applying a force F, how much force is needed to stretch the second wire by the same amount?

(1) $4F$ **(2)** $6F$

(3) $9F$ **(4)** F

Solution

Given:

Wire 1: Cross-sectional area = A;
Change in length = Δl

Wire 2: Cross-sectional area = $3A$

Now, we know that $Y = \frac{F/A}{\Delta l/l} \Rightarrow \Delta l = \frac{Fl}{YA}$

where Y is Young's modulus, F is force, A is area, l is length of wire, Δl is change in length.

Now, it is required that $\Delta l_1 = \Delta l_2$. Therefore,

$$\frac{Fl_1}{AY} = \frac{F'l_2}{3AY} \Rightarrow 3Fl_1 = F'l_2 \Rightarrow F' = \frac{3Fl_1}{l_2}$$

Since, $V = Al \Rightarrow l = \frac{V}{A}$, therefore, $l_1 = V/A$ and $l_2 = V/3A$.

Therefore, $F' = 3F\left(\frac{V}{A}\right)\left(\frac{3A}{V}\right) = 9F$

Thus, $9F$ force is needed to stretch the second wire by same amount.

Answer (3)

45. A sample of 0.1 g of water at 100°C and normal pressure (1.013×10^5 N m^{-2}) requires 54 cal of heat energy to convert to steam at 100°C. If the volume of the steam produced is 167.1 cc, the change in internal energy of the sample, is

(1) 42.2 J **(2)** 208.7 J

(3) 104.3 J **(4)** 84.5 J

Solution

By first law of thermodynamics, we have

$$\Delta U = \Delta Q - \Delta W$$

Now $\Delta Q = 54 \text{ cal} = 54 \times 4.18 \text{ J} = 225.72 \text{ J}$

$$\Delta W = P\,(V_{\text{steam}} - V_{\text{water}})$$
$$= 1.013 \times 10^{-5}\,(167.1 \times 10^{-6} - 0.1 \times 10^{-6}) \text{ J}$$
$$= 1.013 \times 10^{5} \times 167 \times 10^{-6} = 16.917 \text{ J}$$

Therefore, $\Delta U = (225.75 - 16.917) \text{ J} \Rightarrow \Delta U = 208.7 \text{ J}$

Answer (2)