JEE MAIN | 2015 (Offline)

Physics

General Instructions

1. This paper contains 30 Multiple Choice Questions with single correct answer. Each question has four choices (1), (2), (3) & (4), out of which **only one** is Correct.
2. Each question is awarded 4 (four) marks for correct response.
3. One-fourth (1/4) marks will be deducted for indicating incorrect response of each question. No deduction from the total score will be made if no response is indicated for an item in the answer sheet.
4. Filling up more than one response in any question will be treated as wrong response and marks for wrong response will be deducted accordingly as per instruction 3 above.

1. As an electron makes a transition from an excited state to the ground state of a hydrogen-like atom/ion:

(1) kinetic energy, potential energy and total energy decreases

(2) kinetic energy decreases, potential energy increases but total energy remains same

(3) kinetic energy and total energy decrease but potential energy increases

(4) its kinetic energy increases but potential energy and total energy decreases

Solution:

As an electron transits from excited state to ground state, its total energy decreases.

Since total energy = (−) Kinetic energy $= \frac{\text{Potential energy}}{2}$

Therefore, total energy and potential energy decreases and kinetic energy increases.

Hence, the correct option is (4).

2. The period of oscillation of a simple pendulum is $T = 2\pi\sqrt{\frac{L}{g}}$. Measured value of L is 20.0 cm known to 1 mm accuracy and time for 100 oscillations of the pendulum is found to be 90 s using a wrist watch of 1 s resolution. The accuracy in the determination of g is:

(1) 3%

(2) 1%

(3) 5%

(4) 2%

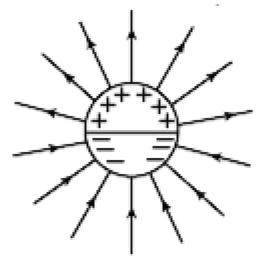
Solution:

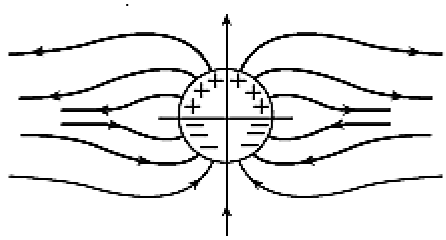
As $T = 2\pi\sqrt{\frac{L}{g}} \Rightarrow g = \frac{4\pi^2 L}{T^2} \Rightarrow \frac{\Delta g}{g} = \frac{\Delta L}{L} + \frac{2\Delta T}{T} \Rightarrow \frac{\Delta g}{g} = \frac{0.1}{20} + 2\times\frac{1}{90}$

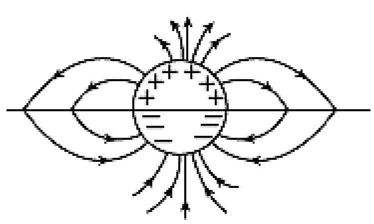
$\Rightarrow \frac{\Delta g}{g} \approx 0.027 \Rightarrow \frac{\Delta g}{g} \approx 3\%$

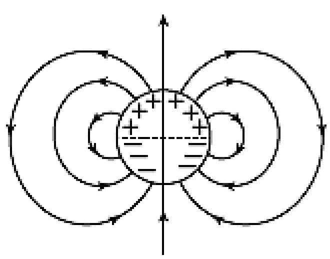
Hence, the correct option is (1).

3. A long cylindrical shell carries positive surface charge σ in the upper half and negative surface charge $-\sigma$ in the lower half. The electric field lines around the cylinder will look like figure given in: (*figures and schematic are not drawn to scale*)

(1) 

(2) 

(3) 

(4) 

Solution:

Electric field lines originate from (+) charge and terminate at (−) charge.
Hence, the correct option is (4).

4. A signal of 5 kHz frequency is amplitude modulated on a carrier wave of frequency 2 MHz. The frequencies of the resultant signal is/are:

(1) 2005 kHz and 1995 kHz

(2) 2005 kHz, 2000 kHz and 1995 kHz

(3) 2000 kHz and 1995 kHz

(4) 2 MHz only

Solution:

Since, $f_r = f_c \pm f_m$

Therefore, frequency content of Resultant wave will have frequencies 1995 kHz, 2000 kHz and 2005 kHz.

Hence, the correct option is (2).

5. Consider a spherical shell of radius R at temperature T. The black body radiation inside it can be considered as an ideal gas of photons with integral energy per unit volume, $u = \frac{U}{V} \propto T^4$ and pressure $p = \frac{1}{3}\left(\frac{U}{V}\right)$. If the shell now undergoes an adiabatic expansion the relation between T and R is:

(1) $T \propto e^{-3R}$

(2) $T \propto \frac{1}{R}$

(3) $T \propto \frac{1}{R^3}$

(4) $T \propto e^{-R}$

Solution:

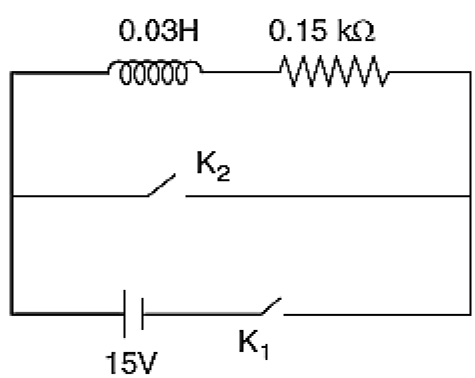
For adiabatic process, $dU = -PdV \Rightarrow \frac{dU}{dV} = -P = \frac{-U}{3V} \Rightarrow +\int \frac{dU}{U} = \frac{-1}{3}\int \frac{dV}{V}$

$\Rightarrow \ln U = \frac{-1}{3}\ln V + \ln C \Rightarrow \ln U(V)^{1/3} = \ln C \Rightarrow UV^{1/3} = C$

Since, $\frac{U}{V} \propto T^4 \Rightarrow U = k\,VT^4 \Rightarrow V^{4/3}T^4 = C' \Rightarrow V^{1/3}T = C' \Rightarrow T \propto \frac{1}{(V)^{1/3}} \propto \frac{1}{R}$

Hence, the correct option is (2).

6. An inductor (L = 0.03 H) and a resistor (R = 0.15 kΩ) are connected in series to a battery of 15V EMF in a circuit shown below. The key K_1 has been kept closed for a long time. Then at t = 0, K_1 is opened and key K_2 is closed simultaneously. At t = 1 ms, the current in the circuit will be: $(e^5 \cong 150)$



(1) 67 mA

(2) 6.7 mA

(3) 0.67 mA

(4) 100 mA

Solution:

At t = 0, when K_1 is open and K_2 is closed, then $i_{t=0} = \dfrac{E}{R}$

$$i_{t=1\text{ ms}} = \frac{E}{R}e^{-t/\lambda} \text{ where } \lambda = \frac{L}{R}$$

$$i_{(t=1\text{ ms})} = \frac{E}{R}e^{-\frac{10^{-3}\times 0.15\times 10^{3}}{3\times 10^{-2}}}$$

$$= \frac{15}{0.15\times 10^{3}}e^{-5} = \frac{100\times e^{-5}}{10^{3}} = 0.67\text{ mA}$$

Hence, the correct option is (3).

7. A pendulum made of a uniform wire of cross sectional area A has time period T. When an additional mass M is added to its bob, the time period changes to T_M. If the Young's modulus of the material of the wire is Y when $1/Y$ is equal to:

(g = gravitational acceleration)

(1) $\left[\left(\frac{T_M}{T}\right)^2 - 1\right]\frac{Mg}{A}$

(2) $\left[1-\left(\frac{T_M}{T}\right)^2\right]\frac{A}{Mg}$

(3) $\left[1-\left(\frac{T}{T_M}\right)^2\right]\frac{A}{Mg}$

(4) $\left[\left(\frac{T_M}{T}\right)^2 - 1\right]\frac{A}{Mg}$

Solution:

Time period of the pendulum, $T = 2\pi\sqrt{\dfrac{l}{g}}$

When mass M is added to the bob, then $T_M = 2\pi\sqrt{\dfrac{l+\Delta l}{g}}$

Since, $Y = \dfrac{Mgl}{A\,\Delta l} \Rightarrow \Delta l = \dfrac{Mg\,l}{A\,Y}$

Therefore, $T_M = 2\pi\sqrt{\dfrac{l+\dfrac{Mg\,l}{A\,Y}}{g}} \Rightarrow \left(\dfrac{T_M}{T}\right) = \sqrt{1+\dfrac{Mg}{AY}} \Rightarrow \dfrac{1}{Y} = \dfrac{A}{Mg}\left[\left(\dfrac{T_M}{T}\right)^2 - 1\right]$

Hence, the correct option is (4).

8. A red LED emits light at 0.1 watt uniformly around it. The amplitude of the electric field of the light at a distance of 1 m from the diode is:

(1) 2.45 V/m

(2) 5.48 V/m

(3) 7.75 V/m

(4) 1.73 V/m

Solution:

Pressure = Energy Density = $\dfrac{\text{Power}}{\text{Area} \times C}$

$$\frac{1}{2}\varepsilon_0 E^2 = \frac{P}{4\pi r^2 \times C} \Rightarrow E = \sqrt{\frac{P^2}{(4\pi\varepsilon_0)r^2 \times C}} \Rightarrow E = \sqrt{\frac{2\times 0.1\times 9\times 10^9}{1^2 \times 3\times 10^8}} = \sqrt{6}\ \text{V/m} = 2.45\ \text{V/m}$$

Hence, the correct option is (1).

9. Two coaxial solenoids of different radii carry current I in the same direction. Let $\vec{F}_1$ be the magnetic force on the inner solenoid due to the outer one and $\vec{F}_2$ be the magnetic force on the outer solenoid due to the inner one. Then:

(1) $\vec{F}_1$ is radially inwards and $\vec{F}_2$ is radially outwards

(2) $\vec{F}_1$ is radially inwards and $\vec{F}_2 = 0$

(3) $\vec{F}_1$ is radially outwards and $\vec{F}_2 = 0$

(4) $\vec{F}_1 = \vec{F}_2 = 0$

Solution:

Since both solenoids are in equilibrium, so net Force = 0
Therefore, $F_1 = F_2 = 0$.

Hence, the correct option is (4).

10. Consider an ideal gas confined in an isolated closed chamber. As the gas undergoes an adiabatic expansion, the average time of collision between molecules increases as V^q, where V is the volume of the gas. The value of q is:

$\left(\gamma = \dfrac{C_P}{C_V}\right)$

(1) $\dfrac{3\gamma - 5}{6}$

(2) $\dfrac{\gamma + 1}{2}$

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

(4) $\frac{3\gamma+5}{6}$

Solution:

Average time between collision = $\frac{\text{Mean free path}}{V_{\text{rms}}}$

Now, Mean free path = $\left(\frac{V}{\pi r^2 N}\right)$

$$V_{\text{rms}} = \sqrt{\frac{3RT}{M}}$$

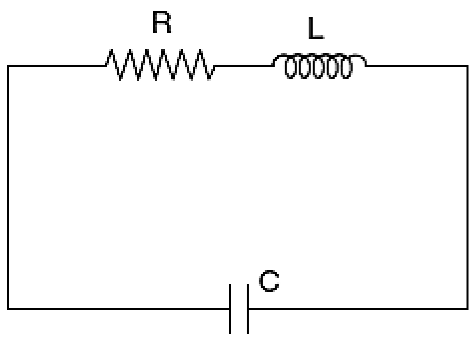
$$t_{AV} = \frac{CV}{\sqrt{T}} \left(\text{where} \quad C = \sqrt{\frac{M}{\pi r^2 N\sqrt{3}R}}\right) \Rightarrow T = \frac{C^2V^2}{t_{AV}^2}$$

For adiabatic process, TV^{r-1} = constant (K)

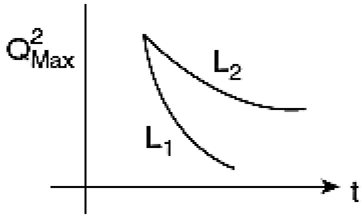
Therefore, $\frac{C^2V^2V^{r-1}}{t_{AV}^2} = K \Rightarrow \frac{C^2V^{r+1}}{t_{AV}^2} = K \quad \Rightarrow t_{AV} \propto V^{\left(\frac{r+1}{2}\right)} \Rightarrow q = \frac{r+1}{2}$

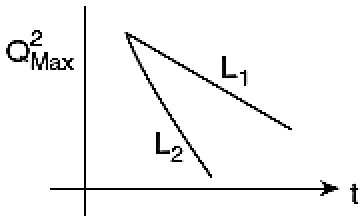
Hence, the correct option is (2).

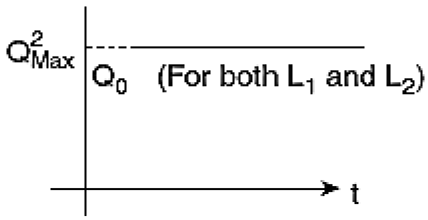
11. An LCR circuit is equivalent to a damped pendulum. In an LCR circuit the capacitor is charged to Q_0 and then connected to the L and R as shown below:

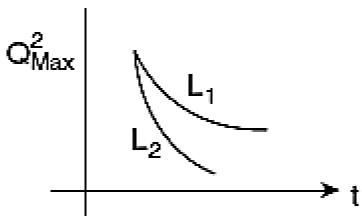


If a student plots graphs of the square of maximum charge $\left(Q_{Max}^2\right)$ on the capacitor with time(t) for two different values L_1 and L_2 ($L_1>L_2$) of L then which of the following represents this graph correctly? (*plots are schematic and not drawn to scale*)

(1) 

(2) 

(3) 

(4) 

Solution:

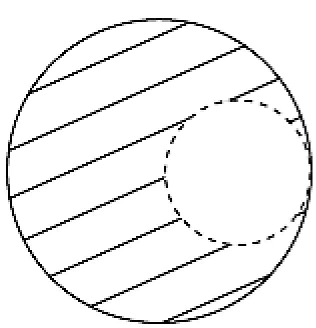
Since $L_1 > L_2$

Therefore, ate of energy dissipation through R from L_1 is less as compared to L_2.

Hence, the correct option is (4).

12. From a solid sphere of mass M and radius R, a spherical portion of radius $R/2$ is removed, as shown in the figure. Taking gravitational potential $V = 0$ at $r = \infty$, the potential at the centre of the cavity thus formed is:

(G = gravitational constant)



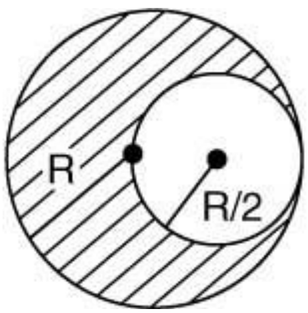
(1) $\frac{-GM}{R}$

(2) $\frac{-2GM}{3R}$

(3) $\frac{-2GM}{R}$

(4) $\frac{-GM}{2R}$

Solution:



$V_{\text{Net}} = V_M - V_{M/8}$

$$= \frac{-GM}{2R^3}\left[\frac{3R^2 - R^2}{4}\right] + \left[\frac{GM/8}{2R^3/8}\left(\frac{3R^2}{4} - 0\right)\right] = \frac{-11GMR^2}{8R^3} + \frac{3GMR^2}{8\,R^3} = \frac{-8GM}{8R} = \frac{-GM}{R}$$

Hence, the correct option is (1).

13. A train is moving on a straight track with speed 20 m/s. It is blowing its whistle at the frequency of 1000 Hz. The percentage change in the frequency heard by a person standing near the track as the train passes him is (speed of sound = 320 m/s) close to:

(1) 12%

(2) 18%

(3) 24%

(4) 6%

Solution:

When Train approaches

$$f_1 = 1000\left[\frac{320}{320-20}\right] = \frac{1000 \times 320}{300}$$

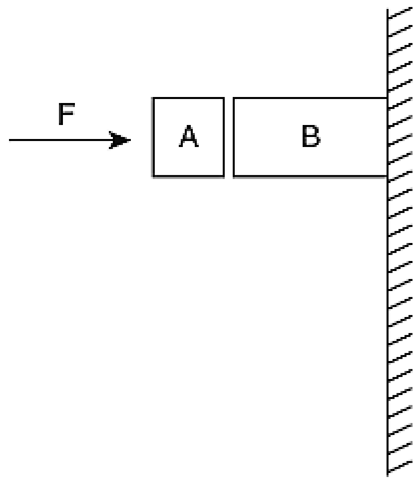
When train goes away

$$f_2 = 1000\left[\frac{320}{320+20}\right] = \frac{1000 \times 320}{340}$$

Therefore, $\frac{\Delta f}{f_1} = \left(\frac{f_1 - f_2}{f_1}\right) = \frac{340-300}{340} = \frac{40}{340} \Rightarrow \frac{\Delta f}{f_1} = 0.117 \approx 12\%$

Hence, the correct option is (1).

14.



Given in the figure are two blocks A and B of weight 20 N and 100 N, respectively. These are being pressed against a wall by a force F as shown. If the coefficient of friction between the blocks of 0.1 and between block B and the wall is 0.15, the frictional force applied by the wall on block B is:

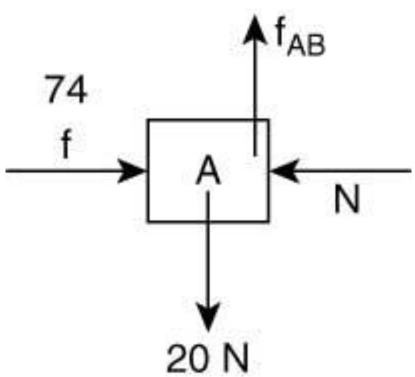
(1) 80 N

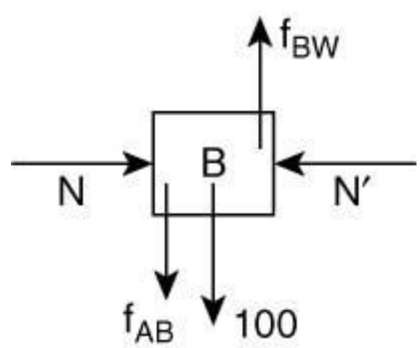
(2) 120 N

(3) 150 N

(4) 100 N

Solution:





For *A*

$F = N$

$f_{AB} = 20$ N

For *B*

$N = N' = F$

$f_{BW} = f_{AB} + 100$

$f_{BW} = 120$ N

Hence, the correct option is (2).

15. Distance of the centre of mass of a solid uniform cone from its vertex is z_0. If the radius of its base is R and its height is h then z_0 is equal to:

(1) $\frac{3h}{4}$

(2) $\frac{5h}{8}$

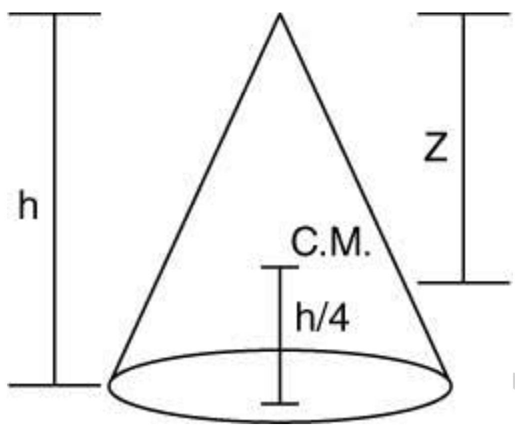
(3) $\frac{3h^2}{8R}$

(4) $\frac{h^2}{4R}$

Solution:

From base its $h/4$

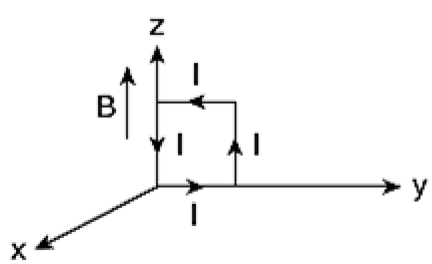
$\therefore \; Z_0 = h - \frac{h}{4} = \frac{3h}{4}$



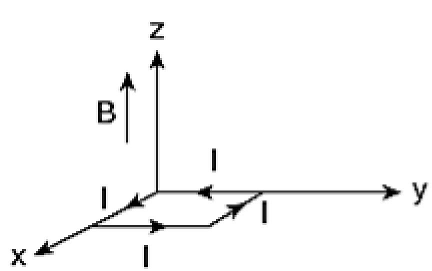
Hence, the correct option is (1).

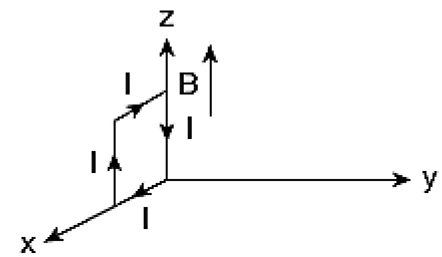
16. A rectangular loop of sides 10 cm and 5 cm carrying a current I of 12 A is placed in different orientations as shown in the figures below:

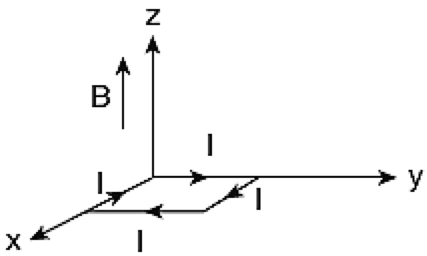
(1)



(2)



(3) 

(4) 

If there is a uniform magnetic field of 0.3 T in the positive z direction, in which orientations the loop would be in (i) stable equilibrium and (ii) unstable equilibrium?

(1) (a) and (c), respectively

(2) (b) and (d), respectively

(3) (b) and (c), respectively

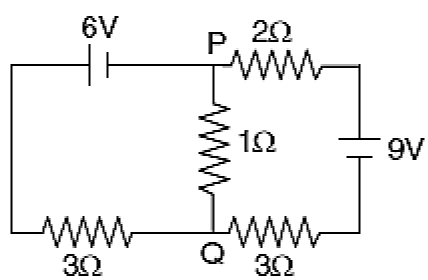
(4) (a) and (b), respectively

Solution:

By Right hand thumb Rule angle between $\vec{M}$ and $\vec{B}$ is 0° in option (b) and 180° in option (d)

Hence, the correct option is (2).

17.



In the circuit shown, the current in the 1Ω resistor is:

(1) 0 A

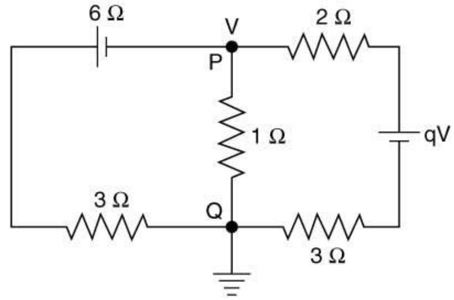
(2) 0.13 A, from Q to P

(3) 0.13 A, from P to Q

(4) 1.3 A, from P to Q

Solution:

Apply Kirchoff's Law



$$\frac{V-q}{5}+\frac{V}{1}+\frac{V+6}{3}=0$$

$3V - 27 + 15V + 5V + 30 = 0$

$V = -0.13\text{V}$

Therefore, $i_{(1\Omega)} = \frac{0.13}{1} = 0.13\text{ A}$ (from Q to P)

Hence, the correct option is (2).

18. A uniformly charged solid sphere of radius R has potential V_0 (measured with respect to ∞) on its surface. For this sphere the equipotential surface with potentials $\frac{3V_0}{2}, \frac{5V_0}{4}, \frac{3V_0}{4}$ and $\frac{V_0}{4}$ have radius R_1, R_2, R_3 and R_4 respectively. Then

(1) $R_1 \neq 0$ and $(R_2 - R_1) > (R_4 - R_3)$

(2) $R_1 = 0$ and $R_2 < (R_4 - R_3)$

(3) $2R < R_4$

(4) $R_1 = 0$ and $R_2 > (R_4 - R_3)$

Solution:

For a Non conducting sphere,

$$V_{in} = \frac{KQ}{2R^3}\left[3R^2 - x^2\right]$$

$$V_0 = \frac{KQ}{R} \text{ (at surface)}$$

$$V_{out} = \frac{KQ}{r} \text{ where } (r > R) \text{ and } V_{in} > V_0 > V_{out}$$

Now,

$$V_{in} = \frac{3V_0}{2} \Rightarrow R_1 = 0$$

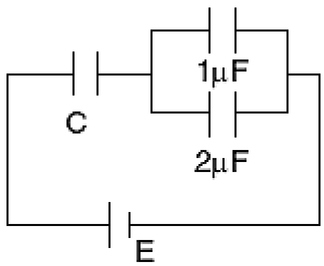
$$V_{in} = \frac{5V_0}{4} \Rightarrow R_2 = \frac{R}{\sqrt{2}}$$

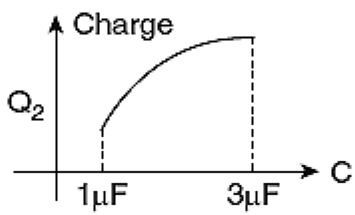
$$V_{out} = \frac{3V_0}{4} \Rightarrow R_3 = \frac{4R}{3}$$

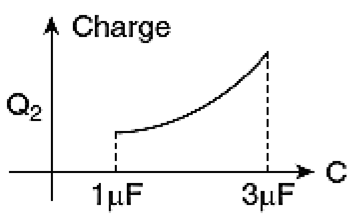
$V_{out} = \frac{V_0}{4} \Rightarrow R_4 = 4R$

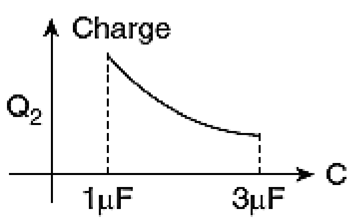
Hence, the correct options are (2) and (3).

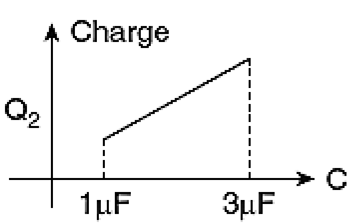
19. In the given circuit, charge Q_2 on the 2 μF capacitor changes as C is varied from 1 μF to 3 μF. Q_2 as a function of 'C' is given properly by: (figures are drawn schematically and are not to scale)



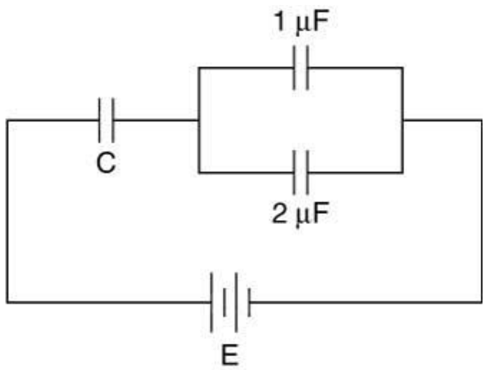
(1) 

(2) 

(3) 

(4) 

Solution:



$$\frac{1}{C_{eff}} = \frac{1}{C} + \frac{1}{3}$$

$$C_{eff} = \frac{3C}{C+3}$$

$$\therefore \ Q = \frac{3CE}{C+3}$$

$$\therefore \ V_{across\ 2\mu F} = \frac{CE}{C+3}$$

$$\therefore \ Q_2 = \frac{2CE}{C+3}$$

Hence, the correct option is (1).

20. A particle of mass m moving in the *x* direction with speed 2*v* is hit by another particle of mass 2 m moving in the *y* direction with speed *v*. If the collision is perfectly inelastic, the percentage loss in the energy during the collision is close to:

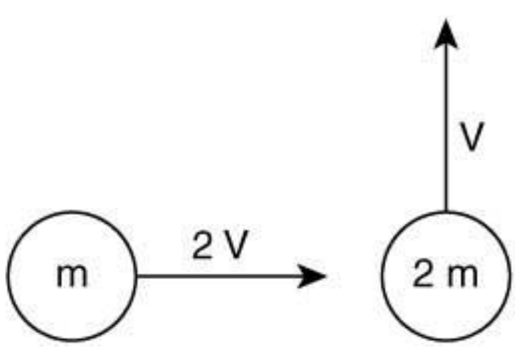
(1) 50 %

(2) 56 %

(3) 62 %

(4) 44 %

Solution:



Apply Momentum Conservation

$$(m)(2v)\hat{i} + 2mv\hat{j} = 3mv'$$

$v' = \frac{2v}{3}(\hat{i} + \hat{j})$

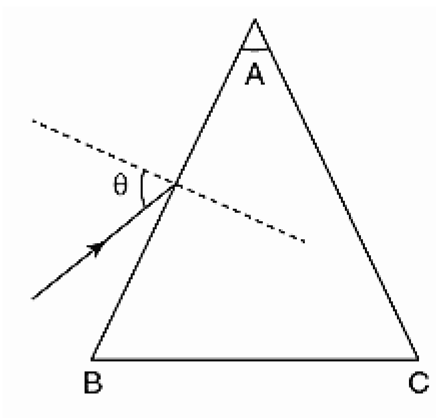
Therefore, energy loss $= \left(\frac{1}{2}m \cdot 4v^2 + \frac{1}{2}2mv^2\right) - \left(\frac{1}{2} \cdot 3m \cdot \frac{8v^2}{9}\right)$

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

Therefore, fraction loss $= \frac{5mv^2}{3(3mv^2)} = \frac{5}{9} = 56\%$

Hence, the correct option is (2).

21. Monochromatic light is incident on a glass prims of angle *A*. If the refractive index of the material of the prism is μ, a ray, incident at an angle θ, on the face *AB* would get transmitted through the face *AC* of the prism provided:



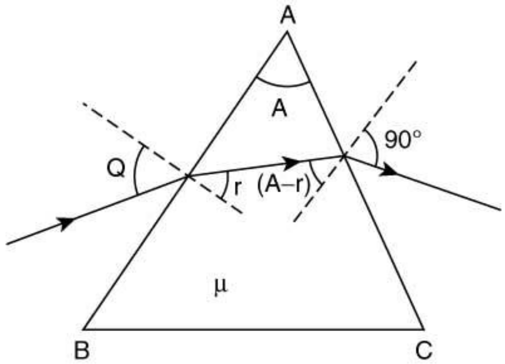
(1) $\theta < \sin^{-1}\left[\mu \sin\left(A - \sin^{-1}\left(\frac{1}{\mu}\right)\right)\right]$

(2) $\theta > \cos^{-1}\left[\mu \sin\left(A + \sin^{-1}\left(\frac{1}{\mu}\right)\right)\right]$

(3) $\theta < \cos^{-1}\left[\mu \sin\left(A + \sin^{-1}\left(\frac{1}{\mu}\right)\right)\right]$

(4) $\theta > \sin^{-1}\left[\mu \sin\left(A - \sin^{-1}\left(\frac{1}{\mu}\right)\right)\right]$

Solution:



For face AB

$1 \sin \theta = \mu \sin r$

For face AC

$\mu \sin (A - r) < 1 \sin 90$

$$(A - r) < \sin^{-1} \frac{1}{\mu}$$

$$r > \left(A - \sin^{-1} . \frac{1}{\mu} \right)$$

$$\sin r > \sin \left(A - \sin^{-1} \left(\frac{1}{\mu} \right) \right)$$

$$\frac{\sin \theta}{\mu} > \sin \left[A - \sin^{-1} \left(\frac{1}{\mu} \right) \right]$$

$$\theta > \sin^{-1} \left(\mu \sin \left(A - \sin^{-1} \frac{1}{\mu} \right) \right)$$

Hence, the correct option is (4).

22. From a solid sphere of mass M and radius R and cube of maximum possible volume is cut. Moment of inertia of cube about an axis passing through its centre and perpendicular to one of its faces is:

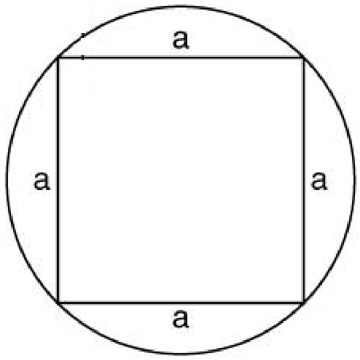
(1) $\frac{MR^2}{16\sqrt{2}\pi}$

(2) $\frac{4MR^2}{9\sqrt{3}\pi}$

(3) $\frac{4MR^2}{3\sqrt{3}\pi}$

(4) $\frac{MR^2}{32\sqrt{2}\pi}$

Solution:



For Maximum Volume

$2R = \sqrt{3}a$

$$M_{cube} = \frac{Ma^3}{4/3\,\pi R^3}$$

$$M_{cube} = \frac{3M \cdot 8}{4\pi \cdot 3\sqrt{3}} = \frac{2M}{\pi\sqrt{3}}$$

$$I_{cube} = \frac{M_{cube}a^2}{6} = \frac{2M \cdot 4R^2}{\pi\sqrt{3} \cdot 6 \cdot 3} = \frac{4MR^2}{9\sqrt{3}\pi}$$

Hence, the correct option is (2).

23. Match **List – I** (Fundamental Experiment) with **List – II** (its conclusion) and select the correct option from the choices given below the list :

	List – I		List – II
(A)	Franck-Hertz Experiment	(i)	Particle nature of light
(B)	Photo-electric, experiment	(ii)	Discrete energy levels of atom
(C)	Davison-Germer Experiment	(iii)	Wave nature of electron
		(iv)	Structure of atom

(1) (A) – (ii) (B) – (iv) (C) – (iii)

(2) (A) – (ii) (B) – (i) (C) – (iii)

(3) (A) – (iv) (B) – (iii) (C) – (ii)

(4) (A) – (i) (B) – (iv) (C) – (iii)

Solution:

The correct match is:

Frank-Hertz experiment → Discrete energy level of Atom
Photoelectric effect → for particle Nature of light
Davison-Germer experiment → for wave nature of electron

Hence, the correct option is (2).

24. When 5 V potential difference is applied across a wire of length 0.1 m, the drift speed of electrons is 2.5×10^{-4} m/s. If the electron density in the wire is 8×10^{28} m^{-3}, the resistivity of the material is close to:

(1) 1.6×10^{-7} Ωm

(2) 1.6×10^{-6} Ωm

(3) 1.6×10^{-5} Ωm

(4) 1.6×10^{-8} Ωm

Solution:

From ohm's law,

$$V = IR = \frac{\rho l}{A} \times I$$

$$V = \frac{\rho l}{\cancel{A}} n \cancel{A} V_d e$$

$$V = \rho l n V_d e$$

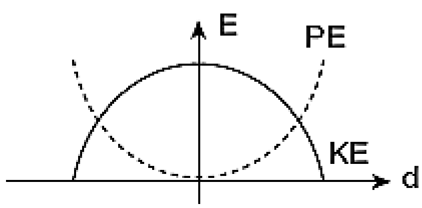
$$\rho = \frac{V}{l n V_d e} = \frac{5 \times 10^4 \times 10^{19}}{0.1 \times 2.5 \times 8 \times 10^{28} \times 1.6}$$

$$\rho = 1.6 \times 10^{-5}\ \Omega\text{m}$$

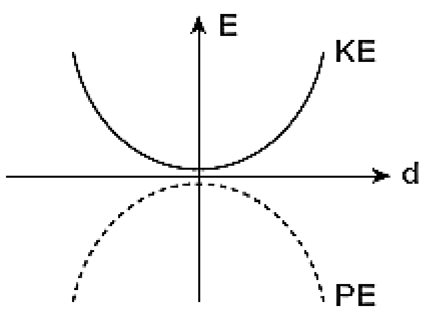
Hence, the correct option is (3).

25. For a simple pendulum, a graph is plotted between its kinetic energy (KE) and potential energy (PE) against its displacement d. Which one of the following represents these correctly? (Graphs are schematic and not drawn to scale)

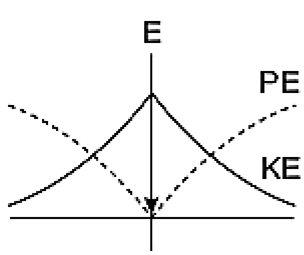
(1)

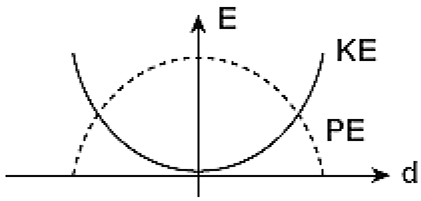


(2)



(3)



(4) 

Solution:

KE + PE = TE = Constant
So at the mean position KE is maximum and PE = 0
And at the extreme position, KE = 0 and PE = Maximum

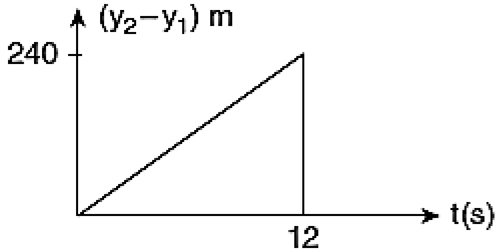
Hence, the correct option is (1).

26. Two stones are thrown up simultaneously from the edge of a cliff 240 m high with initial speed of 10 m/s and 40 m/s respectively. Which of the following graph best represents the time variation of relative position of the second stone with respect to the first?

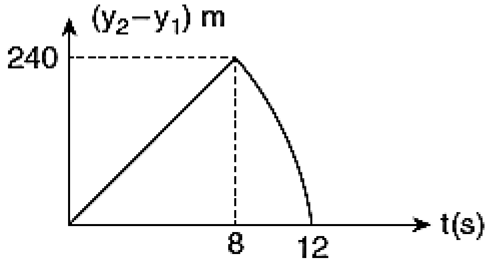
(Assume stones do not rebound after hitting the ground and neglect air resistance, take g = 10 m/s^2)

(The figures are schematic and not drawn to scale)

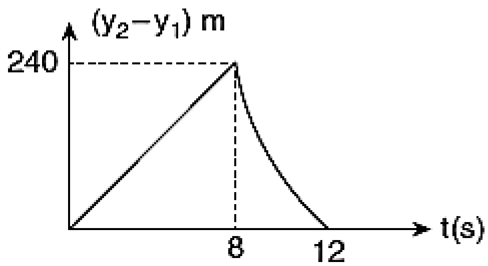
(1)



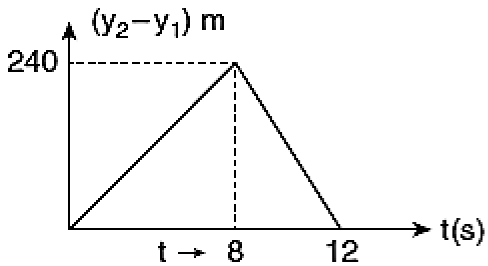
(2)



(3)



(4)



Solution:

For stone 1:

$$y_1 = 10t - \frac{gt^2}{2}$$

For stone 2:

$$y_2 = 40t - \frac{gt^2}{2}$$

$(y_2 - y_1) = 30t$

Therefore straight line till stone 2 reaches ground. And after that only stone 1 will travel with equation,

$y = 10t - \frac{gt^2}{2}$. So parabola afterwards.

Hence, the correct option is (2).

27. A solid body of constant heat capacity 1 J/°C is being heated by keeping it in contact with reservoirs in two ways:

(i) Sequentially keeping in contact with 2 reservoirs such that each reservoir supplies same amount of heat.

(ii) Sequentially keeping in contact with 8 reservoirs such that each reservoir supplies same amount of heat.

In both the cases body is brought from initial temperature 100°C to final temperature 200°C. Entropy change of the body in the two cases respectively is:

(1) $\ln 2,\ \ln 2$

(2) $\ln 2,\ 2\ln 2$

(3) $2\ln 2,\ 8\ln 2$

(4) $\ln 2,\ 4\ln 2$

Solution:

For case (I):

Since, $S = C\int \frac{dT}{T}$

Therefore, $S = 1\left[\int_{373}^{423} \frac{dT}{T} + \int_{423}^{473} \frac{dT}{T}\right] = \ln\left(\frac{473}{373}\right)$

For case (II):

$$S = 1\left[\int_{373}^{385.5} \frac{dT}{T} + \int_{385.5}^{398} \frac{dT}{T} + \int_{398}^{410.5} \frac{dT}{T} + \int_{410.5}^{423} \frac{dT}{T} + \int_{423}^{435.5} \frac{dT}{T} + \int_{435.5}^{448} \frac{dT}{T} + \int_{448}^{460.5} \frac{dT}{T} + \int_{460.5}^{473} \frac{dT}{T}\right]$$

$$= \ln\left(\frac{473}{373}\right)$$

So none of the option match.

Hence, no option correct.

28. Assuming human pupil to have a radius of 0.25 cm and a comfortable viewing distance of 25 cm, the minimum separation between two objects that human eye can resolve at 500 nm wavelength is :

(1) 30 μm

(2) 100 μm

(3) 300 μm

(4) 1 μm

Solution:

Since, $\theta = \frac{1.22\lambda}{D}$

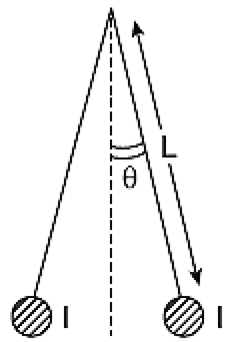
Substituting the values, we have,

$$\theta = \frac{1.22 \times 500 \times 10^{-9}}{25 \times 10^{-4} \times 2} = \frac{24.4 \times 10^{-5}}{2} = 12.2 \times 10^{-5}$$

Hence minimum separation = $(25 \times 10^{-2})\theta = = 25 \times 10^{-2} \times \frac{24.4}{2} \times 10^{-5}$ = 30 μm

Hence, the correct option is (1).

29.



Two long current carrying thin wires, both with current I, are held by insulating threads of length L and are in equilibrium as shown in the figure, with threads making an angle 'θ' with the vertical. If wires have mass λ per unit length then the value of I is:

(g = gravitational acceleration)

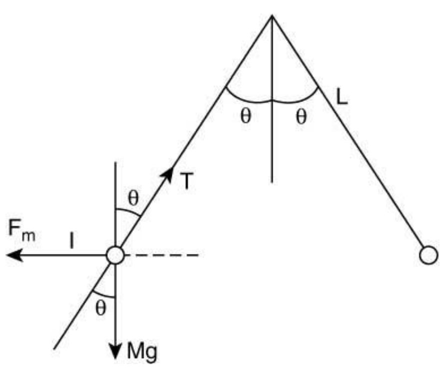
(1) $2\sin\theta\sqrt{\dfrac{\pi\lambda gL}{\mu_o \cos\theta}}$

(2) $2\sqrt{\dfrac{\pi gL}{\mu_0}\tan\theta}$

(3) $\sqrt{\dfrac{\pi\lambda gL}{\mu_0}\tan\theta}$

(4) $\sin\sqrt{\dfrac{\pi\lambda gL}{\mu_0 \cos\theta}}$

Solution:



At equilibrium

$T\cos\theta = \text{Mg}$

$T\sin\theta = F_M$

Therefore, $\tan\theta = \dfrac{F_M}{Mg} = \dfrac{(F_M/l)}{(Mg)/l} = \dfrac{\mu . I^2}{2\pi 2L\sin\theta\lambda g} = \dfrac{\mu . I^2}{4\pi\lambda Lg\sin\theta}$

$$\Rightarrow I = \sqrt{\frac{4\pi Lg \sin\theta \tan\theta}{\mu_0}} = 2\sin\theta\sqrt{\frac{\pi Lg}{\mu\cos\theta}}$$

Hence, the correct option is (1).

30. On a hot summer night, the refractive index of air is smallest near the ground and increases with height from the ground. When a light beam is directed horizontally, the Huygen's principle leads us to conclude that as it travels, the light beam:

(1) goes horizontally without any deflection

(2) bends downwards

(3) bends upwards

(4) becomes narrower

Solution:

Since the light beam is parallel to the ground there will not be any change in the refractive index of its path. So neither refraction nor total internal reflection will take place. As a result the light beam will go horizontally without any deflection.

Hence, the correct option is (1).