NEET 2025 - Paper Code - Narmada 48

Physics

Question 1: A parallel plate capacitor made of circular plates is being charged such that the surface charge density on its plates is increasing at a constant rate with time. The magnetic field arising due to displacement current is:

Options:

(a) Non-zero everywhere with maximum at the imaginary cylindrical surface connecting peripheries of the plates

(b) Zero between the plates and non-zero outside

(c) Zero at all places

(d) Constant between the plates and zero outside the plates

Answer: (a)

Solution: Non-zero everywhere with maximum at the imaginary cylindrical surface connecting peripheries of the plates

$$\oint \vec{B}.d\vec{l} = \mu_0\left(i_C + \varepsilon_0 \frac{\partial \phi}{\partial t}\right)$$

$\therefore$ Maxwell Ampere law

In the gap, there's no conduction but there is displacement current due to changing electric field.

This current leads to magnetic field in the region

If increases radially with in the places, reaching maximum at the edge.

Question 2: An electric dipole with dipole moment $5\times10^{-6}Cm$ is aligned with the direction of a uniform electric field of magnitude $4\times10^{5}N/C$. The dipole is then rotated through an angle of $60°$ with respect to the electric field. The change in the potential energy of the dipole is:

Options:

(a) 1.2 J

(b) 1.5 J

(c) 0.8 J

(d) 1.0 J

Answer: (d)

Solution: $\Delta U = U_2 - U_1$

$$= \left(-pE\cos\theta_2\right) - \left(-pE\cos\theta_1\right)$$

$$= -pE\cos 60 + pE\cos 0$$

$$= \frac{-pE}{2} + pE$$

$$= \frac{1}{2}pE = \frac{1}{2}\times5\times10^{-6}\times4\times10^{5} = 1.0J$$

Question 3: A ball of mass 0.5 kg is dropped from a height of 40 m. The ball hits the ground and rises to a height of 10 m. The impulse imparted to the ball during its collision with the ground is (Take $g = 9.8m/s^2$)

Options:

(a) 0

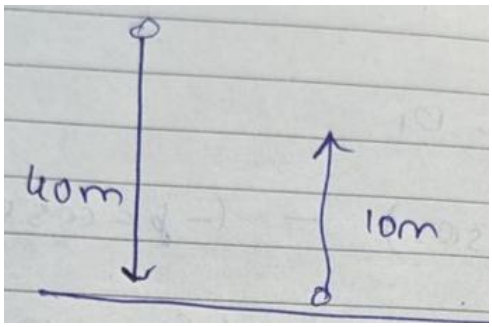
(b) 84 NS

(c) 21 NS

(d) 7 NS

Answer: (c)

Solution:



$v_1 = \sqrt{2gh} = \sqrt{2\times 9.8\times 40} = \sqrt{196\times 4}$

$= 14\times 2 = 28 m/s$

$v_2 = \sqrt{2gh} = \sqrt{2\times 9.8\times 10} = \sqrt{196} = 14 m/s$

$3 = p_2 - p_1$

$= mv_2 - mv_1$

$= 0.5(+14) - 0.5(-28) = 7 + 14 = 21$

Question 4: The intensity of transmitted light when a polaroid sheet, placed between two crossed polaroids at $22.5°$ from the polarization axis of one of the polaroid, is (I_0 is the intensity of polarized light after passing through the first polaroid):

Options:

(a) $\frac{I_0}{8}$

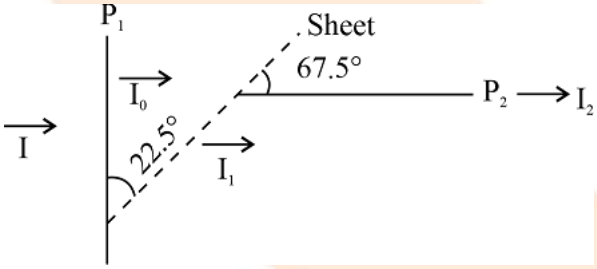
(b) $\frac{I_0}{16}$

(c) $\frac{I_0}{2}$

(d) $\frac{I_0}{4}$

Answer: (a)

Solution:



$I_1 = 30\cos^2\theta = I_0\cos^2(22.5)$

$I_2 = I_1\cos^2\theta = I_1\cos^2 67.5$

$I_2 = (I_0\cos^2 22.5)(\cos^2 67.5)$ ....(1)

$\cos 22.5 = \sqrt{\frac{1+\cos 45}{2}} = \sqrt{1+\frac{1}{\sqrt{2}}} = \sqrt{\frac{1}{2}+\frac{1}{2\sqrt{2}}}$

$\cos 67.5 = \sin 22.5 = \sqrt{\frac{1-\cos 45}{2}} = \sqrt{\frac{1}{2}-\frac{1}{2\sqrt{2}}}$

From (1)

$I_2 = I_0\left(\frac{1}{2}+\frac{1}{2\sqrt{2}}\right)\left(\frac{1}{2}-\frac{1}{2\sqrt{2}}\right)$

$= I_0\left(\frac{1}{4} - \frac{1}{4\times 2}\right) = I_0\left(\frac{1}{4} - \frac{1}{8}\right)$

$= \frac{I_0}{8}$

Question 5: The kinetic energies of two similar cars A and B are 100 J and 225 J respectively. On applying breaks, car A stops after 1000 m and car B stops after 1500 m. If F_A and F_B are the forces applied by the breaks on cars A and B respectively, then the ratio $\frac{F_A}{F_B}$ is

Options:

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

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

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

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

Answer: (d)

Solution: $W = \Delta KE$

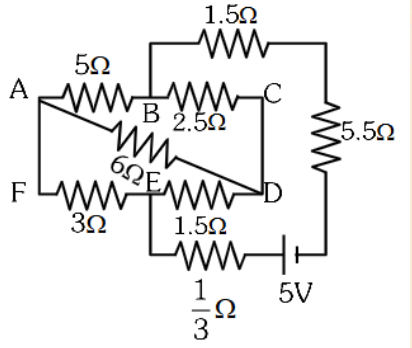
$-Fs = 0 - KE$

$Fs = KE$

$F_1 = \frac{100}{1000} = \frac{1}{10}, F_2 = \frac{225}{1500} = \frac{15}{100}$

$\frac{F_1}{F_2} = \frac{1}{10}\times\frac{100}{15} = \frac{10}{15} = \frac{2}{3}$

Question 6: The current passing through the battery in the given circuit, is:



Options:

(a) 2.5 A

(b) 1.5 A

(c) 2.0 A

(d) 0.5 A

Answer: (d)

Solution: ABCDEF forms wheat stone $5\times 1.5 = 7.5$

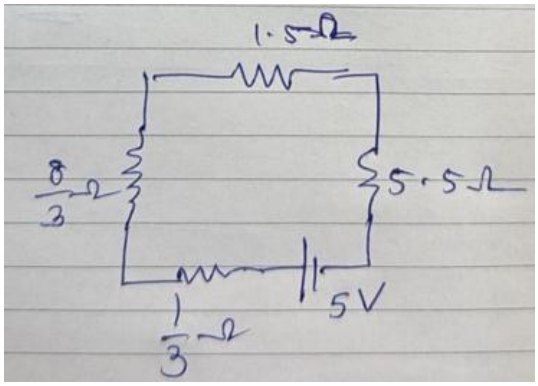
$3\times 2.5 = 7.5$

$\therefore$ Ignoring 6Ω resistance $3\Omega, 5\Omega$ in series gives 4Ω

$1.5, 2.5$ in series gives 4Ω

Now, $8\Omega, 4\Omega$ in parallel gives $\frac{8\times 4}{8+4} = \frac{8}{3}\Omega$

New circuit:

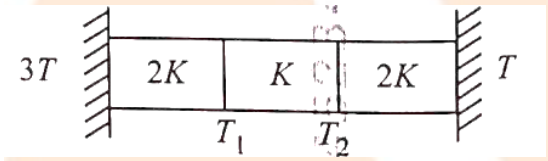


$$V = IR = i\left(\frac{1}{3}+\frac{8}{3}+1.5+5.5\right) = i(10)$$

$$5 = i(10)$$

$$i = 0.5A$$

Question 7: Three identical heat conducting rods are connected in series as shown in the figure. The rods on the sides have thermal conductivity 2K while that in the middle has thermal conductivity K. The left end of the combination is maintained at temperature 3T and the right end at T. The rods are thermally insulated from outside. In steady state, temperature at the left junction is T_1 and that at the right junction is T_2. The ratio $\frac{T_1}{T_2}$ is



Options:

(a) $\frac{5}{3}$

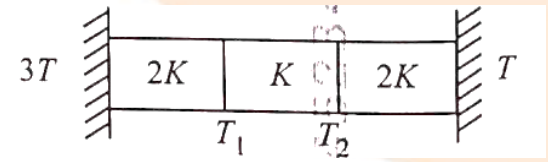
(b) $\frac{5}{4}$

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

(d) $\frac{4}{3}$

Answer: (a)

Solution:



$$Q = \frac{kA\Delta T}{L}$$

$$Q = \frac{2kA}{L}(3T - T_1) = \frac{kA}{L}(T_1 - T_2) = \frac{2kA}{L}(T_2 - T)$$

$$\therefore 2(3T - T_1) = (T_1 - T_2) = 2(T_2 - T) = constant$$

$$\therefore \boxed{6T - 2T_1 = C} \quad ....(1)$$

$$\boxed{T_1 - T_2 = C} \quad ....(2)$$

$$\boxed{2T_2 - T = C} \quad ....(3)$$

$$\boxed{2T_1 - 2T_2 = 2C} \quad ....(4)$$

And (1) & (4)

$\boxed{6T - 2T_2 = 3C}$ $..(5)$

$\boxed{2T_2 - 2T = C}$ from (3)

Add above $4T = 4C$

$\boxed{T = C}$

From (1), $6T - 2T_1 = C$

$6C - 2T_1 = C$

$5C = 2T_1$

$\boxed{\frac{5C}{2} = T_1}$

From 3, $2T_2 - 2T = C$

$2T_2 - 2C = C$

$2T_2 = 3C$

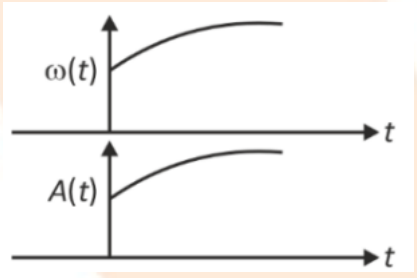
$\boxed{T_2 = \frac{3C}{2}}$

$\frac{T_1}{T_2} = \frac{\frac{5C}{2}}{\frac{3C}{2}} = \frac{5}{3}.$

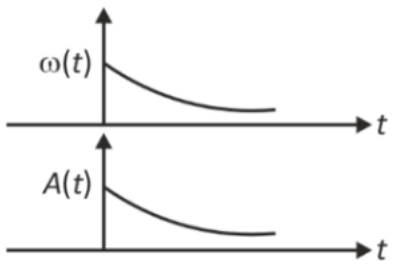
Question 8: In an oscillating spring mass system, a spring is connected to a box filled with sand. As the box oscillates, sand leaks slowly out of the box vertically so that the average frequency $\omega(t)$ and average amplitude $A(t)$ of the system change with the time t. Which one of the following options schematically depicts these changes correctly?

Options:

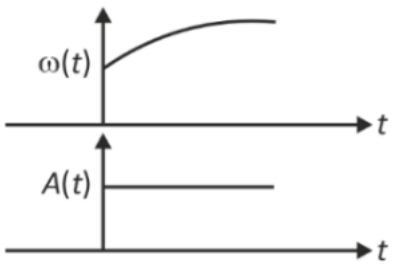
(a)

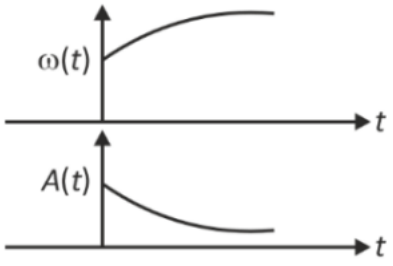


(b)



(c)





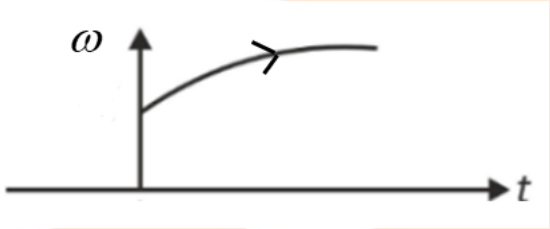
(d)

Answer: (d)

Solution:

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

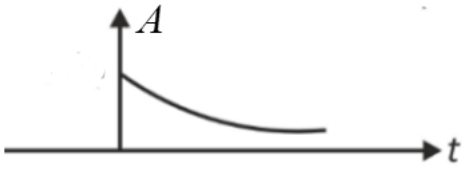
$m \downarrow, \omega \uparrow$ until it becomes constant



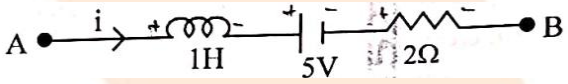
$E = \frac{1}{2}kA^2$

$\sqrt{\frac{2E}{k}} = A$

If energy is lost due to leakage, amplitude can decrease.



Question 9: AB is a part of an electrical circuit (see figure). The potential difference "$V_A - V_B$", at the instant when current $i = 2A$ and is increasing at a rate of 1 amp/second is:



Options:

(a) 9 volt

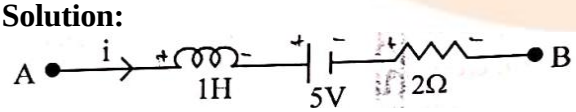
(b) 10 volt

(c) 5 volt

(d) 6 volt

Answer: (b)

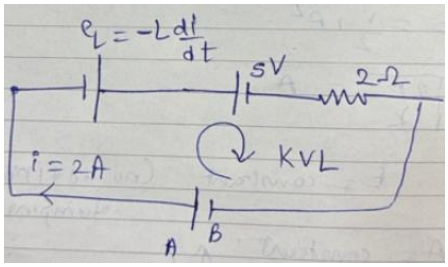
Solution:



$\frac{di}{dt} = +\frac{1A}{s}$

Redraw

$e_L = -L\frac{di}{dt}$



$(V_A - V_B) + e_L - 5 - iR = 0$

$(V_A - V_B) - L\frac{di}{dt} - 5 - iR = 0$

$(V_A - V_b) - 1(1) - 5 - 2(2) = 0$

$V_A - V_B = 10V$

Question 10: A particle of mass m is moving around the origin with a constant force F pulling it towards the origin. If Bohr model is used to describe its motion, the radius of the nth orbit and the particle's speed v in the orbit depend on n as

Options:

(a) $r \propto n^{\frac{2}{3}}; v \propto n^{\frac{1}{3}}$

(b) $r \propto n^{\frac{4}{3}}; v \propto n^{-\frac{1}{3}}$

(c) $r \propto n^{\frac{1}{3}}; v \propto n^{\frac{1}{3}}$

(d) $r \propto n^{\frac{1}{3}}; v \propto n^{\frac{2}{3}}$

Answer: (a)

Solution: Bohr's quantization

(1) $L = mvr = nh, v = \frac{nh}{mr}$

(2) F = constant

$\frac{mv^2}{r} = F$

$\frac{m}{r}\left(\frac{n^2h^2}{m^2r^2}\right) = F$

$n^2 \propto r^3$

$n^{\frac{2}{3}} \propto r$

$\because v = \frac{nh}{mr}$

$v \propto \frac{n}{r} \propto \frac{n}{n^{2/3}} \propto n^{\frac{1}{3}}$

Question 11: In some appropriate units, time (t) and position (x) relation of a moving particle is given by $t = x^2 + x$. The acceleration of the particle is

Options:

(a) $+\frac{2}{(x+1)^3}$

(b) $+\frac{2}{2x+1}$

(c) $-\frac{2}{(x+2)^3}$

(d) $-\frac{2}{(2x+1)^3}$

Answer: (d)

Solution: $t = x^2 + x$

Derivative w.r.t x

$\frac{dt}{dx} = 2x+1$

$\therefore \frac{dx}{dt} = \frac{1}{2x+1}$

$\therefore \boxed{v = \frac{1}{2x+1}}$

Derivative w.r.t. time t

$\therefore a = \frac{-1}{(2x+1)^2}\frac{2dx}{dt}$

$= \frac{-1}{(2x+1)^2}2v$

$= \frac{-1}{(2x+1)^2}2\frac{1}{(2x+1)}$

$= \frac{-2}{(2x+1)^3}$

Question 12: A model for quantized motion of an electron in a uniform magnetic field B states that the flux passing through the orbit of the electron is $n\left(\frac{h}{e}\right)$ where n is an integer, h is Planck's constant and e is the magnitude of electron's charge. According to the model, the magnetic moment of an electron in its lowest energy state will be (m is the mass of the eletron)

Options:

(a) $\frac{heB}{\pi m}$

(b) $\frac{heB}{2\pi m}$

(c) $\frac{he}{\pi m}$

(d) $\frac{he}{2\pi m}$

Answer: (d)

Solution: $\boxed{\phi = \frac{nh}{e}}$

Given but $\phi = BA$

$\therefore \frac{\phi}{B} = A$

$\therefore A = \frac{\phi}{B} = \frac{nh}{eB}$

For n = 1 (lowest energy given)

$$A = \frac{h}{eB}$$

$$\pi r^2 = \frac{h}{eB}$$

$$r^2 = \frac{h}{\pi eB}$$

We know, magnetic moment $\mu = \frac{evr}{2}$

We need velocity.

Centripetal force = Magnetic force

$$\frac{mv^2}{r} = evB$$

$$\mu = \frac{eBr}{m}$$

$$\therefore \mu = \frac{evr}{2}$$

$$= \frac{e}{2}\frac{eBr}{m}r$$

$$= \frac{e^2B}{2m}r^2 = \frac{e^2B}{2m}\frac{h}{\pi eB}$$

$$= \frac{he}{2\pi m}$$

Question 13: A microscope has an objective of focal length 2 cm, eyepiece of focal length 4 cm and the tube length of 40 cm. If the distance of distinct vision of eye is 25 cm, the magnification in the microscope is

Options:

(a) 150

(b) 250

(c) 100

(d) 125

Answer: (d)

Solution: It is a compound microscope

$$M_{\text{objective}} \approx \frac{L}{f_0} \approx \frac{40cm}{2cm} \approx 20cm$$

Case 1: For relaxed eye (V = 0)

$$MP_{\text{eyepiece}} = \frac{D}{f_e} = \frac{25}{4} = 6.25$$

$$M_{\text{compound}} = 20 \times 6.25 = 125$$

(For relaxed eye $V = \infty$)

Case 2: For $LDDV$

$$MP_{\text{eyepiece}} = 1 + \frac{D}{f_e} = 7.25$$

$$M_{\text{compound}} = 20 \times 7.25 = 145$$

Note: They have NOT asked for maximum magnification explicitly.

Question 14: There are two inclined surfaces of equal length (L) and same angle of inclination $45°$ with the horizontal. One of them is rough and the other is perfectly smooth. A given body takes 2 times as much time to slide down on rough surface than on the smooth surface. The

coefficient of kinetic friction (μ_k) between the object and the rough surface is close to

Options:

(a) 0.5

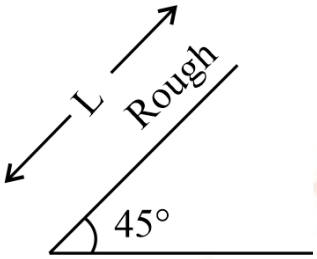
(b) 0.75

(c) 0.25

(d) 0.40

Answer: (b)

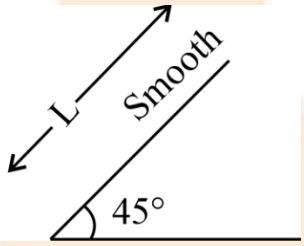
Solution:



$t_1 = 2t$

$a_1 = g\sin\theta - \mu g\cos\theta$

$L = \frac{1}{2}a_1 t_1^2$



$t_2 = t$

$a_2 = g\sin\theta$

$L = \frac{1}{2}a_2 t_2^2$

$a_1 t_1^2 = a_2 t_2^2$

$(g\sin\theta - \mu g\cos\theta)4t^2 = (g\sin\theta)t^2$

$4g\sin\theta - 4\mu g\cos\theta = g\sin\theta$

$3g\sin\theta = 4\mu g\cos\theta$

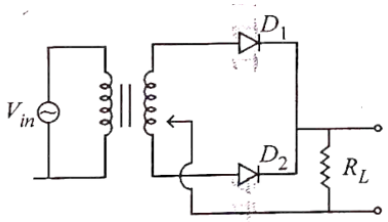
$\tan\theta = \frac{4\mu}{3}$

$\tan 45 = \frac{4\mu}{3}$

$1 = \frac{4\mu}{3}$

$\mu = \frac{3}{4}$

Question 15: A full wave rectifier circuit with diodes (D_1) and (D_2) is shown in the figure. If input supply voltage $V_{in} = 220\sin(100\pi t)volt$, then at t = 15 m sec



Options:

(a) D_1 and D_2 both are forward biased

(b) D_1 and D_2 both are reverse biased

(c) D_1 is forward biased, D_2 is reverse biased

(d) D_1 is reverse biased, D_2 is forward biased

Answer: (d)

Solution: $V_{in} = 220\sin(100\pi t)$

$\omega = 100\pi$

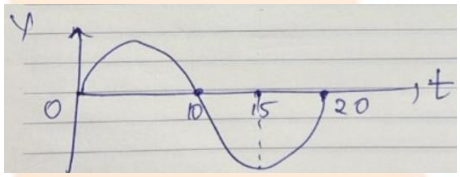
$\frac{2\pi}{T} = 100\pi$

$\frac{2}{T} = 100$

$\frac{2}{100} = T$

$T = \frac{20}{1000} = s$

$T = 20ms$



$\therefore$ At 15 ms

$V = -ve\max$

Question 16: A uniform rod of mas 20 kg and length 5 m leans against a smooth vertical wall making an angle of $60°$ with it. The other end rests on a rough horizontal floor. The friction force that the floor exerts on the rod is (take $g = 10m/s^2$)

Options:

(a) 200 N

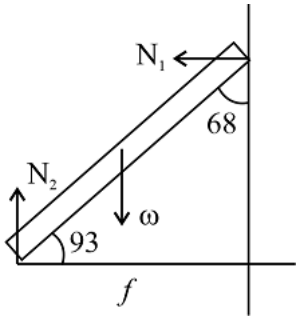
(b) $200\sqrt{3}\,N$

(c) 100 N

(d) $100\sqrt{3}N$

Answer: (d)

Solution:



Mass m = 20 kg

Length = 5m

$\omega = mg = 20 \times 10 = 200N$

The rod is in equilibrium

E_{net} on horizontal

$N_1 = f$

$\omega = N_2$

Since the rod is in rotational equilibrium

$\tau_1 = \tau_2$

$\omega \times \frac{l}{2}\cos 80 = N_1 \times \frac{l}{2}\cos 60$

$100 \times \frac{5}{2} \times \frac{\sqrt{3}}{2} = N_1 \times 5 \times \frac{1}{2}$

$N_1 = 100\sqrt{3}$

$f = 100\sqrt{3}$

Question 17: Two identical charged conducting spheres A and B have their centres separated by a certain distance. Charge on each sphere is q and the force of repulsion between them is F. A third identical uncharged conducting sphere is brought in contact with sphere A first and then with B and finally removed from both. New force of repulsion between spheres A and B (Radii of A and B are negligible compared to the distance of separation so that for calculating force between them they can be considered as point charges) is best given as :

Options:

(a) $\frac{F}{2}$

(b) $\frac{3F}{8}$

(c) $\frac{3F}{5}$

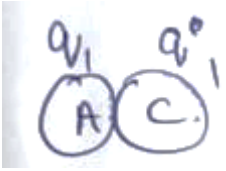
(d) $\frac{2F}{3}$

Answer: (b)

Solution:

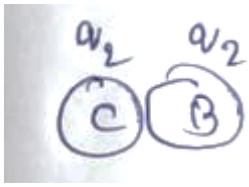


Force of repulsion $F = \frac{kq^2}{d^2}$ a third identical uncharged conducting sphere is brought in constant with A sphere and then with B.



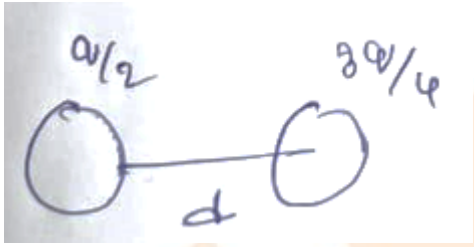
$q_1 = \frac{q+0}{2} = \frac{q}{2}$

Now charge on both A and C $= \frac{q}{2}$



$$q_2 = \frac{q + \frac{q}{2}}{2} = \frac{8q}{4}$$

Now force between A and B



$$F' = \frac{kq_1q_2}{d^2} = \frac{k\left(\frac{q}{2}\right)\left(\frac{8q}{4}\right)}{d^2}$$

$$F' = \frac{3}{8}\frac{kq^2}{d^2} = \frac{3}{8}F$$

Question 18: Two cities X and Y are connected by a regular bus service with a bus leaving in either direction every T min. A girl is driving scotty with a speed of 60 km/h in the direction X to Y notices that a bus goes past her every 30 minutes in the direction of her motion, and every 10 minutes in the opposite direction. Choose the correct option for the period T of the bus service and the speed (assumed constant) of the buses.

Options:

(a) 10 min, 90 km/h

(b) 15 min, 120 km/h

(c) 9 min, 40 km/h

(d) 25 min, 100 km/h

Answer: (b)

Solution: Speed of the bus $= V\,km/h$

While the girl is driving the scooty with speed 60 km/hr

From X to Y direction bus goes past her every 30 minutes in the direction of her motion 10 minutes in the opposite direction.

Bus leaves at every T min w.r.t of ground distance between two buses

$$d = VT = V \times \frac{T}{60} km \ ..(1)$$

w.r.t of max (X to Y) in same direction $V_{B/m} = (V - 60)$

Distance $D = (V - 60)\frac{30}{60} ..(2)$

In opposite direction $V_{B/m} = v + 60$

$$D = (V + 60)\frac{10}{60} \ ....(3)$$

$$(1) = (3)$$

$$(V - 60)\frac{30}{60} = (V + 60)\frac{10}{60}$$

$$3V - 180 = V + 60$$

$$2V = 240$$

$$V = 120 km/hr$$

$(1)=(2)$

$$\frac{VT}{60}=\frac{(V-60)30}{60}$$

$$120\times T=(20-60)30$$

$$120\times T=60\times 30$$

$$T=15\,\text{min}$$

Question 19: A container has two chambers of volumes $V_1=2$ litres and $V_2=3$ litres separated by a partition made of a thermal insulator. The chambers contains $n_1=5$ and $n_2=4$ moles of ideal gas at pressure $p_1=1$ atm and $p_2=2$ atm, respectively. When the partition is removed, the mixture attains an equilibrium pressure of:

Options:

(a) 1.4 atm

(b) 1.8 atm

(c) 1.3 atm

(d) 1.6 atm

Answer: (d)

Solution: $v_1=2Lt, v_2=3Lt$

$n_1=5mol, n_2=4mol$

$p_1=1atm, p_2=2atm$

Chamber 1 $P_1V_1=n_1RT_1$

Chamber 2 $P_2V_2=n_2RT_2$

When partition is removed

Gasses will mix without loss of energy

From kinetic theory of gasses $PV=\frac{2}{3}n(K.E)$

For chamber 1 $P_1V_2=\frac{2}{2}n_1E_1$

For Chamber 2 $P_2V_2=\frac{2}{3}n_2E_2$

$$\frac{3}{2}P_1V_1=n_1E_1$$

$$\Rightarrow(n_1E_1+n_2E_2)=\frac{3}{2}(P_1V_1+P_2V_2)$$

$$\frac{3}{2}P_2V_2=n_2E_2$$

We know $PV=\frac{2}{3}nE$

$$P(V_1+V_2)=[P_1V_1+P_2V_2]$$

$$P=\frac{P_1V_1+P_1V_2}{V_1+V_2}=\frac{2\times1+2\times3}{2+3}$$

$$P=\frac{2+6}{5}=\frac{8}{5}=1.6$$

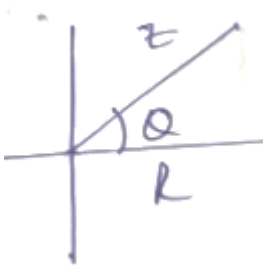
Question 20: De-Broglie wavelength of an electron obtaining in the n = 2 state of hydrogen atom is close to (Given Bohr radius = 0.052 nm)

Options:

(a) 1.67 nm

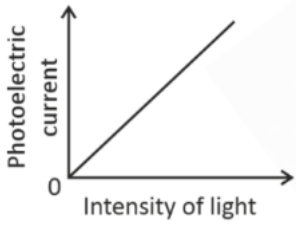
(b) 2.67 nm
(c) 0.067 nm
(d) 0.67 nm
Answer: (d)
Solution: $n = 2$
De Broglie wavelength $\lambda = ?$
$r = 0.052nm$
$\lambda = \frac{2\pi r}{n}$
$r = n^2.r_0 = 2^2 \times 0.052$
$= 4 \times 0.052 = 0.208$
$r = 0.208$
$\lambda = \frac{2 \times 3.14 \times 0.208}{2} = 0.653$
$\cong 0.67nm$

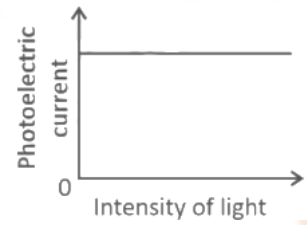
Question 21: To an ac power supply of 220V at 50 Hz, a resistor of 20Ω, a capacitor of reactance 25Ω and an inductor of reactance 45Ω are connected in series. The corresponding current in the circuit and the phase angle between the current and the voltage is, respectively -
Options:
(a) 1.56 A and $30°$
(b) 1.56 A and $45°$
(c) 7.8 A and $30°$
(d) 7.8 A and $45°$
Answer: (d)
Solution: V = 200 V, f = 50 Hz
$R = 20\Omega, X_C = 25\Omega, X_L = 45\Omega$
$I = \frac{V}{Z}$
$Z = \sqrt{R^2 + X^2}$
$X = X_L - X_C$
$X = 45 - 25 = 20$
$Z = \sqrt{20^2 + 20^2} = \sqrt{800}$
$Z = 20\sqrt{2}$
$I = \frac{V}{Z} = \frac{220}{20\sqrt{2}} = \frac{11}{\sqrt{2}}$
$I = 7.8$

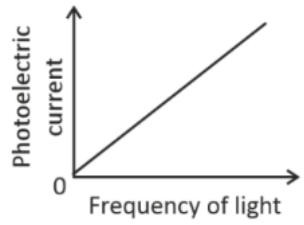


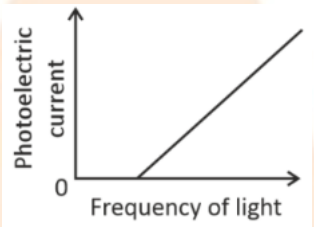
$\cos\theta = \frac{R}{Z} = \frac{20}{20\sqrt{2}}$
$\cos\theta = \cos 45$
$\theta = 45°$

Question 22: Which of the following options represent the variation of photoelectric current with property of light shown on the x-axis?

A. 

B. 

C. 

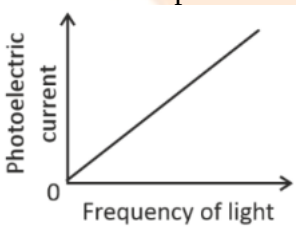
D. 

Options:

(a) A and D
(b) B and D
(c) A only
(d) A and C

Answer: (c)

Solution: The intensity of light refers to the amount of photon energy per unit area.
So greater intensity of light more will be number of photons, as a result, the more will be the number ejected photo electron. More photo electrons constitute more photo current
Hence if intensity increased, photo current also gets increased.
So amount of photo current lineary dependent on the intensity of incident ratidation .



Question 23: A pipe open at both ends has a fundamental frequency f in air. The pipe is now dipped vertically in a water drum to half of its length. The fundamental frequency of the air column is now equal to:

Options:

(a) $\frac{3f}{2}$
(b) $2f$

(c) $\frac{f}{2}$

(d) f

Answer: (d)

Solution: Before dipping $f = \frac{nv}{2L} = \frac{v}{2L}$ ....(1)

After dipping in water $f_1 = \frac{nv}{4\left(\frac{L}{2}\right)} = \frac{v}{2L}$ ....(2)

From (1) & (2)

$\boxed{f_1 = f}$

Question 24: Two identical point masses P and Q, suspended from two separate massless springs of spring constant k_1 and k_2, respectively, oscillate vertically. If their maximum speeds are the same, the ratio $\left(\frac{A_Q}{A_P}\right)$ of the amplitude A_Q of mass Q to the amplitude A_P of mass P is:

Options:

(a) $\sqrt{\frac{k_2}{k_1}}$

(b) $\sqrt{\frac{k_1}{k_2}}$

(c) $\frac{k_2}{k_1}$

(d) $\frac{k_1}{k_2}$

Answer: (b)

Solution: $A_1\omega_1 = A_2\omega_2$

$A_P\omega_P = A_Q\omega_Q$

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

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

$\Rightarrow \frac{A_P}{A_Q} = \frac{\omega_Q}{\omega_P}$

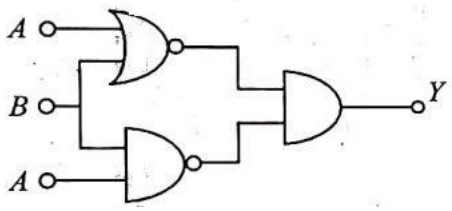
$= \frac{T_P}{T_Q}$

$= \frac{\sqrt{k_Q}}{\sqrt{k_P}}$

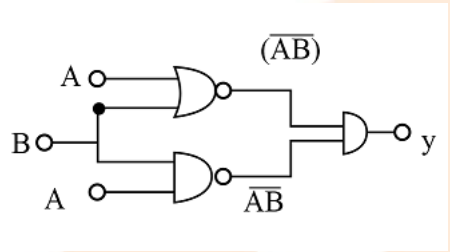
$= \sqrt{k_2 : k_1}$

$A_Q : A_P = \sqrt{k_1 : k_2}$

Question 25: The output (Y) of the given logic implementation is similar to the output of an/a ____ gate.



Options:
(a) OR
(b) NOR
(c) AND
(d) NAND
Answer: (b)
Solution:



$y = \left(\overline{A+B}\right)\overline{AB}$

$= \left(\bar{A}.\bar{B}\right)\left(\bar{A}+\bar{B}\right)$

$= \bar{A}\bar{A}\bar{B} + \bar{A}\bar{B}\bar{B}$

$= \bar{A}\bar{B} + \bar{A}\bar{B}$

$= \overline{AB}$

$= \bar{A}.\bar{B}$

$= \overline{A+B}$ = NOR

Question 26: An oxygen cylinder of volume 30 litre has 18.20 moles of oxygen. After some oxygen is withdrawn from the cylinder, its gauge pressure drops to 11 atmospheric pressure at temperatures $27°C$. The mass of the oxygen withdrawn from the cylinder is nearly equal to:

[Given, $R = \frac{100}{12}\, J\, mol^{-1}K^{-1}$, and molecular mass of $O_2 = 32$, 1 atm pressure

$= 1.01\times10^5\, N/m$]

Options:
(a) 0.116 kg
(b) 0.156 kg
(c) 0.125 kg
(d) 0.144 kg
Answer: (b)
Solution: Since $PV = nRT$
New no. of moles

$$\therefore n' = \frac{PV}{RT} = \frac{11\times1.01\times30\times10^{-3}\times10^5}{\frac{100}{12}\times300} = \frac{33330}{2500}$$

$n' = 13.33$

Now $M = \left(n-n'\right)\times32$

$= \left(4.87\right)\times32g$

$= 155.84\,g$ or $0.1558\ kg$

$= 0.156\ kg$

Question 27: In a certain camera, a combination of four similar thin convex lenses are arranged axially in contact. Then the power of the combination and the total magnification in comparison to the power (p) and magnification (m) for each lens will be, respectively -

Options:

(a) $4p$ and m^4

(b) p^4 and m^4

(c) $4p$ and $4m$

(d) p^4 and $4m$

Answer: (a)

Solution: Power is additive when lenses are in contact

So each lens has power P, then 4 lenses

$P_{\text{total}} = P + P + P + P = 4P$

Magnification $m_{\text{total}} = m \times m \times m \times m$ (series) $= m^4$

Question 28: Two gases A and B are filed at the same pressure in separate cylinders with movable pistons of radius r_A and r_B, respectively. On supplying an equal amount of heat to both the systems reversibly under constant pressure, the pistons of gas A and B are displaced by 16 cm and 9 cm, respectively. If the change in their internal energy is the same, then the ratio $\frac{r_A}{r_B}$ is equal to

Options:

(a) $\frac{2}{\sqrt{3}}$

(b) $\frac{\sqrt{3}}{2}$

(c) $\frac{4}{3}$

(d) $\frac{3}{4}$

Answer: (d)

Solution: ΔU are same

$\Delta\theta$ are same.

$\therefore \Delta\omega$ should be same

$P\pi r_A^2 L_A = P\pi r_B^2 L_B$

$\frac{r_A}{r_B} = \sqrt{\frac{L_B}{L_A}} = \sqrt{\frac{9}{16}} = \frac{3}{4}$

Question 29: A balloon is made of a material of surface tension S and its inflation outlet (from where gas is filled in it) has small area A. It is filled with a gas of density ρ and takes a spherical shape of radius R. When the gas is allowed to flow freely out of it, its radius r changes from R to 0 (zero) in time T. If the speed $v(r)$ of gas coming out of the balloon depends on r as r^a and $T \propto S^\alpha A^\beta \rho^\gamma R^\delta$ then

Options:

(a) $a = -\frac{1}{2}, \alpha = -\frac{1}{2}, \beta = -1, \gamma = \frac{1}{2}, \delta = \frac{7}{2}$

(b) $a = \frac{1}{2}, \alpha = \frac{1}{2}, \beta = -\frac{1}{2}, \gamma = \frac{1}{2}, \delta = \frac{7}{2}$

(c) $a=\frac{1}{2},\alpha=\frac{1}{2},\beta=-1,\gamma=+1,\delta=\frac{3}{2}$

(d) $a=-\frac{1}{2},\alpha=-\frac{1}{2},\beta=-1,\gamma=-\frac{1}{2},\delta=\frac{5}{2}$

Answer: (a)

Solution: $T\propto S^{\alpha}A^{\beta}\rho^{r}R^{\delta}$

$[T]=\left[MT^{-2}\right]^{\alpha}\left[L^{2}\right]^{\beta}\left[ML^{-3}\right]^{\gamma}\left[L^{\delta}\right]$

$[T]=\left[M^{\alpha+\gamma}L^{2\beta-3\gamma+\delta}T^{-2\alpha}\right]$

Company powers

$-2\alpha=1....(1)\Rightarrow\alpha=-\frac{1}{2}$

$\alpha+\gamma=0\ ..(2)\Rightarrow\gamma=\frac{1}{2}$

$2\beta-3\gamma+\delta=0\ ....(3)$

$2\beta-\frac{3}{2}+\delta=0$

$2\beta=\frac{3}{2}-\delta$

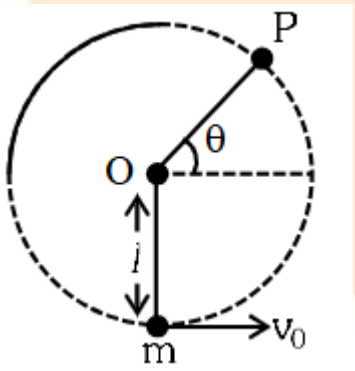
If $\delta=\frac{7}{2}$

$2\beta=\frac{3}{2}-\frac{7}{2}=\frac{-4}{2}=-2$

$\beta=-1$

$a=-\frac{1}{2},\alpha=-\frac{1}{2},\beta=-1,\gamma=-\frac{1}{2},\delta=\frac{7}{2}$

Question 30: A bob of heavy mass m is suspended by a light string of length l. The bob is given a horizontal velocity v_0 as shown in figure. If the string gets slack at some point P making an angle θ from the horizontal, the ratio of the speed v of the bob at point P to its initial speed v_0 is:



Options:

(a) $\left(\frac{\cos\theta}{2+3\sin\theta}\right)$

(b) $\left(\frac{\sin\theta}{2+3\sin\theta}\right)$

(c) $(\sin\theta)^{\frac{1}{2}}$

(d) $\left(\frac{1}{2+3\sin\theta}\right)^{\frac{1}{2}}$

Answer: (b)

Solution: $\frac{mv^2}{l} = mg\sin\theta$

$\frac{1}{2}mv_0^2 = mgl(1+\sin\theta)+\frac{1}{2}mv^2$

$\frac{1}{2}mv_0^2 = mgl(1+\sin\theta)+\frac{1}{2}mgl\sin\theta$

$V_0^2 = 2gl+2gl\sin\theta+gl\sin\theta$

$V_0^2 = gl(2+3\sin\theta)$

$\frac{V_0^2}{V^2} = \frac{gl(2+3\sin\theta)}{gl\sin\theta}$

$\frac{V_0}{V} = \sqrt{\frac{2+3\sin\theta}{\sin\theta}}$

$\frac{V}{V_0} = \sqrt{\frac{\sin\theta}{2+3\sin\theta}}$

Question 31: A physical quantity P is related to four observations a, b, c and d as follows:
$P = a^3b^2/c\sqrt{d}$
The percentage errors of measurement in a, b, c and d are 1%, 3%, 2% and 4% respectively. The percentage errors in the quantity P is

Options:

(a) 13 %
(b) 15 %
(c) 10 %
(d) 2 %

Answer: (a)

Solution: $P = a^3b^2/c\sqrt{d}$

$= a^3b^2c^{-1}d^{-1/2}$

$\%\Delta p = 3\left(\frac{\Delta a}{a}\times100\right)+2\left(\frac{4b}{b}\times100\right)+1\left(\frac{\Delta c}{c}\times100\right)+\frac{1}{2}\left(\frac{\Delta d}{d}\times100\right)$

$=(3\times1)+(2\times3)+(1\times2)+\frac{1}{2}(4)$

$=3+6+2+2=13\%$

Question 32: The Sun rotates around its centre once in 27 days. What will be the period of revolution if the Sun were to expand to twice its present radius without any external influence? Assume the Sun to be a sphere of uniform density.

Options:

(a) 115 days
(b) 108 days
(c) 100 days
(d) 105 days

Answer: (b)

Solution: External force = 0

By applying cons of angular momentum

T = Initial time period = 27 days

T' = Final time period

ω' = Final angular velocity

Li (System) = Lf (System)

$\Rightarrow I\omega = I'\omega'$

$\Rightarrow \left(\frac{2}{5}MR^2\right)\omega = \frac{2}{5}M\left(2R\right)^2\omega'$

$\Rightarrow \omega R^2 = 4R^2\omega'$

$\omega' = \frac{\omega}{4}$

$\therefore T' = \frac{2\pi}{\omega'} = \left(\frac{8\pi}{\omega}\right)$

$= 4T = \left(4\times 27\right) = 108 days$

Question 33: The radius of Martian orbit around the Sun is about 4 times the radius of the orbit of Mercury. The Martain year is 687 Earth days. Then which of the following is the length of 1 year on Mercury?

Options:

(a) 172 earth days

(b) 124 earth days

(c) 88 earth days

(d) 225 earth days

Answer: (c)

Solution: $RM =$ Radius of mass

$RM' =$ Radius of mercury

By Kepler's law: $T^2 \propto r^3$

$RM = 4RM'$

$TM =$ Time period of mass.

$TM' =$ Time period of mercury

$\frac{TM}{TM'} = \left(\frac{RM}{RM'}\right)^{\frac{3}{2}}$

$= \left(\frac{4RM'}{RM'}\right)^{\frac{3}{2}}$ $\qquad TM = 687$ earth days

$= 2^{2\times\frac{3}{2}} = 2^3 = 8$

$\therefore \frac{TM}{TM'} = 8$

$\Rightarrow TM' = \frac{TM}{8} = \frac{687}{8}$

$\cong 88$ (approximate) Earth days.

Question 34: A wire of resistance R is cut into 8 equal pieces. From these pieces two equivalent resistances are made by adding four of these together in parallel. Then these two sets are added in series. The net effective resistance of the combination is:

Options:

(a) $\frac{R}{16}$

(b) $\frac{R}{8}$

(c) $\frac{R}{64}$

(d) $\frac{R}{32}$

Answer: (a)

Solution: Each wire will have resistance of $\frac{R}{8}$.

If R_{eq1} and R_{eq2} are the two sets of resistances that are made by connecting 4 in parallel.

$$\therefore \frac{1}{R_{eq1}} = \frac{1}{R/8} + \frac{1}{R/8} + \frac{1}{R/8} + \frac{1}{R/8}$$

$$= \frac{8}{R} + \frac{8}{R} + \frac{8}{R} + \frac{8}{R} = \frac{32}{R}$$

$$\therefore R_{eq1} = \frac{R}{32}$$

Similarly, $R_{eq2} = \frac{R}{32}$

Now, these two sets are connected in series

$$R_{eq} = R_{eq1} + R_{eq2} = \frac{R}{32} + \frac{R}{32} = \frac{R}{16}$$

Question 35: A photon and an electron (mass m) have the same energy E. The ratio $\left(\lambda_{\text{Photon}} / \lambda_{\text{electron}}\right)$ of their de Broglie wavelengths is: (c is the speed of light)

Options:

(a) $c\sqrt{\frac{2m}{E}}$

(b) $\frac{1}{c}\sqrt{\frac{E}{2m}}$

(c) $\sqrt{\frac{E}{2m}}$

(d) $c\sqrt{2mE}$

Answer: (a)

Solution: For electron: $\lambda e = \frac{h}{\sqrt{2mE}}$

For photon: - $E = pc$ $\left[\because m_0 = \text{rest mass} = 0\right]$

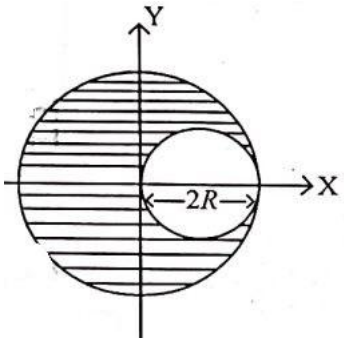
$$\lambda_{Ph} = \frac{hc}{E}\left[\because E = \frac{hc}{\lambda}\right]$$

$$\therefore \frac{\lambda_{ph}}{\lambda_e} = \frac{hc}{E} \div \frac{h}{\sqrt{2mE}}$$

$$= \frac{hc}{E} \times \frac{\sqrt{2mE}}{h}$$

$$= c\sqrt{\frac{2m}{E}}$$

Question 36: A sphere of radius R is cut from a larger solid sphere of radius 2R as shown in the figure. The ratio of the moment of inertia of the smaller sphere to that of the rest part of the sphere about the Y-axis is:



Options:

(a) $\frac{7}{57}$

(b) $\frac{7}{64}$

(c) $\frac{7}{8}$

(d) $\frac{7}{40}$

Answer: (a)

Solution: $I''' = M.O.I$ of rest part of sphere about y-axis

$\therefore I'' = I - I''$

$= \frac{8}{5}MR^2 - \frac{7}{40}MR^2$

$= \frac{(64-7)MR^2}{40} = \frac{57}{40}MR^2$

$\therefore I'' : I''' = \frac{7}{40} \div \frac{57}{40}$

$= \frac{7}{40} \times \frac{40}{57} = \frac{7}{57}$

Question 37: An electron (mass $9\times10^{-31}kg$ and charge $1.6\times10^{-19}C$) moving with speed c/100 (c = speed of light) is injected into a magnetic field $\vec{B}$ of magnitude $9\times10^{-4}T$ perpendicular to its direction of motion. We wish to apply an uniform electric $\vec{E}$ together with the magnetic field so that the electron does not deflect from its path. Then (Speed of light $c = 3\times10^{8}ms^{-1}$)

Options:

(a) $\vec{E}$ is parallel to $\vec{B}$ and its magnitude is $27\times10^{2}Vm^{-1}$

(b) $\vec{E}$ is parallel to $\vec{B}$ and its magnitude is $27\times10^{4}Vm^{-1}$

(c) $\vec{E}$ is perpendicular to $\vec{B}$ and its magnitude is $27\times10^{4}Vm^{-1}$

(d) $\vec{E}$ is perpendicular to $\vec{B}$ and its magnitude is $27\times10^{2}Vm^{-1}$

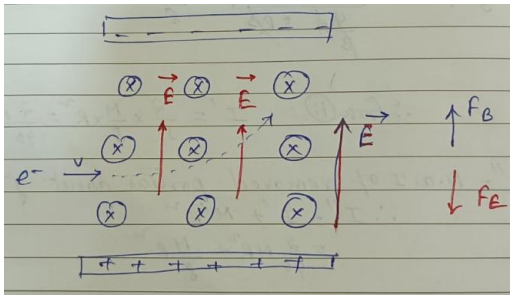
Answer: (d)

Solution:

V = velocity e^-

$v = \frac{c}{100}$

$B = 9\times10^{-4}T$



$F_B =$ Force due to magnetic field

$F_E =$ Force due to $\vec{E}$

$F_B = F_E$

$qvB = qE$

$\Rightarrow E = vB$

$= \frac{c}{100} \times 9 \times 10^{-4}$

$= \frac{3 \times 10^8}{10^2} \times 9 \times 10^{-4}$

$= 27 \times 10^6 \times 10^{-4}$

$= 27 \times 10^2$

$\rightarrow$ direction should be perpendicular to $\vec{B}$

Question 38: The electric field in a plane electromagnetic wave is given by

$E_z = 60\cos\left(5x + 1.5 \times 10^9 t\right) V/m$

Then expression for the corresponding magnetic field is (here subscripts denote the direction of the field):

Options:

(a) $B_z = 60\cos\left(5x + 1.5 \times 10^9 t\right) T$

(b) $B_z = 60\sin\left(5x + 1.5 \times 10^9 t\right) T$

(c) $B_y = 2 \times 10^{-7}\cos\left(5x + 1.5 \times 10^9 t\right) T$

(d) $B_x = 2 \times 10^{-7}\cos\left(5x + 1.5 \times 10^9 t\right) T$

Answer: (c)

Solution: $E_Z = 60\cos\left(5x + 1.5 \times 10^9 t\right) v/m$

Here, $E_0 = 60$

$B_0 = \frac{E_0}{c} = \frac{60}{3 \times 10^8} = 20 \times 10^{-8} = 2 \times 10^{-7}$

$\vec{B}$ Should be perpendicular to $\vec{E}$

$\therefore B_y = 2 \times 10^{-7}\cos\left(5x + 1.5 \times 10^9 t\right) T$

Question 39: A body weighs 48 N on the surface of the earth. The gravitational force experienced by the body due to the earth at a height equal to one-third the radius of the earth form its surface is:

Options:

(a) 32 N

(b) 36 N

(c) 16 N

(d) 27 N

Answer: (d)

Solution: $W =$ Weight on surface of earth

$\omega = mg = 48N$

$g_h =$ acceleration due to gravity at height h.

$$\therefore g_h = \frac{g}{\left(1+\frac{h}{R}\right)^2} = \frac{g}{\left(1+\frac{R}{3R}\right)^2}$$

$$= \frac{g}{\left(1+\frac{1}{3}\right)^2} = \frac{g}{\left(\frac{4}{3}\right)^2}$$

$$= \frac{9g}{16}$$

$\therefore \omega' =$ New ωt

$$= mgh = \frac{m \times 9g}{16}$$

$$= \frac{9}{16}mg = \frac{9}{16} \times 48 = 27N$$

Question 40: An unpolarized light beam travelling in air is incident on a medium of refractive index 1.73 at Brewster's angle. Then -

Options:

(a) Both reflected and transmitted light are perfectly polarized with angles of reflection and refraction close to $60°$ and $30°$, respectively

(b) Transmitted light is completely polarized with angle of refraction close to $30°$

(c) Reflected light is completely polarized and the angle of reflection is close to $60°$

(d) Reflected light is partially polarized and the angle of reflection is close to $30°$

Answer: (c)

Solution: $\mu = 1.73$

$\mu = \tan\theta_B$

$\therefore \theta_B = \tan^{-1}(1.73)$

$= \tan^{-1}\left(\sqrt{3}\right)$

$= \tan^{-1}(\tan 60°)$

$\theta_B = 60°$

Reflected light ray should be completely polorised.

$\theta_B =$ angle of incident

There, $\theta_B =$ angle of incidence

$\therefore$ angle of reflection $= \theta_B = 60°$

$\therefore 1 \times \sin\theta_B = \mu \sin r$

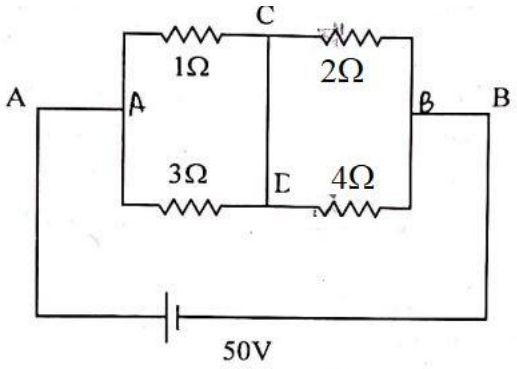
$\Rightarrow \sin(60°) = \sqrt{3} \times \sin r$

$$\Rightarrow \frac{\sqrt{3}}{2} = \sqrt{3}\sin r$$

$\therefore r = 30°$ (angle of refraction).

$\rightarrow$ Transmitted light in partially polorised.

Question 41: A constant voltage of 50 V is maintained between the points A and B of the circuit shown in the figure. The current through the branch CD of the circuit is:



Options:

(a) 2.5 A

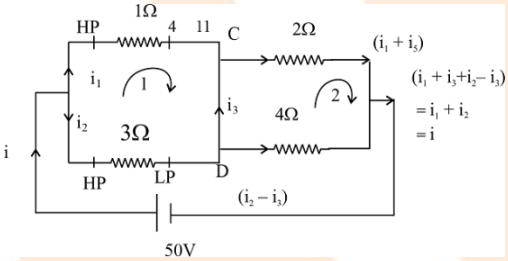
(b) 3.0 A

(c) 1.5 A

(d) 2.0 A

Answer: (d)

Solution:



$$R_{eq_1} = \frac{1\times 3}{1+3} = \frac{3}{4}$$

$$R_{eq_2} = \frac{2\times 4}{2+4} = \frac{8}{6} = \frac{4}{3}$$

$$\therefore R_{eq} = \frac{3}{4} + \frac{4}{3}$$

$$= \frac{9+16}{12} = \frac{25}{12}\Omega$$

$$\therefore i = \frac{50\times 12}{25} = 24A$$

Loop 1: $+3i_2 - 1i_1 = 0$

$3i_2 = i_1$

$i_1 + i_2 = i$

$\Rightarrow 3i_2 + i_2 = i$

$\Rightarrow 4i_2 = 24$

$\Rightarrow i_2 = 6A$

$\therefore i_1 = 3i_2 = 18A$

Loop 2: $4(i_2 - i_3) - 2(i_1 + i_3) = 0$

$\Rightarrow 4i_2 - 4i_3 - 2i_1 - 2i_3 = 0$

$\Rightarrow 4i_2 - 2i_1 - 6i_3 = 0$

$\Rightarrow 24 - (2\times 18) - 6i_3 = 0$

$\Rightarrow 6i_3 = 24 - 26$

$6i_3 = -12$

$\therefore i_3 = -12$

$\therefore i_3 = -2A$

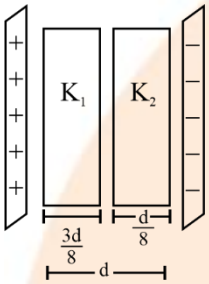
$\therefore$ direction from C to D.

Question 42: The plates of a parallel plate capacitor are separated by d. Two slabs of different dielectric constant K_1 and K_2 with thickness $\frac{3}{8}d$ and $\frac{d}{2}$, respectively are inserted in the capacitor. Due to this, the capacitance becomes two times larger than when there is nothing between the plates.
If $K_1 = 1.25K_2$, the value of K_1 is:

Options:
(a) 1.60
(b) 1.33
(c) 2.66
(d) 2.33

Answer: (c)

Solution:



Given $c' = 2c$

$$c = \frac{\varepsilon_0 A}{d}$$

$$k_2 = \frac{K_1}{1.25} = \frac{4K_1}{5}$$

$$c' = \frac{\varepsilon_0 A}{\left(d - t_1 - t_2 + \frac{t_1}{k_1} + \frac{t_2}{k_2}\right)}$$

$$c' = \frac{\varepsilon_0 A}{d - \frac{3d}{8} - \frac{d}{2} + \frac{3d}{8k_1} + \frac{d}{2k_2}}$$

$$2c = \frac{\varepsilon_0 A}{d\left[1 - \frac{3}{8} - \frac{1}{2} + \frac{3}{8k_1} + \frac{1}{2k_2}\right]}$$

$$2c = \frac{c}{\left[\frac{1}{8} + \frac{3}{8k_1} + \frac{5}{2\times 4k_1}\right]}$$

$$\Rightarrow 2 = \frac{1}{\left(\frac{1}{8} + \frac{3}{8k_1} + \frac{5}{8k_1}\right)}$$

$$\Rightarrow 2\left[\frac{k_1 + 3 + 5}{8k_1}\right] = 1$$

$$\Rightarrow 2k_1 + 16 = 8k_1$$

$$\Rightarrow 6k_1 = 16$$

$$\Rightarrow k_1 = \frac{8}{3} = 2.66$$

Question 43: Consider the dimeter of a spherical object being measured with the help of a Vernier caliper. Suppose its 10 Vernier scale Divisions (V.S.D.) are equal to its 9 Main scale Divisions (M.S.D). The least division in the M.S. is 0.1 cm and the zero of V.S. is at $x = 0.1cm$ when the jaws of Vernier calipers are closed.
If the main scale reading for the diameter is M = 5 cm and the number of coinciding vernier division is 8, the measured diameter after zero error correction, is

Options:

(a) 4.98 cm
(b) 5.00 cm
(c) 5.18 cm
(d) 5.08 cm

Answer: (a)

Solution: Total reading $= MSR + (VSR \times LC) -$ zero error

$= 5 + (8 \times L.C) - 0.1$

L.C 10 VSD = 9 MSD

$L.C = 1MSD - 1VSD$

$= 1MSD - \frac{9}{10} MSD$

$= \frac{1}{10} MSD$

$= \frac{1}{10} \times 0.1cm = 0.01cm$

T reading $= 5 + (8 \times 0.01) - 0.1 = 4.98$

Question 44: A 2 amp current is flowing through two different small circular copper coils having radii ratio 1: 2. The ratio of their respective magnetic moments will be

Options:

(a) 2 : 1
(b) 4 : 1
(c) 1 : 4
(d) 1 : 2

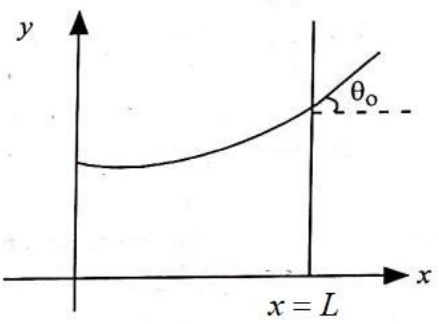
Answer: (c)

Solution: $R_1 : R_2 = 1:2$

$M_1 : M_2 = iA_1 : iA_2$

$= R_1^2 : R_2^2 = 1:4$

Question 45: Consider a water tank shown in the figure. It has one wall at $x = L$ and can be taken to be very wide in the z direction. When filled with a liquid of surface tension S and density ρ, the liquid surface makes angle $\theta_0 (\theta_0 << 1)$ with the $x-$axis at $x = L$. If $y(x)$ is the height of the surface then the equation for $y(x)$ is:



(take $\theta(x) = \sin\theta(x) = \tan\theta(x) = \frac{dy}{dx}$, g is the acceleration due to gravity)

Options:

(a) $\frac{d^2y}{dx^2} = \sqrt{\frac{\rho g}{S}}$

(b) $\frac{dy}{dx} = \sqrt{\frac{\rho g}{S}}x$

(c) $\frac{d^2y}{dx^2} = \frac{\rho g}{S}x$

(d) $\frac{d^2y}{dx^2} = \frac{\rho g}{S}y$

Answer: (d)

Solution: $R = \frac{\left[1+\left(\frac{dy}{dx}\right)^2\right]^{\frac{3}{2}}}{\left|\frac{d^2y}{dx^2}\right|}$

θ is very small, $\frac{dy}{dx}$ is small

$R \approx \frac{1}{\left(\frac{d^2y}{dx^2}\right)}$

Laplace equation : $\Delta p = \frac{T}{R}$

$\Delta p = T\frac{d^2y}{dx^2}$

$\frac{\rho g h}{T} = \frac{d^2y}{dx^2}$