विध्न विचारत भीरु जन, नहीं आरम्भे काम, विपति देख छोड़े तुरंत मध्यम मन कर श्याम।
पुरुष सिंह संकल्प कर, सहते विपति अनेक, 'बना' न छोड़े ध्येय को, रघुबर राखे टेक।।

रचितः मानव धर्म प्रणेता

सद्गुरु श्री रणछोड़दासजी महाराज

Subject : PHYSICS

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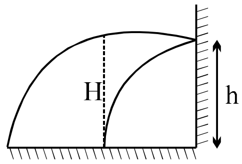
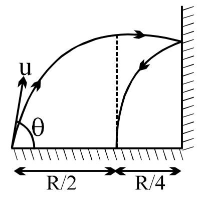
Q.1 A stone is projected from a horizontal plane. It attains maximum height 'H' & strikes a stationary smooth wall & falls on the ground vertically below the maximum height. Assume the collision to be elastic the height of the point on the wall where ball will strike is:



(A) H/2 (B) H/4
(C*) 3H/4 (D) none of these

[Sol. Because horizontal velocity is constant so



$$T = \frac{2u\sin\theta}{g}$$

given $H = \frac{u^2\sin^2\theta}{2g}$, $u\sin\theta = \sqrt{2gH}$

$T = \frac{2\sqrt{2gH}}{g}$ at the time of hitting the wall

The horizontal distance covered is $\frac{3R}{4}$, so time taken to cover horizontal distance $\frac{3R}{4}$

$$T' = \frac{3T}{4} = 3\sqrt{\frac{H}{2g}},\ h = \sqrt{2gH} \times 3\sqrt{\frac{H}{2g}} - \frac{1}{2}\times g\times a\times\frac{H}{2g}$$

$h = \frac{3H}{4}$]

Q.2 A man in a balloon rising vertically with an acceleration of 4.9 m/s^2 releases a ball 2 seconds after the balloon is let go from the ground. The greatest height above the ground reached by the ball is ($g = 9.8$ m/s^2)

(A*) 14.7 m (B) 19.6 m (C) 9.8 m (D) 24.5 m

[Sol. $v = 0 + 4.9 \times 2 = 9.8$ m/s

$h_1 = \frac{1}{2} \times 4.9 \times 4 = 9.8$ m

$0 = v^2 - 2gh_2$

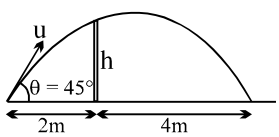
$h_2 = \frac{v^2}{2g} = \frac{9.8\times9.8}{2\times9.8} = 4.9$

$H = h_1 + h_2 = 9.8 + 4.9 = 14.7$ m]

Q.3 A particle is projected at an angle of 45° from a point lying 2 m from the foot of a wall. It just touches the top of the wall and falls on the ground 4 m from it. The height of the wall is

(A) 3/4 m (B) 2/3 m (C*) 4/3 m (D) 1/3 m

[Sol. $R = 6 = \frac{u^2\sin 2\theta}{g}$, $\theta = 45°$



$60 = u^2$, $u = \sqrt{60}$

$u\cos\theta = \sqrt{30}$, $u\sin\theta = \sqrt{30}$

$t = \frac{2}{\sqrt{30}}$,

$h = \sqrt{30} \times \frac{2}{\sqrt{30}} - \frac{1}{2} \times 10 \times \frac{4}{30}$

$h = 2 - \frac{2}{3} = \frac{4}{3}$ m,

$h = \frac{4}{3}$ m]

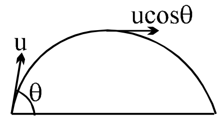
Q.4 The velocity at the maximum height of a projectile is half its initial velocity of projection. Its range on the horizontal plane is

(A*) $\frac{\sqrt{3}u^2}{2g}$ (B) $\frac{u^2}{2g}$ (C) $\frac{3u^2}{2g}$ (D) $\frac{3u^2}{g}$

[Sol. Given:— $u\cos\theta = u/2$

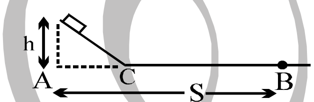
$\cos\theta = 1/2,\ \theta = 60°$

$$R = \frac{2u^2 \sin\theta \cos\theta}{g} = \frac{2u^2 \times \frac{\sqrt{3}}{2} \times \frac{1}{2}}{g}$$



$\Rightarrow \quad R = \frac{\sqrt{3}u^2}{2g}$]

Q.5 A block slides down on an icy hill of height h (as shown in figure) and stops after covering a distance CB. The distance AB is equal to 'S'. The coefficient of friction μ between the block & ice surface (inclined & horizontal) is



(A*) $\mu = \frac{h}{S}$ (B) $\mu = \frac{h}{\sqrt{S^2 - h^2}}$ (C) $\mu = \frac{S}{h}$ (D) data's are insufficient

[Sol. $W_G + W_f = \Delta KE$

$W_f = -W_G$

$-\mu mg\cos\theta \times \frac{h}{\sin\theta} - \mu mg(S - h\cot\theta) = -mgh$

$-\mu mgh\cot\theta - \mu mg(S - h\cot\theta) = -mgh$

$-\mu mS = -mgh$

$\mu = h/S$]

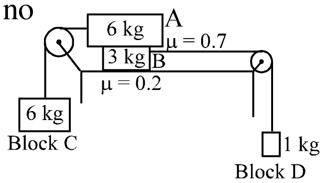
Q.6 An arrangement of the masses and pulleys is shown in the figure. Strings connecting masses A and B with pulleys are horizontal and all pulleys and strings are light. Friction coefficient between the surface and the block B is 0.2 and between blocks A and B is 0.7. The system is released from rest (use $g = 10$ m/s^2).

(A*) The magnitude of acceleration of the system is 2 m/s^2 and there is no slipping between block A and block B

(B) The magnitude of friction force between block A and block B is 42 N

(C) Acceleration of block C is 1 m/s^2 downwards

(D*) Tension in the string connecting block B and block D is 12 N



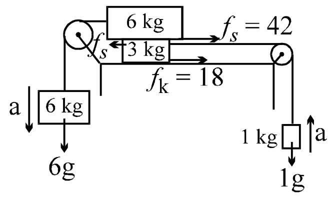
[Sol. (A) $6g - 18 - 1g = 16a$

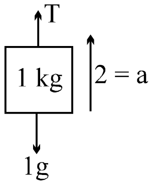
$a = 2\ m/s^2$ C moving down

(B) $f_s - 18 - 10 = 4 \times 2$

$f_s = 36$

(C) $a_c = 2\ m/s^2$ downward



(D) 

$T - 10 = 1 \times 2 \Rightarrow T = 12\ N$]

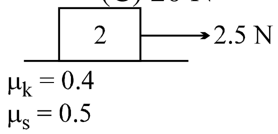
Q.7 A body of mass 2 kg is placed on a horizontal surface having kinetic friction 0.4 and static friction 0.5. If the force applied on the body is 2.5 N, the frictional force acting on the body will be ($g = 10\ m/s^2$)

(A) 8 N (B) 10 N (C) 20 N (D*) 2.5 N

[Sol. $f_{l \cdot s} = \mu_s mg = 0.5 \times 2g = 10\ N$

Block is stationary $P < f_{l \cdot s}$

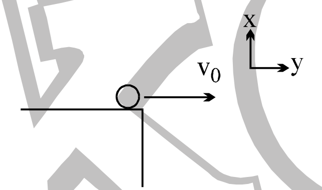
$\Rightarrow$ friction force $f = P = 2.5\ N$]



Q.8 A particle is projected horizontally from the top of a tower with a velocity v_0. If v be its velocity at any instant, then the radius of curvature of the path of the particle at the point (where the particle is at that instant) is directly proportional to:

(A*) v^3 (B) v^2 (C) v (D) 1/v

[Sol. $\vec{v} = v_0\hat{i} - gt\hat{j}$ and $\vec{a} = -g\hat{j}$



$\therefore$ Component of $\vec{a} \perp$ to $\vec{v} = \vec{a} - \left(\frac{\vec{a}\cdot\vec{v}}{v^2}\right)\vec{v}$

i.e. $\vec{a}_{\perp} = \left(-\frac{v_0 g}{v_0^2 + g^2t^2}\right)(gt\hat{i} + v_0\hat{j})$

$\therefore$ $|\vec{a}_{\perp}| = \frac{v_0 g}{\sqrt{v_0^2 + gt^2}}$

Also, $r = \frac{|\vec{v}|^2}{|a_{\perp}|} = \frac{(v_0^2 + g^2t^2)^{3/2}}{v_0 g} = \frac{v^3}{v_0 g}$

$\therefore$ $r \propto v^3$

$\therefore$ Option (A) is correct]

Q.9 There are two massless springs A and B of spring constant K_A and K_B respectively and $K_A > K_B$. If W_A and W_B be denoted as work done on A and work done on B respectively, then

(A*) If they are compressed to same distance, $W_A > W_B$

(B*) If they are compressed by same force (upto equilibrium state) $W_A < W_B$

(C) If they are compressed by same distance, $W_A = W_B$

(D) If they are compressed by same force (upto equilibrium state) $W_A > W_B$

[Sol. For same compression x_0 (say)

$W_A = \frac{1}{2}k_A x_0^2$ & $W_B = \frac{1}{2}k_B x_0^2$

$\Rightarrow$ $W_A > W_B$ [$\because k_A > k_B$]

for same force at equilibrium force = F_0

$$x_A = \frac{F_0}{k_A},\ x_B = \frac{F_0}{k_B}$$

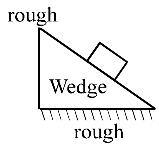
$$\therefore \quad W_A = \frac{1}{2}k_A x_A^2 = \frac{F_0^2}{2k_A}$$

Similarly, $W_B = \frac{F_0^2}{2k_B}$

$\Rightarrow \quad W_B > W_A$

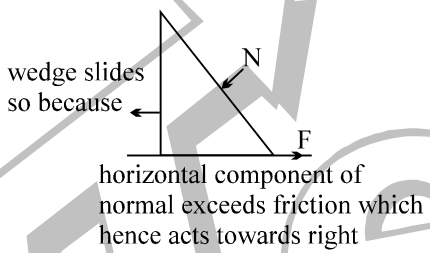
$\therefore$ (A) & (B) are correct options]

Q.10 When a block is placed on a wedge as shown in figure, the block starts sliding down and the wedge also start sliding on ground. All surfaces are rough. The centre of mass of (wedge + block) system will move

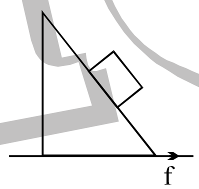


(A) leftward and downward
(B*) rightward and downward
(C) leftward and upward
(D) only downward

[Sol. (B) Wedge



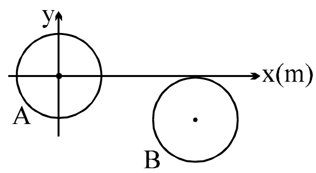
System



external force are gravity friction towards right so com shifts right + downward]

Question No. 11 to 13 (3 questions)

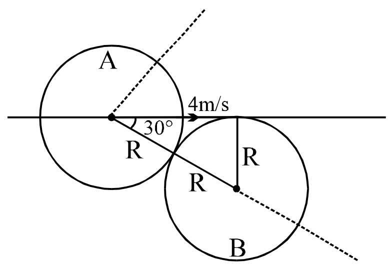
Two smooth balls A and B, each of mass m and radius R, have their centres at (0,0,R) and at (5R,–R,R) respectively, in a coordinate system as shown. Ball A, moving along positive x axis, collides with ball B. Just before the collision, speed of ball A is 4 m/s and ball B is stationary. The collision between the balls is elastic.



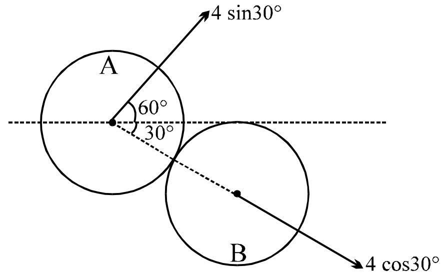
Q.11 Velocity of the ball A just after the collision is

(A*) $(i+\sqrt{3}j)$ m/s (B) $(i-\sqrt{3}j)$ m/s (C) $(2i+\sqrt{3}j)$ m/s (D) $(2i+2j)$ m/s

[Sol. (A) Before collision



After collision



$v_A = 4\sin 30°\,[\cos 60\,\hat{i} + \sin 60\,\hat{j}]$

$v_A = \hat{i} + \sqrt{3}\,\hat{j}$]

Q.12 Impulse of the force exerted by A on B during the collision, is equal to

(A) $(\sqrt{3}mi + 3mj)$ kg-m/s (B) $(\frac{\sqrt{3}}{2}mi - \sqrt{3}mj)$ kg-m/s

(C*) $(3mi - \sqrt{3}mj)$ kg-m/s (D) $(2\sqrt{3}mi + 3mj)$ kg-m/s

[Sol. $\overrightarrow{J_{A\,on\,B}} = m\,\overrightarrow{V_{B_f}} - \overrightarrow{V_{B_i}}$

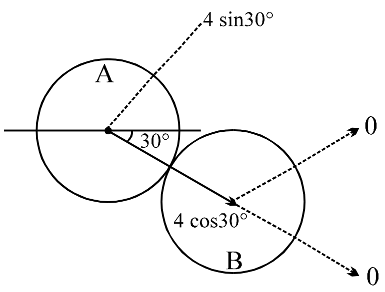
$= m\,[4\cos 30°(\cos 30°\hat{i} - \sin 30°\hat{j}) - 0]$

$= (3mi - \sqrt{3}mj)$ kg-m/s]

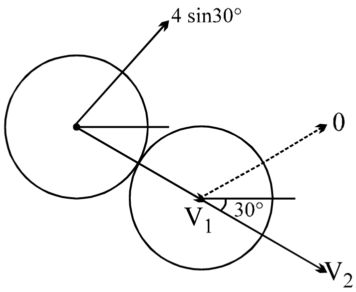
Q.13 Coefficient of restitution during the collision is changed to 1/2, keeping all other parameters unchanged. What is the velocity of the ball B after the collision?

(A) $\frac{1}{2}(3\sqrt{3}i + 9j)$ m/s (B*) $\frac{1}{4}(9i - 3\sqrt{3}j)$ m/s (C) $(6i + 3\sqrt{3}j)$ m/s (D) $(6i - 3\sqrt{3})$ m/s

[Sol. Before collision



After collision



(1) $\frac{1}{2} = \frac{-(V_2 - V_1)}{(0 - 4\cos 30°)}$

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$V_2 - V_1 = \sqrt{3}$

(2) $m\frac{4\sqrt{3}}{2} = mV_1 + mV_2$

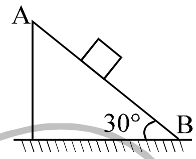
$V_2 + V_1 = 2\sqrt{3}$

$V_2 = \frac{3\sqrt{3}}{2}$ m/s

$\vec{V}_2 = \frac{3\sqrt{3}}{2}\ [\cos 30°\,\hat{i} + \sin 30°\,(-\hat{j})]$

$= \frac{9}{4}\hat{i} - \frac{3\sqrt{4}}{4}\hat{j}$]

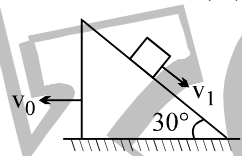
Q.14 A particle of mass m = 0.1 kg is released from rest from a point A of a wedge of mass M = 2.4 kg free to slide on a frictionless horizontal plane. The particle slides down the smooth face AB of the wedge. When the velocity of the wedge is 0.2 m/s the velocity of the particle in m/s relative to the wedge is:



(A) 4.8 (B*) $\frac{10}{\sqrt{3}}$ (C) 7.5 (D) 10

[Sol. (1) $O = 0.1\,(v_1 \cos 30° - v_0) - 2.4\,v_0$

$v_1 \cos 30° = 25\,v_0$



(2) $v_1 = \frac{25(0.2)}{\sqrt{3}/2} = \frac{5}{\sqrt{3}/2} = \frac{10}{\sqrt{3}}$ m/s]

Q.15 A bullet of mass 0.01 kg and travelling at a speed of 500 m/s strike a block of mass of 2 kg which is suspended by a string of length 5 m. The centre of gravity of the block is found to rise a vertical distance of 0.1 m. What is the speed of the bullet after it merge from the block:

(A) 780 m/s (B*) 220 m/s (C) 1.4 m/s (D) 7.8 m/s

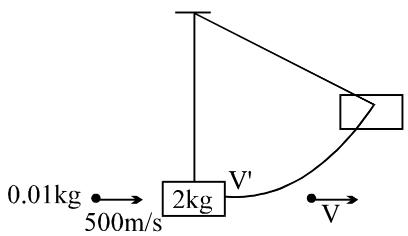
[Sol. For block

$V'^2 = 2gh$

$V'^2 = 2\times10\times0.1$

$V' = \sqrt{2}$ m/s

Just before and after bullet strikes, momentum conserved



$0.01 \times 500 = 2V' + 0.01\,V$

$5 - 2\sqrt{2} = 0.01\,V$

$V = \frac{5 - 2.828}{0.01} = 217.2$ m/s]

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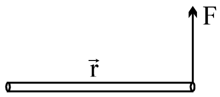
Q.16$_{rot}$ The density of a rod gradually decreases from one end to the other. It is provided at an end so that it canmove about a vertical axis through the pivot. A horizontal force F is applied on the free end in a direction perpendicular to the rod. The quantities, that do not depend on which end of the rod is pivoted, are

(A) angular acceleration
(B) angular velocity when the rod completes on rotation
(C) angular momentum when the rod completes one rotation
(D*) torque of the applied force

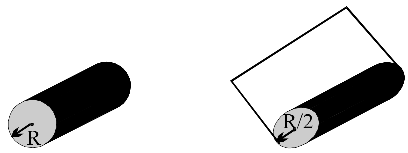
[Sol. $\vec{\tau} = \vec{r} \times \vec{F}$ = r F sin 90 = rF



$\tau = I\,\alpha$

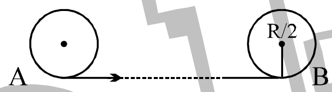
I will a vary]

Q.17$_{rot}$ A carpet of mass 'M' made of inextensible material is rolled along its length in the form of a cylinder of radius 'R' and is kept on a rough floor. The carpet starts unrolling without sliding on the floor when a negligibly small push is given to it. The horizontal velocity of the axis of the cylindrical part of the carpet when its radius reduces to R/2 will be:



(A*) $v = \sqrt{\dfrac{14gR}{3}}$ (B) $v = \sqrt{\dfrac{2gR}{3}}$ (C) $\sqrt{2gR}$ (D) $\sqrt{5gR}$

[Sol. $m' = \sigma\left(\pi\left(\dfrac{R}{2}\right)^2\right)$



$m' = \sigma\,\dfrac{\pi R^2}{4}$

$m' = \dfrac{m}{4}$

C.O.E.

$mgR = \left(\dfrac{m}{4}\right) g \left(\dfrac{R}{2}\right) + \dfrac{1}{2} I\, w^2 + \dfrac{1}{2} m'\, v^2$

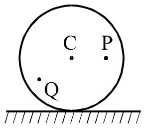
$mgR = \dfrac{mgR}{8} + \dfrac{1}{2}\left(\dfrac{m}{4}\right)\dfrac{1}{2}\left(\dfrac{R}{2}\right)^2 w^2 \left(\dfrac{v}{(R/2)}\right)^2 + \dfrac{1}{2}\left(\dfrac{m}{4}\right) v^2$

$mgR = \dfrac{mgR}{8} + \dfrac{1}{16} mv^2 + \dfrac{1m}{8} v^2$

$\dfrac{7mgR}{8} = \dfrac{1+2}{16} mv^2$

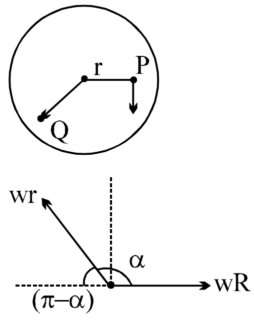
$v = \sqrt{\dfrac{14gR}{3}}$]

Q.18$_{rot}$ A disc is rolling without slipping with angular velocity ω. P and Q are two points equidistant from the centre C. The order of magnitude of velocity is:



(A) $v_Q > v_C > v_P$ (B) $v_P > v_C > v_Q$ (C) $v_P = v_C = v_p/2$ (D*) $v_P > v_C > v_Q$

[Sol. $v_p^2 = (wR)^2 + (w\,r)^2 = w\sqrt{R^2 + r^2}$



$v_Q^2 = (wR)^2 + (wr)^2 + 2(wR)\,(wr)\cos(\pi-\alpha)$

$v_Q^2 = w^2\sqrt{R^2 + r^2 - 2Rr\,w\,r\alpha}$

since cos α < 1 Let α = 45

$v_Q = w\sqrt{R^2 + r^2 - Rr\sqrt{2}}$

$v_C = wR$

$v_P > v_C > v_Q$]

Q.19$_{waves}$ In the experiment for the determination of the speed of sound in air using the resonance column method, the length of the air column that resonates in the fundamental mode, with a turning fork is 0.1 m. When this length is changed to 0.35 m, the same tuning fork resonates with the first overtone. The end correction is:

(A*) 0.025 m (B) 0.012 m (C) 0.05 m (D) 0.024 m

[Sol. $L_1 + e = \frac{\lambda}{4}$

$L_2 + e = \frac{\lambda 3}{4}$

$L_2 - L_1 = \frac{\lambda}{2}$

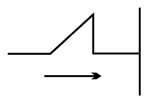
$L_2 - L_1 = 2\,(L_1 + e)$

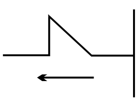
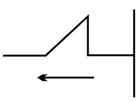
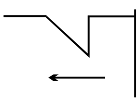
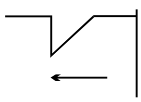
$e = \frac{L_2 - 3L_1}{2}$

$e = \frac{0.35 - 0.3}{2} = \frac{0.5}{2}$

e = 0.025 m]

Q.20$_{waves}$ A pulse is incident on a yielding surface then the possible form of reflected pulse is:



(A)  (B*)  (C)  (D) 

[Sol. Incident ray will be reflected back yielding surface hence last end will be treated as free-end]

Q.21$_{waves}$ A listener is at rest with respect to the source of sound. A wind starts blowing along the line joining the source and the observer. Which of the following quantities do not change?
(A) wavelength (B*) frequency (C*) time period (D) velocity of sound

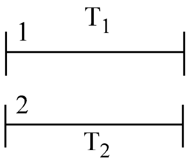
[Sol. Source Observe

$$f' = \frac{v_{sound} - v_0 + v_w}{v_{sound} - v + v_w}\, f$$

f' = f
frequency will not change]

Q.22$_{waves}$ Two identical straight wires are stretched so as to produce 6 beats/sec, when vibrating simultaneously. On changing the tension slightly in one of them, the beat frequency remains unchanged. Denoting T_1, T_2 the higher & the lower initial tensions in the strings, then it could be said that while making the above changes in tension:
(A) T_2 was decreased (B) T_2 was increased (C) T_1 was increased (D) T_1 was decreased

[Sol. $f_1 = 6$ beat /sec



$f_1 - f_2 = \pm 6$

$$\frac{n_1}{2L}\sqrt{\frac{T_1}{\mu}} - \frac{n_2}{2L}\sqrt{\frac{T_2}{\mu}}$$

$n_1 = n_2 = n$

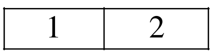
$$\frac{n}{2L}\sqrt{\mu}\left[\sqrt{T_1} - \sqrt{T_2}\right] = +6$$

either T_1 is decreased or T_2 was increased]

Q.23 The liquid of a liquid-thermometer should have the following properties:
(A) Large value of specific heat & low value of coefficient of the small expansion
(B) Small value of specific heat & large value of coefficient of the small expansion
(C) Large value of boiling point and low value of freezing point
(D) Low value of boiling point and large value of freezing point

[Sol. Small value of specific heat and large value of coefficient of the small expansion.]

Q.24 A composite bar of length $L = L_1 + L_2$ is made up from a rod of material 1 and of length L_1 attached to a rod of material 2 and of length L_2 as shown. If α_1 and α_2 are their respective coefficients of linear expansion, then equivalent coefficient of linear expansion for the composite rod is:



(A) $\frac{\alpha_1 L_2 + \alpha_2 L_1}{L}$ (B) $\frac{\alpha_1 L_2 + \alpha_2 L_2}{L}$ (C) $\frac{\alpha_1 L_1 + \alpha_2 L_2}{L}$ (D) $\frac{\alpha_1\alpha_2(L_1^2 + L_2)}{(\alpha_1 L_1 + \alpha_2 L_2)}$

[Sol. $\alpha_{eq}(L_1 + L_2)\,\Delta T = L_1\,\alpha_1\,\Delta T + L_2\,\alpha_2\,\Delta T$

$$\alpha_{eq} = \frac{L_1\,\alpha_1 + L_2\,\alpha_2}{L_1 + L_2}$$]

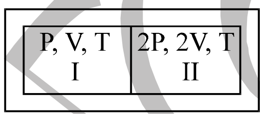
Q.25$_{thermo}$ A closed vessel contains a mixture of two diatomic gases A and B. Molar mass of A is 16 times and that of B and mass of gas A, contained in the vessel is 2 times that of B.
(A) Average kinetic energy per molecule of gas A is equal to that of gas B
(B) Root mean square value of translational velocity of gas B is four times that of A
(C) Pressure exerted by gas B is eight times of that exerted by gas A
(D) Number of molecules of gas B in the cylinder is eight times that of gas A

[Sol. $\frac{5}{2}KT$ avg. KE is same $\rightarrow$ A

$$V_{rms\,A} = \sqrt{\frac{3RT}{M}},\ V_{rms\,B} = \sqrt{\frac{3RT}{(M/16)}} = 4V_{rms\,A} \rightarrow B$$

$$\left.\begin{aligned} n_A = \frac{2m}{M},\ n_B = \frac{2m}{(M/16)} = 16m/M \\ P_B = \left(\frac{n_B}{n_A + n_B}\right)P_0,\ P_A = \left(\frac{n_A}{n_A + n_B}\right)P_0 \end{aligned}\right\} \rightarrow C, D$$
]

Q.26$_{thermo}$ A partition divides a container having insulated walls into two compartments I and II. The same gas fills the two compartments whose initial parameters are given. The partition is a conducting wall which can move freely without friction. Which of the following statements is/are correct, with reference to the final equilibrium position?
(A) The pressure in the two compartments are equal
(B) Volume of compartment I is 3V/5
(C) Volume of compartment II is 12V/5
(D) Final pressure in compartment I is 5P/3



[Sol. $\frac{PV}{T} = \frac{P_1V_1}{T}$ Temp. will not change as internal energy of the system will remain unchanged

For 2nd compartment

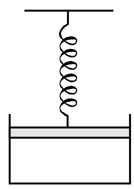
$$\frac{(2P)2V}{T} = \frac{P_1(3V - V_1)}{T} \Rightarrow 4PV = \frac{PV}{V_1}(3V - V_1)$$

$$\Rightarrow 4V_1 = 3V - V_1$$

$$\Rightarrow V_1 = \frac{3V}{5},\ V_2 = \frac{12V}{5}$$

$$P_1 = \frac{5P}{3}$$]

Q.27$_{thermo}$ One mole of an ideal gas is kept enclosed under a light piston (area = 10^{-2} m^2) connected by a compressed spring (spring constant 100 N/m). The volume of gas is 0.83 m^3 and its temperature is 100 K. The gas is heated so that it compresses the spring further by 0.1 m. The work done by the gas in the process is (Take R = 8.3 J/mole and suppose there is no atmosphere):



(A) 3 J (B) 6 J (C) 9 J (D) 1.5 J

[Sol. $kx_0 = PA$ [x_0 is initial compression]

$$100x_0 = \left(\frac{nRT}{V}\right) \times 10^{-2}$$

$$x_0 = \frac{1}{100} \times \frac{1\times 8.3\times 100}{0.83} \times \frac{1}{100} = 0.1$$

$x_1 = 0.2$ (total compression)

$$W_{gas} = \frac{1}{2} \times 100 \times (0.2)^2 - \frac{1}{2} \times 100 \times (0.1)^2 = \frac{100}{2} \times \frac{1}{100}[4-1] = 1.5 \quad]$$

Q.28$_{\text{thermo}}$ Number of collisions of molecules of a gas on the wall of a container per m^2 will:
(A) Increase if temperature and volume both are doubled
(B) Increase if temperature and volume both are halved
(C) Increase if pressure and temperature both are doubled
(D) Increase if pressure and temperature both are halved

[Sol. N(2mV) = P

$$N \propto \frac{P}{\sqrt{T}} = \sqrt{\frac{T}{V}} = \quad]$$

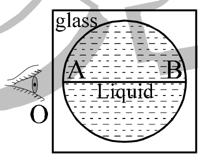
Q.29$_{\text{go}}$ The image produced by a concave mirror is one quarter the size of object. If the object is moved 5 cm closer to the mirror, the image will only be half the size of the object. The focal length of mirror is
(A) f = 5.0 cm (B*) f = 2.5 cm (C) f = 7.5 cm (D) f = 10 cm

[Sol.
$$\frac{1}{4} = \frac{f}{x_0 - f}$$

$$\frac{1}{2} = \frac{f}{x_0 - 5 - f}$$

Solving $f = 2.5$]

Q.30$_{\text{go}}$ The observer 'O' sees the distance AB as infinitely large. If refractive index of liquid is μ_1 and that of glass is μ_2, then μ_1/μ_2 is:



(A) 2 (B) 1/2 (C) 4 (D) None of these

[Sol. B must be appearing at infinity

$$\frac{h_2}{\infty} - \frac{\mu_1}{-2R} = \frac{\mu_2 - \mu_1}{-R}$$

Solving $\dfrac{\mu_1}{\mu_2} = 2$]

Q.31$_{go}$ For a prism kept in air it is found that for an angle of incidence 60°, the angle of refraction 'A', angle of deviation 'δ' and angle of emergence 'e' become equal. Then the refractive index of the prism is

(A) 1.73 (B) 1.15 (C) 1.5 (D) 1.33

[Sol. $\delta = e = A$

$\delta = i + e - A$

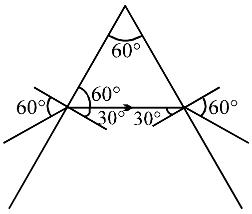
$\delta = i = 60°$

$e = 60°$

$A = 60°$

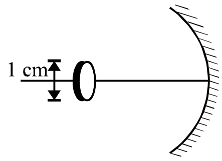
$1 \times \sin 60° = \mu \sin 30°$

$\mu = \frac{\sqrt{3}}{2} \times 2 = \sqrt{3}$]



Question No. 32 to 34 (3 questions)

A concave mirror of radius of curvature 20 cm is shown in the figure. A circular disc of diameter 1 cm is placed on the principle axis of mirror with its plane perpendicular to the principal axis at a distance 15 cm from the pole of the mirror. The radius of disc increasing according to the law r = (0.5 + 0.1t) cm/sec.



Q.32$_{go}$ The image formed by the mirror will be in the shape of a:

(A) circular disc (B) elliptical disc with major axis horizontal

(C) elliptical disc with major axis vertical (D) distorted disc

Q.33$_{go}$ In the **above question**, the area of image of the disc at t = 1 second is:

(A) 1.2 π cm^2 (B) 1.44 π cm^2 (C) 1.52 π cm^2 (D) none of these

[Sol. $r_0 = 0.6$

$r_i = 0.6 \times 2$ (m = 2)

$= 1.2$

$A = \pi \times (1.2)^2 = 1.44\,\pi$ ⇒ Option (B) is correct]

Q.34$_{go}$ What will be the rate at which the horizontal radius of image will be changing

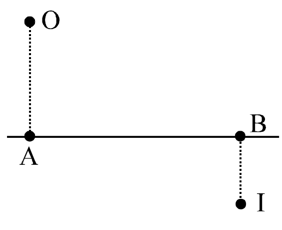
(A) 0.2 cm/sec increasing (B) 0.2 cm/sec decreasing

(C) 0.4 cm/sec increasing (D) 0.4 cm/sec decreasing

[Sol. $r_i = 2(0.5 + 0.1t) = 1 + 0.2t$

$\frac{dr_i}{dt} = 0.2$]

Q.35$_{go}$ A luminous point object is placed at O, whose image is formed at I as shown in figure. Line AB is the optical axis. Which of the following statement is/are correct?



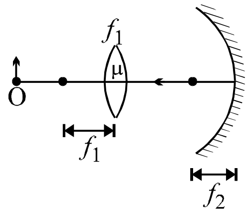
(A) If a lens is used to obtain the image, then it must be a diverging lens and its optical centre will be the intersection point of line AB and OI.

(B*) If a lens is used to obtain the image, then it must be a converging lens and its optical centre will be the intersection point of line AB and OI.

(C*) If a mirror is used to obtain the image then the mirror must be concave and object and image subtend equal angles at the pole of the mirror.

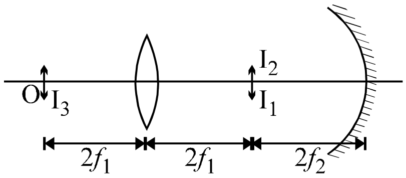
(D*) I is a real image.

Q.36$_{go}$ An object is placed infront of a converging lens at a distance equal to twice the focal length f_1 of the lens. On the other side of the lens is a concave mirror of focal length f_2 separated from the lens by a distance $2(f_1 + f_2)$. Light from the object passes rightward through the lens, reflects from the mirror, passes leftward through the lens and forms a final image of the object.



(A) The distance between the lens and the final image is equal to $2f_1$.
(B) The distance between the lens and the final image is equal to $2(f_1 + f_2)$
(C*) The final image is real, inverted and of same size as that of the object
(D) The final image is real, erect and of same size as that of the object

[Sol.

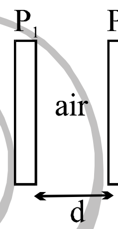


]

Q.37$_{go}$ A parallel beam of light passes parallel to the axis and falls on one face of a thin convex lens of focal length f and after two internal reflections emerges from the second face and forms a real image. Find the distance of the image from the lens if μ is the refractive index of the lens.
(A*) f (μ–1) / 3μ–1 (B) (μ–1) / f (3 μ–1) (C) (3μ – 1)/f (μ – 1) (D) f (μ –1)

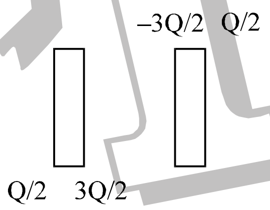
[Sol. Using formula]

Q.38$_{es}$ Two conducting large plates P_1 & P_2 are placed parallel to each other at very small separation 'd'. The plate area of either face of plate is A. A charge +2Q is given to plate P_1 & –Q to the plate P_2 (neglect ends effects). If plate P_1 & P_2 are now connected by conducting wire, then total amount of heat produced is



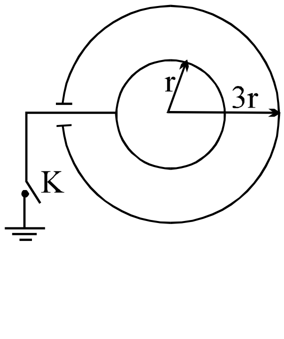
(A) $\dfrac{4Q^2d}{3\epsilon_0 A}$ (B*) $\dfrac{9\,Q^2d}{8\epsilon_0 A}$ (C) $\dfrac{3Q^2d}{4\epsilon_0 A}$ (D) None of these

[Sol.



$$E_{in} = \frac{q^2}{2C} = \frac{(3Q/2)^2}{2\left(\frac{A\varepsilon_0}{d}\right)} = \frac{9Q^2d}{8A\varepsilon_0}$$]

Q.39$_{es}$ Figure shows two conducting thin concentric shells of radii r and 3r. The outer shell carries charge q and inner shell is neutral. The amount of charge which flows from inner shell to the earth after the key K is closed, is equal to:



(A*) –q/3 (B) q/3
(C) 3q (D) –3q

[Sol. $V_{in} = 0 = \dfrac{kq_1}{r} + \dfrac{kq}{3r}$

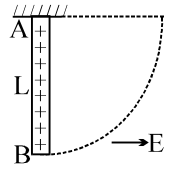
$q_1 = -q/3$]

Q.40$_{es}$ A point charge $q = 50\mu C$ is located in the x-y plane at the point of position vector $\vec{r}_0 = 2\hat{i} + 3\hat{j}$. What is the electric field at the point of position vector $\vec{r} = 8\hat{i} - 5\hat{j}$?

(A) 1200 V/m (B) 4×10^{-2} V/m (C) 900 V/m (D*) 4500 V/m

[Sol. $\vec{E} = \dfrac{kq(\vec{r} - \vec{r}_0)}{|\vec{r} - \vec{r}_0|^3} = \dfrac{9\times10^9 \times 50\times10^{-6}(6\hat{i}+8\hat{j})}{10^3} = 4500$ V/m]

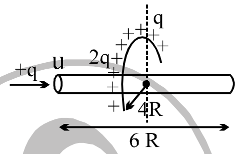
Q.41$_{es}$ A rod AB of length L and mass m is uniformly charged with a charge Q and it is freely suspended from end A as shown in figure. An electric field E is suddenly switched on in the horizontal direction due to which rod get turned by a maximum angle 90°. The magnitude of E is:



(A) $\dfrac{2Mg}{Q}$ (B) $\dfrac{4Mg}{Q}$ (C) $\dfrac{3Mg}{Q}$ (D*) $\dfrac{Mg}{Q}$

[Sol. $\dfrac{qEL}{2} - \dfrac{mgL}{2} = 0$]

Q.42$_{es}$ On a semicircular ring of radius = 4 R, charge +3q is distributed in such a way that on one quarter +q is uniformly distributed and on another quarter +2q is uniformly distributed. Along its axis a smooth nonconducting and uncharged pipe of length 6R is fixed axially as shown. A small ball of mass m and charge +q is thrown from the other end of pipe. **The ball can come out of the pipe if**:



(A) $u > \sqrt{\dfrac{7q^2}{40\pi\varepsilon_0 Rm}}$ (B*) $u > \sqrt{\dfrac{3q^2}{40\pi\varepsilon_0 Rm}}$ (C) $u \geq \sqrt{\dfrac{3q^2}{40\pi\varepsilon_0 Rm}}$ (D) $u > \sqrt{\dfrac{9q^2}{40\pi\varepsilon_0 Rm}}$

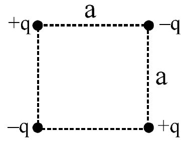
[Sol. $U_C + K_C = U_e + K_e$

$$q \times \frac{k\times3q}{\sqrt{(4R)^2+(3R)^2}} + \frac{1}{2}mu^2 = \frac{k\times3q^2}{4R}$$

$$\frac{1}{2}mu^2 = \frac{3kq^2}{R}\left[\frac{1}{4} - \frac{1}{5}\right]$$

$$u = \sqrt{\frac{3q^2}{40\pi\varepsilon_0 Rm}}$$]

Q.43$_{es}$ In a system of two dipoles placed in the way as shown in figure:



(A*) It is possible to consider a spherical surface of radius a and whose centre lies within the square shown, through which total flux is +ve.

(B*) It is possible to consider a spherical surface of radius a and whose centre lies within the square shown through which total flux is –ve

(C) There are two points within the square at which EF is zero.

(D*) It is possible to consider a spherical surface of radius a and whose centre lies within the square shown through which total flux is zero.

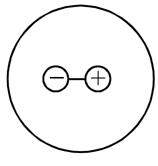
$Q.44_{es}$ Consider a gaussian spherical surface, covering a dipole of charge q and –q, then

(A*) $q_{in} = 0$ (Net charge enclosed by the spherical surface)

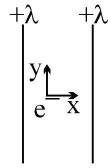
(B*) $\phi_{net} = 0$ (Net flux coming out the spherical surface)

(C) E = 0 at all points on the spherical surface

(D*) $\int \vec{E} \cdot d\vec{s} = 0$ (Surface integral of $\vec{E}$ over the spherical surface)



$Q.45_{es}$ An electron is placed just in the middle between two long fixed line charges of charge density $+\lambda$ each. The wires are in the xy plane (Do not consider gravity)



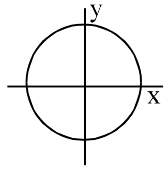
(A*) The equilibrium of the electron will be unstable along x-direction

(B*) The equilibrium of the electron will be neutral along y-direction

(C*) The equilibrium of the electron will be stable along z-direction

(D) The equilibrium of the electron will be stable along y-direction

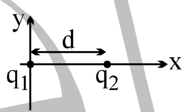
$Q.46_{es}$ 1 μC charge is uniformly distributed on a spherical shell given by equation $x^2 + y^2 + z^2 = 25$. What will be intensity of electric field at a point (1, 1, 2)?



(A) 5 N/C (B) 45 N/C (C*) $\frac{5\sqrt{3}}{2}$ N/C (D) Zero

[Sol. $r = \sqrt{1+1+4} = \sqrt{6} < 5 \Rightarrow E_{in} = 0$]

$Q.47_{es}$ Two particles of charge q_1 and q_2 are separated by distance d as shown in figure. Charge q_1 is situated at the origin. The net electric field due to the particles is zero at x = d/4. With V = 0 at infinity, the location of a point in terms of d on the x axis (other than at infinity) at which the electrical potential due to the two particles is zero, is given by:



(A) d/4 (B) 16 d (C) – 16 d (D*) no point on the axis

[Sol. $\frac{kq_1}{\left(\frac{d}{4}\right)^2} - \frac{kq_2}{\left(\frac{3d}{4}\right)^2} = 0$

$\Rightarrow$ $9q_1 = q_2$ $\Rightarrow$ both positive so no point except ∞.]

$Q.48_{es}$ Pick the correct statements:

(A) If a point charge is placed off-centre inside an electrically neutral spherical metal shell then induced charge on its inner surface is uniformly distributed.

(B*) If a point charge is placed off-centre inside an electrically neutral, isolated spherical metal shell, then induced charge on its outer surface is uniformly distributed.

(C*) A non metal shell of uniform charge attracts or repels a charged particle that is outside the shell as if all the shell's charge were concentrated at the centre of the shell.

(D*) If a charged particle is located inside a non metal shell of uniform charge, there is no electrostatic force on the particle due to the shell.

Question No. 49 to 51 (3 questions)

A charged particle is suspended at the centre of two thin concentric spherical charged shells, made of non conducting material. Figure A shows cross section of the arrangement. Figure B gives the net flux ϕ through a Gaussian sphere centered on the particle, as a function of the radius r of the sphere.

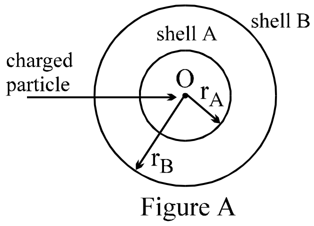


Figure A

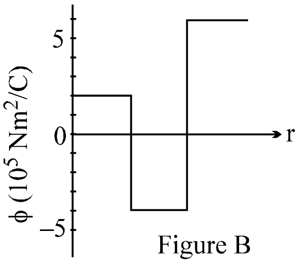


Figure B

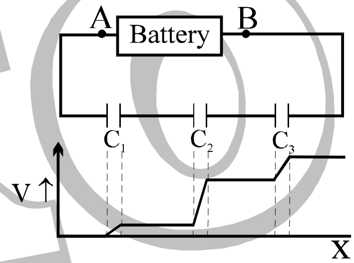
Q.49$_{es}$ What is the charge on the central particle?
(A) 0.2 μC (B) 2 μC (C*) 1.77 μC (D) 3.4 μC

Q.50$_{es}$ What is the charge on shell A?
(A) 5.31×10^{-6} C (B*) -5.31×10^{-6} C (C) -3.54×10^{-6} C (D) -1.77×10^{-6} C

Q.51$_{es}$ In which range of the values of r is the electric field zero?
(A) 0 to r_A (B) r_A to r_B
(C) for $r > r_B$ (D*) for no range of r, electric field is zero

Question No. 52 to 54 (3 questions)

Figure shows a circuit containing a battery and three parallel plate capacitors with identical plate separation (filled with air). The capacitors lie along x-axis and a graph of the electric potential V along that axis is shown.

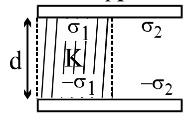


Q.52$_{cap}$ The charge on capacitor C_1, C_2 & C_3 are q_1, q_2 & q_3 respectively then
(A) $q_1 > q_2 > q_3$ (B) $q_1 < q_2 > q_3$ (C*) $q_1 = q_2 = q_3$ (D) $q_1 > q_2 < q_3$

Q.53$_{cap}$ If the area of the plates of capacitors are A_1, A_2 & A_3 respectively then
(A) $A_1 < A_2 > A_3$ (B*) $A_1 > A_3 > A_2$ (C) $A_1 = A_2 = A_3$ (D) $A_1 > A_2 > A_3$

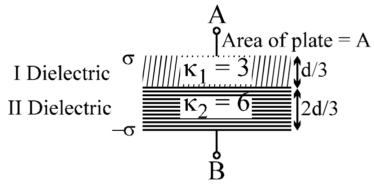
Q.54$_{cap}$ If the magnitude of electric field between their plates are E_1, E_2 & E_3 respectively then
(A) $E_1 > E_2 > E_3$ (B*) $E_1 < E_2 > E_3$ (C) $E_1 > E_2 < E_3$ (D) $E_1 < E_2 < E_3$

Q.55$_{cap}$ A parallel plate capacitor of area A and separation d is charged to potential difference V and removed from the charging source. A dielectric slab of constant K = 2, thickness d and area A/2 is inserted, as shown in the figure. Let σ_1 be free charge density at the conductor-dielectric surface and σ_2 be the charge density at the conductor-vacuum surface.



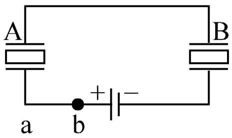
(A) The electric field have the same value inside the dielectric as in the free space between the plates.
(B) The ratio σ_1/σ_2 is equal to 2:1
(C*) The new capacitance is $3\varepsilon_0 A/(2d)$
(D*) The new potential difference is (2/3)V

Q.56$_{cap}$ In the figure shown σ is the surface charge density on the upper metallic plate



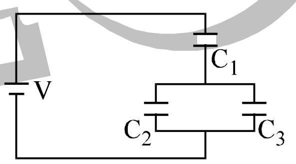
(A) The ratio of energy density in I dielectric to second dielectric is 5/3
(B) The ratio of energy density in I dielectric to second dielectric is 3/5
(C) Total induced surface charge density on the interface of the two dielectric is $-3\sigma/15$
(D) Total induced surface charge density on the interface of the two dielectric is $-2\sigma/15$

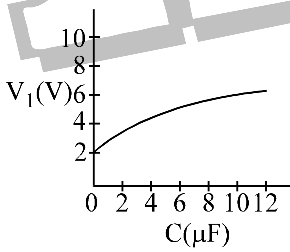
Q.57$_{cap}$ Identical dielectric slabs are inserted into two identical capacitors A and B. These capacitors and a battery are connected as shown in figure. Now the slab of capacitor B is pulled out with battery remaining connected:



(A*) During the process positive charge flows from a to b
(B) Finally charge on capacitor B will be less than that on capacitor A
(C) During the process, a work is done by the external force F, which appears as heat in the circuit
(D*) During the process, internal energy of the battery increases

Question No. 58 to 60 (3 questions)
Capacitor C_3 in the circuit is a variable capacitor (its capacitance can be varied). Graph is plotted between potential difference V_1 (across capacitor C_1) versus C_3. Electric potential V_1 approaches on asymtote of 10 V as $C_3 \to \infty$.



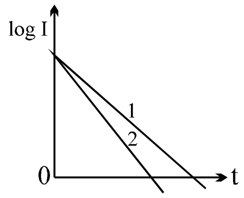


Q.58$_{cap}$ The electric potential V across the battery is equal to:
(A*) 10 V (B) 12 V (C) 16 V (D) 20 V

Q.59$_{cap}$ The capacitance of the capacitor C_1 has value:
(A) 2 μF (B) 6 μF (C*) 8 μF (D) 12 μF

Q.60$_{cap}$ The capacitance of C_2 is equal to:
(A*) 2 μF (B) 6 μF (C) 8 μF (D) 12 μF

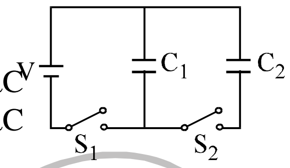
Q.61$_{cap}$ A capacitor of capacitance C is charged to a potential difference V_0 and is then discharged through a resistance R. The discharge current gradually decreases, with a straight line 1 corresponding to this process, as shown in figure where time is along x axis and the logarithm of the current on y-axis. Later on, one of the three parameters V_0, R or C, is changed (keeping the other two unchanged) in such a manner than the ln I v/s t dependence is represented by the straight line 2. Which option correctly represents the change?



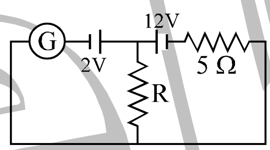
(A) V_0 is decreased (B) R is decreased (C) R is increased (D*) C is decreased

Q.62$_{cap}$ Consider the circuit shown where $C_1 = 6\ \mu F$, $C_2 = 3\ \mu F$ and V = 20 V. Capacitor C_1 is first charged by closing the switch S_1. Switch S_1 is then opened and the charged capacitor is connected to the uncharged capacitor C_2 by closing S_2.

(A*) Total charge that has flown through the battery is 120 μC
(B*) Final charge on C_1 after opening switch S_1 and closing switch S_2 is 80 μC
(C*) Final charge on C_2 after opening switch S_1 and closing switch S_2 is 40 μC
(D) Total heat produced after closing switch S_2 is 1.8 mJ



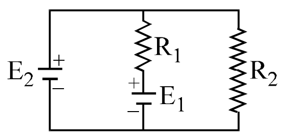
Q.63$_{ce}$ In the circuit shown, the galvanometer shows zero current. The value of resistance R is:

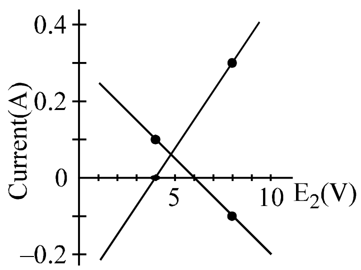


(A*) 1 Ω (B) 2 Ω (C) 4 Ω (D) 9 Ω

Question No. 64 to 66 (3 questions)

In the circuit shown, both batteries are ideal. EMF E_1 of battery 1 has a fixed value, but emf E_2 of battery 2 can be varied between 1 V and 10 V. The graph gives the currents through the two batteries as a function of E_2, but are not marked as which plot corresponds to which battery. But for both plots, current is assumed to be negative when the direction of the current through the battery is opposite the direction of that battery's emf. (direction of from negative to positive)





Q.64$_{ce}$ The value of emf E_1 is
(A) 8 V (B*) 6 V (C) 4 V (D) 2 V

Q.65$_{ce}$ The resistance R_1 has value
(A) 10 Ω (B*) 20 Ω (C) 30 Ω (D) 40 Ω

Q.66$_{ce}$ The resistance R_2 is equal to
(A) 10 Ω (B) 20 Ω (C) 30 Ω (D*) 40 Ω

Question No. 67 to 69 (3 questions)

A car battery with a 12 V emf and an internal resistance of 0.04 Ω is being charged wtih a current of 50 A

Q.67$_{ce}$ The potential difference V across the terminals of the battery are
(A) 10 V (B) 12 V (C*) 14 V (D) 16 V

Q.68$_{ce}$ The rate at which energy is being dissipated as heat inside the battery is:
(A*) 100 W (B) 500 W (C) 600 W (D) 700 W

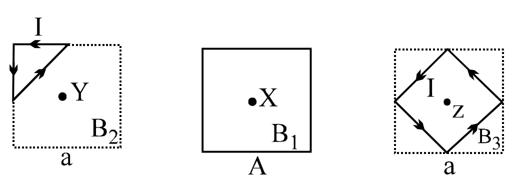
Q.69$_{ce}$ The rate of energy conversion from electrical to chemical is:
(A) 100 W (B) 500 W (C*) 600 W (D) 700 W

Q.70$_{emi}$ Which of the following does not have the same dimensions as the henry?
(A) $\frac{\text{joule}}{(\text{ampere})^2}$ (B*) $\frac{\text{tesla} - \text{m}^2}{(\text{ampere})^2}$ (C) ohm-second (D*) $\frac{1}{\text{farad} - \text{second}}$

Q.71$_{emi}$ The resistance of a circular coil is 50 turns & 10 cm diameter is 5 Ω. What must be the potential difference across the ends of the coil so as to nullify the horizontal component of the earth's magnetic field [$B_H = \pi \times 10^{-5}$ T] at the centre of the coil? How should the coil be placed to achieve this result?
(A) 0.5 V with plane of coil normal to the magnetic meridian
(B) 0.5 V with plane of coil in the magnetic meridian
(C*) 0.25 V with plane of coil normal to the magnetic meridian
(D) 0.25 V with plane of the coil in the magnetic meridian

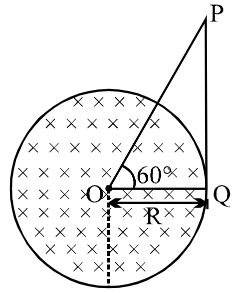
Q.72$_{mec}$ Two parallel conductors carrying current in the same direction attract each other, while two parallel beams of electrons moving in the same direction repel each other. Which of the following statements cannot be the reason for this?
(A) The conductors are electrically neutral
(B) The conductors produce magnetic fields on each other
(C*) The electron beams do not produce magnetic fields on each other
(D) The magnetic forces caused by the electron beams on each other are weaker than the electrostatic forces between them

Q.73$_{emi}$ The magnetic flux density in vaccum at the centre of any square coil (of one turn) of side'a' and carrying a current I is kI / a where k is independent. The magnitude of the induction at X, Y, Z are B_1, B_2 and B_3 respectively. Then



(A*) $B_3 > B_1 > B_2$ (B) $B_2 > B_3 > B_1$ (C) $B_2 > B_1 > B_3$ (D) $B_1 > B_2 > B_3$

Q.74$_{emi}$ In a cylindrical region having radius R, magnetic field varies with time as B = a + bt. OPQ is a triangular loop made of wire having resistance per unit length λ. Current induced in the loop is



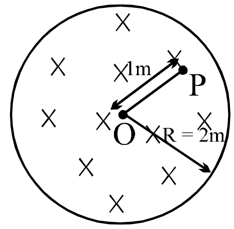
(A*) $\frac{\pi bR(\sqrt{3}-1)}{12\sqrt{3}\lambda}$

(B) $\frac{\pi Rb}{12\sqrt{3}(\sqrt{3}+1)\lambda}$

(C) $\frac{\pi Rb(\sqrt{3}-1)}{6\sqrt{3}\lambda}$

(D) None of the above

Q.75$_{emi}$ The magnetic field in a certain cylindrical region is changing with time according to the law B = [16 – 4t^2]Tesla. The induced electric field at point P at time t = 2 sec.



(A*) 8 volt/m
(B) 6 volt/m
(C) 4 volt/m
(D) none

ANSWER KEY

DIWALI ASSIGNMENT

Q.1	C	Q.2	A	Q.3	C	Q.4	A	Q.5	A	Q.6	A,D	Q.7	D
Q.8	A	Q.9	A,B	Q.10	B	Q.11	A	Q.12	C	Q.13	B	Q.14	B
Q.15	B	Q.16	D	Q.17	A	Q.18	D	Q.19	A	Q.20	B	Q.21	B
Q.22	B	Q.23	B	Q.24	C	Q.25	A,B,C,D	Q.26	A,B,C,D	Q.27	D		
Q.28	C	Q.29	B	Q.30	A	Q.31	A	Q.32	A	Q.33	B	Q.34	A
Q.35	B,C,D	Q.36	C	Q.37	A	Q.38	B	Q.39	A	Q.40	D	Q.41	D
Q.42	B	Q.43	A,B,D	Q.44	A,B,D	Q.45	A,B,C	Q.46	C	Q.47	D	Q.48	B,C,D
Q.49	C	Q.50	B	Q.51	D	Q.52	C	Q.53	B	Q.54	B	Q.55	C,D
Q.56		Q.57	A,D	Q.58	A	Q.59	C	Q.60	A	Q.61	D	Q.62	A,B,C
Q.63	A	Q.64	B	Q.65	B	Q.66	D	Q.67	C	Q.68	A	Q.69	c
Q.70	B,D	Q.71	C	Q.72	C	Q.73	A	Q.74	A	Q.75	A		