Ranker's Package

A meticulous collection of questions

for

JEE Advanced

Unit wise Questions with Solution

Physics

Topic : Electrostatics, Capacitance, Current Electricity, Magnetic Effect of Current, Electromagnetic Induction.

UNIT 1

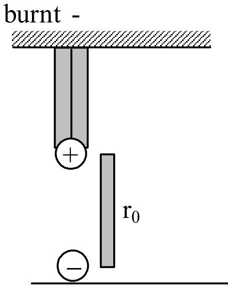
1.SINGLE CORRECT OPTION TYPE QUESTIONS

Q.1 What will be the interaction P.E. of charges q_1 and q_2 if V_1 is the potential at location of charge q_1 due to charge q_2 and V_2 is the potential at the location of charge q_2 due to charge q_1.

(A) $\frac{1}{2}(q_1V_1 + q_2V_2)$ (B) $\frac{1}{2}(q_1V_2 + q_2V_1)$

(C) $2(q_1V_1 + q_2V_2)$ (D) $(q_1V_2 + q_2V_1)$

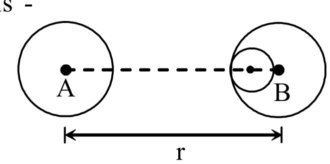
Q.2 A positively charged sphere of mass m = 5 kg is attached by a spring of force constant k $=10^4 Nm^{-1}$. The sphere is tied with a thread so that spring is in its natural length. Another identical, negatively charged sphere is fixed with floor, vertically below the positively charged sphere as shown in fig. If initial separation between spheres is r_0 = 50 cm and magnitude of charge on each sphere is q = 100μC. The maximum elongation of spring when the thread is burnt -



(A) 15 cm (B) 10 cm

(C) 25 cm (D) 22 cm

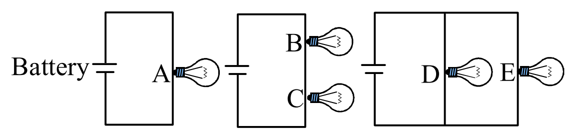
Q.3 Distance between centres of two spheres A and B, each of radius R and their separation r as shown in fig. Sphere B has a spherical cavity of radius R/2 such that distance of centre of cavity is (r –R/2) from the centre of sphere A and R/2 from the centre of sphere B. Dielectric constant of material of each sphere is K = 1 and material of each sphere has a uniform charge density ρ per unit volume. The interaction energy of the two spheres is -



(A) $\frac{\pi\rho^2R^6(r-4R)}{.9\varepsilon_o r(2r-R)}$ (B) $\frac{\pi\rho^2R^6(r+4R)}{9\varepsilon_o r(2r-R)}$

(C) $\frac{\pi\rho^2R^6(7r-4R)}{9\varepsilon_o r(2r-R)}$ (D) $\frac{2\pi\rho^2R^6(r-4R)}{9\varepsilon_o r(2r-R)}$

Q.4 In these three circuits all the batteries are identical and have negligible internal resistance, and all the light bulbs are identical. Rank all 5 light bulbs (A, B, C, D, E) in order of brightness from brightest to dimmest.



(A) A = B = C > D = E

(B) A > B = C > D = E

(C) A = D = E > B = C

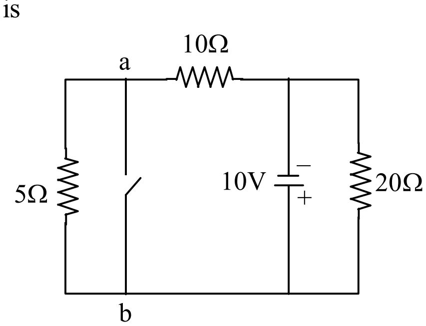
(D) D = E > A > B = C

Q.5 Two identical charged spheres are suspended by strings of equal lengths. The strings make an angle of 30º with each other when suspended in a liquid of density 800 kg m^{-3}, the angle remains the same. What is the dielectric constant of liquid. (The density of material of the spheres is1600 kg m^{-3})

(A) 1 (B) 2

(C) 1.5 (D) 2/3

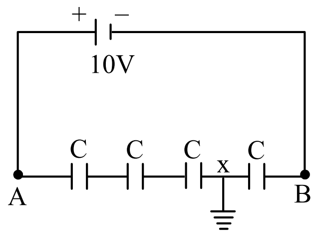
Q.6 In the circuit shown below, the current that flows from a to b when the switch S is closed is



(A) – 1.5 A (B) + 1.5 A

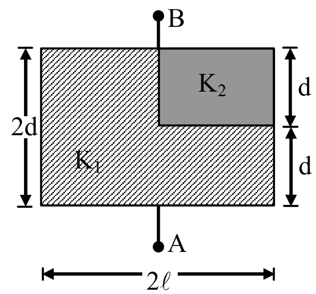
(C) + 1.0 A (D) – 1.0 A

Q.7 Four identical capacitors are connected in series with a battery of emf 10V. The point X is earthed. Then the potential of point A is –



(A) 7.5 V (B) 0V (C) –7.5 V (D) 10 V

Q.8 What is the capacitance of the capacitor of square plates of area A, between A and B shown in fig.



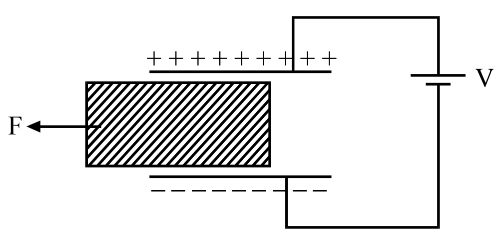
(A) $\dfrac{\varepsilon_0 A}{4d}\ \dfrac{K_1(K_1+2K_2)}{(K_1+K_2)}$

(B) $\dfrac{\varepsilon_0 A}{4d}\ \dfrac{K_1(K_1+3K_2)}{(K_1+K_2)}$

(C) $\dfrac{\varepsilon_0 A}{4d}\ \dfrac{K_1K_2}{K_1+K_2}$

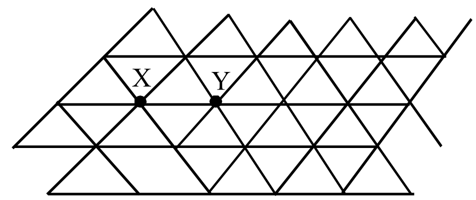
(D) $\dfrac{\varepsilon_0 A}{4d(K_1+3K_2)}$

Q.9 A dielectric slab is slowly inserted between the plates of parallel plate capacitor as shown in Fig. Which of the following statements is true –



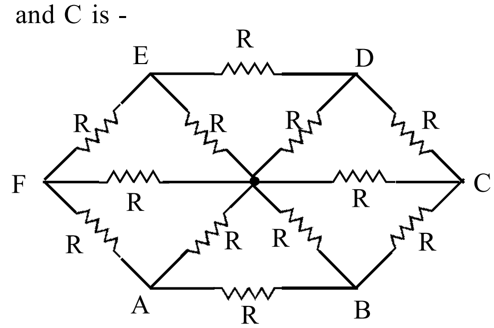
(A) The force required to pull back the slab is independent of ℓ and x
(B) The force required to pull back the slab depends only on ℓ not on x.
(C) The force required to pull back the slab depends only on x not on ℓ.
(D) The force required to pull back the slab depends on ℓ and x both

Q.10 A wire mesh (made of equilateral triangles) of infinite extent in a plane has 1 A of current fed into it at point X and 1 A of current taken from it at point Y, as shown in fig. What is the current in the wire xy-



(A) $\frac{2}{3}$ A (B) $\frac{1}{4}$ A (C) $\frac{1}{6}$ A (D) $\frac{1}{3}$ A

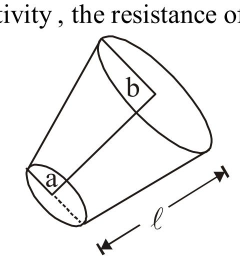
Q.11 Twelve equal resistors are connected as shown in the diagram. The effective resistance between F and C is -



(A) 3R/4 (B) 10 R/3
(C) 10R/9 (D) 4R/3

Q.12 The ratio ot the lengths, densities, masses and resistivity of two wires A and B are 1: 2, 1 : 2 , 1:1, 4 : 1 respectively, The ratio of their resistances are –
(A) 1 : 4 (B) 2 : 1 (C) 1 : 2 (D) 4 : 1

Q.13 A resistance is in the form of a truncated right circular cone as shown in fig. The end radii are a and b and the altitude is ℓ. If the taper is small and the current density is uniform across any section. ρ is the resistivity , the resistance of cone will be–



(A) $\dfrac{\rho\ell}{\pi(b^2-a^2)}$ (B) $\dfrac{\rho\ell}{\pi(b^2+a^2)}$

(C) $\dfrac{\rho\ell}{\pi ab}$ (D) $\dfrac{2\rho\ell}{\pi(b^2-a^2)}$

Q.14 A proton accelerated by a potential difference V flies through a uniform transverse magnetic field with induction B. The field occupies a region of space of thickness d. The angle α through which the proton deviates from the initial direction of its motion is -

(A) $\sin^{-1}\left(Bd\sqrt{\dfrac{q}{2mv}}\right)$

(B) $\sin^{-1}\left(2Bd\sqrt{\dfrac{q}{2mv}}\right)$

(C) $\cos^{-1}\left(Bd\sqrt{\dfrac{q}{2mv}}\right)$

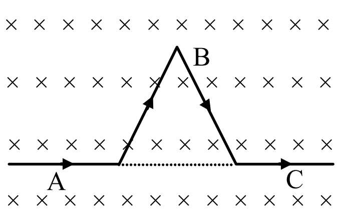
(D) $\cos^{-1}\left(2Bd\sqrt{\dfrac{q}{2mv}}\right)$

Q.15 A rotating rod is pivoted about one end and carries a charge Q uniformly distributed along its length L. If the rod rotates with velocity ω then its magnetic moment is –

(A) $\dfrac{Q\omega L^2}{3}$ (B) $\dfrac{Q\omega L^2}{2}$

(C) $\dfrac{3Q\omega L^2}{2}$ (D) $\dfrac{Q\omega L^2}{6}$

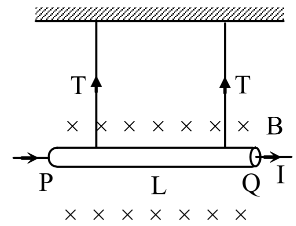
Q.16 A wire ABC is bent such that its two segments are each of length ℓ and inclined at 60º as shown in fig. If the bent wire is placed in a uniform magnetic field B, the net force acting on the wire is -



(A) $B\,I\,\ell$ (B) $\sqrt{3}\,B\,I\,\ell$

(C) $\dfrac{\sqrt{3}}{2}\,B\,I\,\ell$ (D) $\dfrac{BI\ell}{2}$

Q.17 A conducting bar PQ of length L carrying a current I is suspended from a rigid support as shown in fig. A uniform magnetic field B perpendicular to PQ and directed away from the reader is applied. If the mass of the bar is M; the tension in each string is -



(A) (Mg + IBL)/2 (B) (Mg – IBL)/2

(C) Mg – IBL/2 (D) Mg/2

Q.18 A plane spiral coil is made on a thin insulated wire and has N turns. Radii of inside and outside turns are a and b respectively. A magnetic field normal to plane of sprial exists in the space . The magnetic field increase at a constant rate 'α'. Potential difference between the ends of the spiral will be –

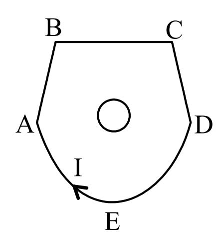
(A) $\dfrac{1}{4}\pi\ N\alpha\ (b^3 - a^3)$

(B) $\dfrac{1}{3}\pi N\alpha\ (b^3 - a^3)$

(C) $\dfrac{1}{4}(\pi N\alpha)\ (a^2 + b^2 + ab)$

(D) $\dfrac{1}{3}\pi N\alpha\ (a^2 + b^2 + ab)$

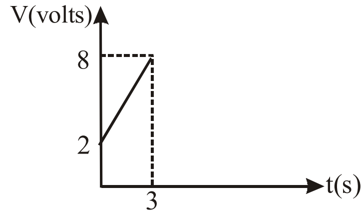
Q.19 In closed circuit shown in Fig. AB, BC, and CD are straight conductors, each of length R and DEA is a semi circle of radius R. A smaller circular loop of radius r is coplanar with the circuit and centre of loop coincides with centre of curvature of the semicircle. If current through the circuit increases at a constant rate $\dfrac{dF}{dt} = \alpha$, the emf induced in the loop is -



(A) $\dfrac{\mu_o(\pi+\sqrt{3})\alpha r^2}{2R}$ (B) $\dfrac{\mu_o(\pi+2\sqrt{3})r^2\alpha}{4R}$

(C) $\dfrac{\mu_o(\pi+\sqrt{3})r^2\alpha}{4R}$ (D) $\dfrac{\sqrt{3}\mu_o r^2\alpha}{4R}$

Q.26 A circuit element is placed in a closed box. At time t = 0, a constant current generator supplying a current of 1 amp. is connected across the box. Potential difference across the box varies according to graph shown in figure. The element in the box is.



(A) resistance of 2Ω.
(B) a battery of emf 6V.
(C) an inductance of 2H.
(D) a capacitance of 0.5F.

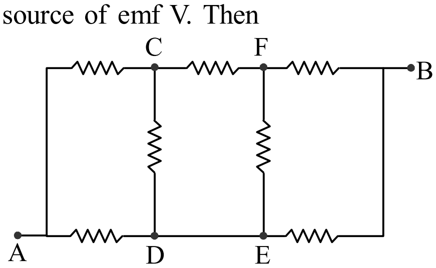
Q.27 A solid non conducting hemisphere of radius R has a uniformly distributed positive charge of density ρ per unit volume. A negatively charged particle having charge q is transferred from centre of its base to infinity. Work performed in the process is -

(A) $\frac{-q\rho R^2}{2\pi\varepsilon_0}$ (B) $\frac{q\rho R^2}{4\pi\varepsilon_0}$ (C) $\frac{-q\rho R^2}{2\varepsilon_0}$ (D) $\frac{q\rho R^2}{4\varepsilon_0}$

Q.28 The amount of heat liberated when a capacitor of C farads charged to a potential difference of V volts is discharged through a resistor of R ohms in H joules. The same capacitor is now charged to a potential difference of 2V and discharged through a resistor of 2R ohms, then heat liberated is –
(A) 4 H (B) 2H (C) H (D) H/2

2. MULTIPLE CORRECT TYPE QUESTIONS

Q.29 The network of identical resistors as shown between points A and B is connected to a DC source of emf V. Then

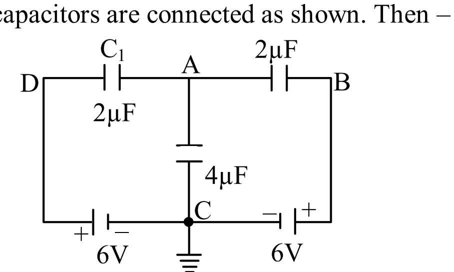


(A) Potential at point D is V/2
(B) current between points A and C is the same as the between points F and B
(C) current between points C and D is half that between points C and F
(D) current between points E and F is one third that between points F and B

Q.30 Which of the following statements is/are false -
(A) A charged particle is free to move in an electric field. It always move along the electric lines of force.
(B) Two identical spheres (metallic) of exactly equal masses are taken. One is given a positive charge q coulomb and the other an equal negative charge. Their masses after charging being equal.
(C) A ring of radius R carries a uniformly distributed charges +Q. A point charge –q is places on the axis of the ring at a distance 2R from the centre of the ring and released from rest, the particle executes SHM along the axis of the ring.
(D) If electric potential is zero at a point , the electric field at that point must be zero.

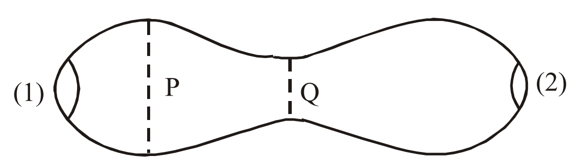
Q.31 Two parallel plate air capacitors are constructed, one by a pair of iron plates and the second by a pair of copper plates, on same area and same spacing then -
(A) The copper plate capacitor has a greater capacitance than the iron core.
(B) Both capacitors have equal non-zero capacitances, in the uncharged state.
(C) Both capacitors will have equal capacitance only if they are charged equally
(D) The capacitances of the two capacitors are equal even if they are unequally charged.

Q.32 Three capacitors are connected as shown. Then –



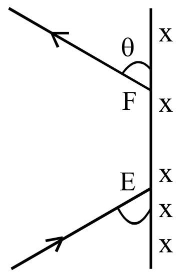
(A) Charge on capacitor C_1 is 6 μC
(B) Potential of point A is 3V
(C) Potential of point B is 6 V
(D) Charge on capacitor C_1 is 3 μc

Q.33 A metallic conductor of irregular cross-section is as shown in the figure. A constant potential difference is applied across the ends (1) and (2) then -



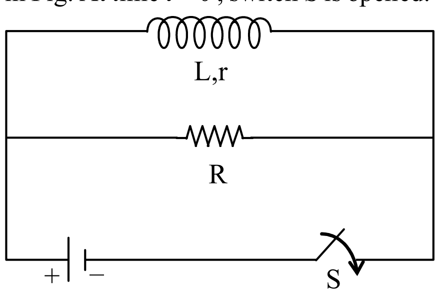
(A) The current at the cross section P equals the current at the cross section Q.
(B) The electric field intensity at P is less than that at Q.
(C) The rate of heat generated per unit time at Q is greater than that at P.
(D) The number of electrons crossing per unit area of cross section at P is less than that at Q.

Q.34 A particle of mass $m = 1.6 \times 10^{-27}$ kg and charge $q = 1.6 \times 10^{-19}$C. enters into a region of uniform magnetic field of strength 1.0 T along the direction shown in Fig. The speed of the particle is 10^7m. The particle leaves the region of the field at the point F then distance EF and angle θ is -



(A) EF = 10.0 cm
(B) EF = 14.1 cm
(C) $\theta = 45°$
(D) $\theta = 60°$

Q.35 A solenoid of inductance L and resistance r is connected in parallel to resistance R. A battery of emf E and of negligible internal resistance is connected across its parallel combination as shown in Fig. At time t = 0 , switch S is opened.



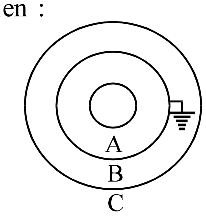
(A) Current I (t) through the solenoid after the switch is opened = $\frac{E}{R}\, e^{-\left(\frac{R+r}{L}\right)t}$

(B) Energy stored in the solenoid initially was $\frac{E^2L}{2r^2}$

(C) Energy stored in the solenoid initially was $\frac{E^2L}{2Rr}$.

(D) Current I(t) through the solenoid after the switch is opened = $\frac{E}{r}\, e^{-\left(\frac{R+r}{L}\right)t}$

Q.36 Figure shows three concentric thin spherical shells A,B and C of radii R, 2R, and 3R. Shells A and C are given charges q and 2q and shell B is earthed. Then :



(A) Charge on inner surface of shell C is $\frac{4}{3}q$

(B) Charge on outer surface of shell B is $-\frac{4}{3}q$

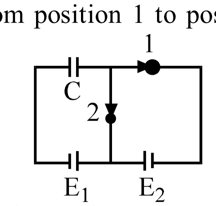
(C) Charge on outer surface of shell C is $\frac{2}{3}q$

(D) Charge on outer surface of shell C is $\frac{4}{3}q$

Q.37 Charges Q_1 and Q_2 lie inside and outside respectively of a closed surface S. Let E be the field at any point on S and ϕ be the flux of E over S :
(A) If Q_1 changes, both E and ϕ will change.
(B) If Q_2 changes E will change but ϕ will change.
(C) If $Q_1 = 0$ and $Q_2 \neq 0$ then $E \neq 0$ but $\phi \neq 0$.
(D) If $Q_1 \neq 0$ and $Q_2 = 0$ then $E = 0$ but $\phi \neq 0$

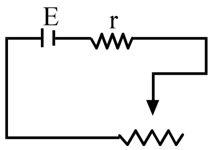
Q.38 An uncharged capacitor having capacitance C is connected across a battery of emf V. Now the capacitor is disconnected and then reconnected across the same battery but with reversed polarity. Then –
(A) After reconnection, heat energy produced in the circuit will be equal to two–third of the total energy supplied by battery.
(B) After reconnection, no energy is supplied by battery
(C) After reconnection, whole of the energy supplied by the battery is converted into heat.
(D) After reconnection, thermal energy produced in the circuit will be equal to $2CV^2$.

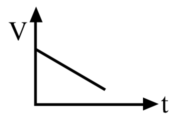
Q.39 In the circuit diagram shown, when switch is shifted from position 1 to position 2, then :

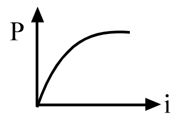


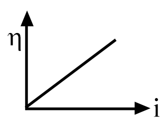
(A) Extra charge drawn from battery is E_2C.
(B) Extra charge drawn from battery is E_1E_2C.
(C) Heat generated in the circuit is $\frac{1}{2}E_2^2C$.
(D) Heat generated in the circuit is $\frac{1}{2}E_1E_2C$.

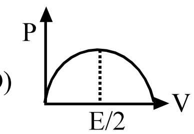
Q.40 Battery shown of emf E has internal resistance r and a variable resistor. At an instant current flowing through the circuit is i, potential difference between the terminals cells is V, thermal power developed in external circuit is P and thermal power developed in the cell is equal to fraction η of total electrical power generated in it, then which of the following graphs is/are correct ?



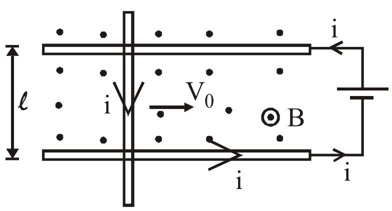
(A)


(B)


(C)


(D)


Q.41 A current i flows through a metal rod of length l and mass m that slides on a frictionless rails as shown. If initial speed of the rod is v_o and a magnetic field B acts vertically up, then-



(A) speed of the rod at time t is $v_0 + \dfrac{Bi\ell}{m}t$

(B) speed of the rod at time t is $v_0 - \dfrac{Bi\ell}{m}t$

(C) distance moved by rod before it stops is $\dfrac{mv_0^2}{2Bi\ell}$

(D) distance moved by rod before it stops is $\dfrac{3mv_0^2}{2Bi\ell}$.

Q.42 A uniform magnetic field B exists in space directed along positive y-axis. A particle of mass m and charge q is projected towards negative x-axis with speed v from a point (x, 0, 0). The maximum value of v for which the particle does not hit the Y-Z plane is :

(A) directly proportional to the mass m of the particle.

(B) directly proportional to the magnetic field.

(C) directly proportional to the charge of particle

(D) directly proportional to the distance x of the particle from origin.

Q.43 Two different coils have inductances L_1 = 8 mH and L_2 = 2mH. At a certain instant the current in the two coils is increasing at the same constant rate and power supplied to the two coils is same. Then :

(A) $\dfrac{e_1}{e_2} = 4$ (B) $\dfrac{i_1}{i_2} = \dfrac{1}{4}$

(C) $\dfrac{U_1}{U_2} = \dfrac{1}{4}$ (D) $\dfrac{U_1}{U_2} = 4$

Q.44 Two concentric spherical shells of radii R_1 and R_2 carrying charges Q_1 and Q_2 respectively then $(R_2 > R_1)$ –

(A) $V = \dfrac{1}{4\pi\varepsilon_o}\left(\dfrac{Q_1+Q_2}{r}\right)$,

$E = \dfrac{1}{4\pi\varepsilon_o}\dfrac{Q_2}{r^2}$ when $r > R_2$

(B) $V = \dfrac{1}{4\pi\varepsilon_o}\left(\dfrac{Q_2}{R_2}+\dfrac{Q_1}{r}\right)$,

$E = \dfrac{1}{4\pi\varepsilon_o}\dfrac{Q_1}{r^2}$ $R_1 < r < R_2$

(C) $V = \dfrac{1}{4\pi\varepsilon_o}\left(\dfrac{Q_2}{R_2}+\dfrac{Q_1}{R_1}\right)$,

$E = 0$, $r < R_1 < R_2$

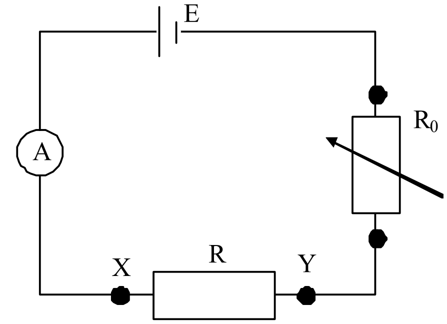
(D) $V = \dfrac{1}{4\pi\varepsilon_o}\left(\dfrac{Q_2}{R_1}+\dfrac{Q_1}{R_2}\right)$,

$E = \dfrac{1}{4\pi\varepsilon_o}\left(\dfrac{Q_1}{R_1^2}+\dfrac{Q_2}{R_2^2}\right)$ $r < R_1 < R_2$

3. PASAGE BASED QUESTIONS

Passage : (Questions 45 & 46)

The circuit in figure 1 contains a cell of emf E, a known variable resistance R_0, an unknown resistance R and an ammeter. When X and Y are short circuited $E = I_0R_0$. When R is inserted the current is αI_0, where α is a constant.



(Figure 1)

Q.45 R in terms of R_0 & α is equal to :

(A) $\frac{R_0\alpha}{(1-\alpha)}$ (B) $\frac{R_0\alpha}{(1+\alpha)}$

(C) $\frac{R_0(1+\alpha)}{\alpha}$ (D) $\frac{R_0(1-\alpha)}{\alpha}$

Q.46 For R in the range, ∞ ? R ? 0, the range of α is given by :

(A) $0 \le \alpha \le 1$ (B) $0 \le \alpha \le \infty$

(C) $0 \le \alpha \le 2$ (D) $\alpha > 1$

Passage : (Questions 47 & 48)

Figure 1 shows a unit used to build a system known as ladder network.

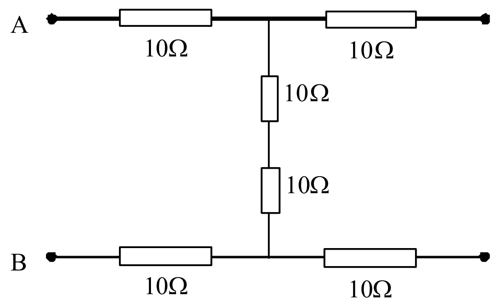


Figure 1

A second unit is added on the left as shown in figure 2.

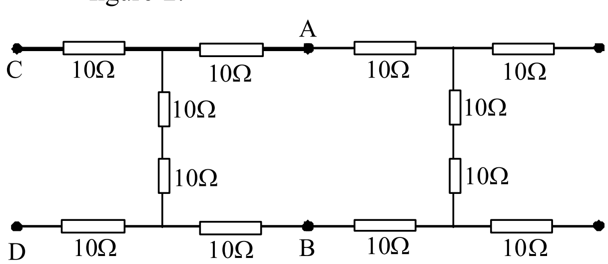


Figure 2

It would be possible to add a very large number of such units to form a ladder network of resistance r, as shown in figure 3. By this stage, adding one extra unit would make no significant difference to the resistance between Y & Z.

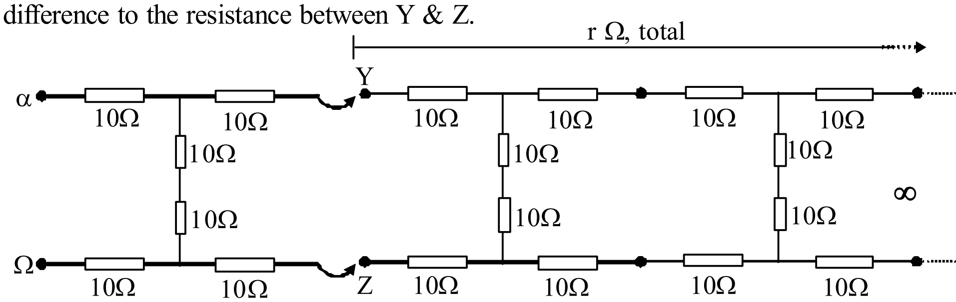


Figure 3

Q.47 The resistance between α & Ω when one extra ladder unit is added to the left of Y, Z as suggested by small arrows in figure, is :

(A) $\frac{20r+1200}{r-20}$ (B) $\frac{20r+1200}{r+20}$

(C) $\frac{40r+1200}{r+40}$ (D) $\frac{40r+40}{r+40}$

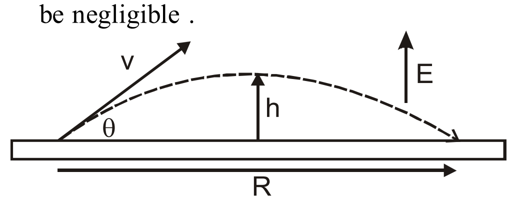
Q.48 Use result of previous question to find the equivalent resistance R of an infinite ladder made of these units.

(A) $R = 20\sqrt{3}\ \Omega$ (B) $R = 10\sqrt{3}\ \Omega$

(C) $R = 20\sqrt{2}\ \Omega$ (D) $R = 10\sqrt{2}\ \Omega$

Passage : (Questions 49 to 54)

A very large, charged plate floats in deep space. Due to the charge on the plate, a constant electric field E exists everywhere above the plate. An object with mass m and charge q is shot upward from the plate with a velocity v and at an angle θ. It follows the path shown reaching a height h and a range R. Assume the effects of gravity to be negligible .



Q.49 Which of the following must be true concerning the object –

(A) q must be positive

(B) q must be negative

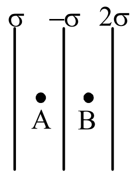
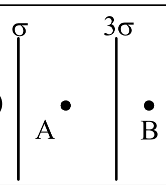
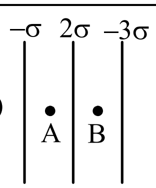
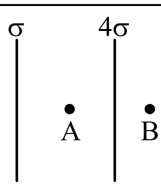
(C) m must be large

(D) m must be small

4. COLUMN MATCHING QUESTIONS

Answer Q.108, Q.109 and Q.110 by appropriately matching the information given in the three columns of the following table.

For infinite conducting plate having surface change density σ c/m^2, the electric field at any point at distance r is given by $\frac{\sigma}{\epsilon_0}$ and it is independent of distance from infinite conducting plate. Now consider the plate configurations given in column 1.

Column-1	Column-2 Magnitude of electric field at point 'A'	Column-3 Magnitude of electric field at point 'B'
(I) 	(i) 0	(P) $\frac{2\sigma}{\epsilon_0}$
(II) 	(ii) $\frac{2\sigma}{\epsilon_0}$	(Q) $\frac{3\sigma}{\epsilon_0}$
(III) 	(iii) $\frac{3\sigma}{\epsilon_0}$	(R) $\frac{4\sigma}{\epsilon_0}$
(IV) 	(iv) $\frac{4\sigma}{\epsilon_0}$	(S) $\frac{5\sigma}{\epsilon_0}$

Q.108 Which of the following combination is correctly matched :

(A) (I) (i) (P)
(B) (I) (ii) (P)
(C) (II) (i) (R)
(D) (III) (i) (P)

Q.109 Which of the following combination is correctly matched :

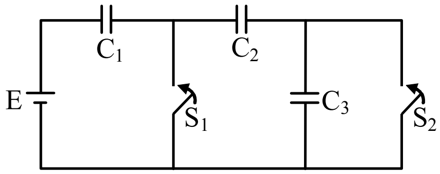
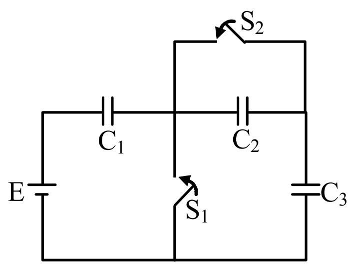
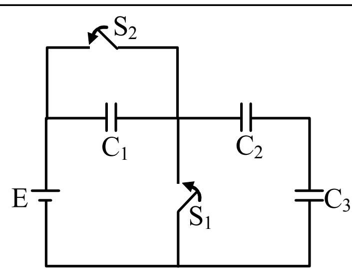
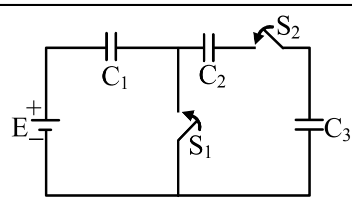
(A) (I) (i) (Q)
(B) (III) (i) (S)
(C) (III) (iii) (Q)
(D) (II) (ii) (R)

Q.110 Which of the following combination is correctly matched :

(A) (IV) (iv) (S)
(B) (III) (i) (Q)
(C) (III) (iii) (P)
(D) (IV) (iii) (S)

Answer Q.111, Q.112 and Q.113 by appropriately matching the information given in the three columns of the following table.

Consider the following four circuits given in column 1. Capacitance of C_1, C_2 & C_3 are 1μF, 2μF and 3μF. The e.mf. of battery 10 V.

Column-1 **Circuit**	**Column-2** **Condition of S_1 & S_2**	**Column-3** **Total energy of all capacitors**
(I) 	(i) S_1 closed S_2 open	(P) 37.5 μJ
(II) 	(ii) S_1 closed S_2 closed	(Q) 50 μJ
(III) 	(iii) S_1 open S_2 open	(R) 27.27 μJ
(IV) 	(iv) S_1 open S_2 closed	(S) 33.34 μJ

Q.111 Which of the following combination is correct :

(A) (II) (i) (P)

(B) (II) (ii) (Q)

(C) (I) (ii) (P)

(D) (I) (i) (P)

Q.112 Which of the following combination is correct :

(A) (I) (i) (P)

(B) (II) (iv) (Q)

(C) (II) (iv) (P)

(D) (IV) (iv) (P)

Q.113 Which of the following combination is correct :

(A) (III) (iv) (P)

(B) (IV) (ii) (R)

(C) (IV) (iv) (R)

(D) (III) (iv) (Q)

Q.114 The following table gives the length of four copper rods at same temerature, their diameters and the potential differences between their ends.

Rod	Length	Diameter	Potential difference
1	L	3d	V
2	2L	d	3V
3	3L	2d	2V
4	3L	d	V

Match Column–I with Column–II

	Column-I	Column-II
(I)	Greatest Drift speed of electron	(P) Rod 1
(II)	Greatest Current	(Q) Rod 2
(III)	Greatest rate of thermal energy produced	(R) Rod 3
(IV)	Greatest Electric field	(S) Rod 4

Code :

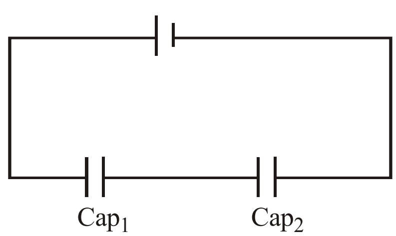
(A) I $\rightarrow$ P; II $\rightarrow$ P; III $\rightarrow$ P; IV $\rightarrow$ Q

(B) I $\rightarrow$ Q; II $\rightarrow$ Q; III $\rightarrow$ P; IV $\rightarrow$ Q

(C) I $\rightarrow$ Q; II $\rightarrow$ P; III $\rightarrow$ Q; IV $\rightarrow$ P

(D) I $\rightarrow$ Q; II $\rightarrow$ P; III $\rightarrow$ P; IV $\rightarrow$ Q

Q.115 Two identical capacitors are connected in series, then combination is connected to battery some changes in capacitor 1 are now made independentely after state, listed in column I. Same effects which may occur in new steady state due to these changes on capacitor 2 are listed in column II.



Match Column–I with Column–II

	Column-I		Column-II
(I)	A dielectric slab is inserted	(P)	Charge on capacitor increases
(II)	Sepration between the plates increased	(Q)	Charge on capacitor decreases
(III)	A metal plate is inserted connecting both plotes	(R)	Energy stored in capacitor increases
(IV)	The left plates is grounded	(S)	No change is occurred

Code :

(A) I $\rightarrow$ P,Q; II $\rightarrow$ Q; III $\rightarrow$ P; IV $\rightarrow$ S

(B) I $\rightarrow$ P; II $\rightarrow$ Q,R; III $\rightarrow$ Q; IV $\rightarrow$ Q

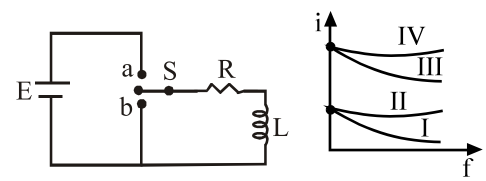
(C) I $\rightarrow$ P,R; II $\rightarrow$ Q; III $\rightarrow$ Q; IV $\rightarrow$ S

(D) I $\rightarrow$ R; II $\rightarrow$ Q; III $\rightarrow$ P; IV $\rightarrow$ Q

Q.116

	Column-I		Column-II
(A)	Dielectric ring uniformly charged.	(P)	Time independent electrostatic field.
(B)	Dielectric ring uniformly charged rotating with constant angular velcoity ω	(Q)	Magnetic field
(C)	Conducting ring with constant current I_0.	(R)	Induced electric field
(D)	Conducting ring with variable current I_0 sinwt.	(S)	Magnetic moment

Q.117



The switch S is connected with point ‘a’ for a very long time, then it is shifted to position ‘b’ the resulting current through inductor is shown by curves in the graph for four sets of values for the resistance R & inductance L (given at left column)

Match Column–I with Column–II

Column I	Column II
(A) R_0 & L	(P) I
(B) $2R_0$ and L_0	(Q) II
(C) R_0 and $2L_0$	(R) III
(D) $2R_0$ and $2L_0$	(S) IV

Q.118 Match Column–I with Column–II

Column I	Column II
(A) A current carrying coil placed in a magnetic field experiences torque. For given values of N (number of turns). i (current), A (area), ω (angular speed) and the torque will be maximum when the magnetic field is	(P) Perpendicular to the plane of coil

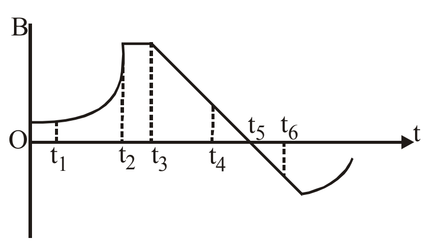
(B) As a coil is rotate in a magnetic field, emf is induced across the coil For given values of N (Number of turns). A (area). ω (angular speed) and B (magnetic flux density), induced emf will be maximum when the magnetic field is. (Q) Along the plane of coil.

(C) As a coil rotates in a uniform magnetic field, magnetic flux through it will be maximum when the magnetic field is. (R) Inclined at 45º to the plane of coil.

(D) Force on a current carrying coil placed in a uniform magnetic field will be zero when the magnetic field is. (S) Inclined 60º to the plane of the coil.

Q.119 A loop is kept in a magnetic field. It is fixed such that field lines pass perpendicular to its area. At any instant, magnetic flux density over the entire area has the same value but it varies with time as shown in the figure

Match Column - I with Column - II.

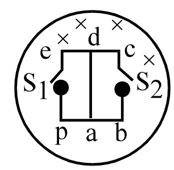


Column I	Column II
(A) Magnetic flux and induced current both are maximum	(P) at t_4
(B) Induced current is maximum	(Q) at t_2
(C) Induced current is non-zero	(R) at t_3
(D) Induced current is constant	(S) at t_5

Q.120 In regard to discharging of a capacitor through a resistance match Column–I with Column–II :

Column I	Column II
(A) Exponential variation	(P) Current
(B) Oscillatory variation	(Q) Charge
(C) Time in which the quantity becomes half of its initial value is mininmum.	(R) Electric energy stored in capacitor
(D) Time in which the quantity becomes zero is the same for.	(S) Electric field strength between the plates.

Q.121 The magnetic field in the cylindrical region in fig. increases at a constant rate of 10.0 mT/sec each side of the square loop abcd and defa has a length 2.00cm and resistance of 2.00Ω. Correctly match the current in the wire 'ad' in four different situations as listed in left column with value given.



Match Column–I with Column–II

Column I	Column II
(A) The switch S_1 is closed and S_2 is open	(P) 5×10^{-7}A, d to A
(B) S_1 is open but S_2 is closed	(Q) 5×10^{-7}A, a to d
(C) Both S_1 & S_2 are open	(R) 2.5×10^{-8}A, d to a
(D) Both S_1 & S_2 are closed	(S) No current

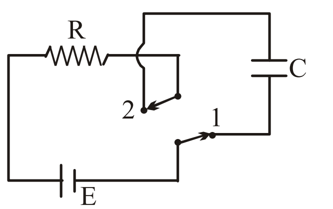
5. NUMERICAL RESPONSE TYPE QUESTIONS

Q.122 An alpha particle is moving in the field of an infinitely charged straight conductor towards it from A to B. The velocities of the alpha particles at A and B are 3×10^6 m/s and 2×10^5 m/s. The distances of A and B are 4 cm and 1 cm respectively from the conductor. The linear density of charge on the conductor is found to be $\beta \times 10^{-n}$ C/m where $1 < \beta < 10$. Mass of an alpha particle = 6.65×10^{-27} kg; Charge of an alpha particle = $+ 2\times1.6 \times 10^{-19}$ C. Find the integer n?

Q.123 A dielectric sphere has a uniform volume distribution of charge. The electric field intensities due to the charge at distances 60 cm and 6 cm from the centre of the sphere are respectively 2500 $\frac{V}{m}$ and 2000 $\frac{V}{m}$. The electric field intensity on the surface of the sphere is found to be 10^n V/m. Find the integer n ?

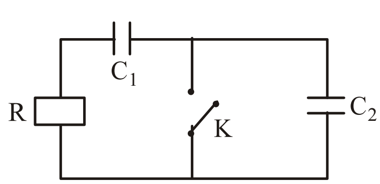
Q.124 The spherical region a < r carries a charge per unit volume of $\rho = \frac{A}{r}$, where A is a constant. At the centre (r = 0) of the enclosed cavity is a point charge Q = 125π. The value of A so that the electric field in the region a < r has constant magnitude (given a = ½) is given by 50n. Find the integer n ?

Q.125 A capacitor C, a resistor R and a battery of e.m.f E are connected in series with a commutator as shown in the diagram.

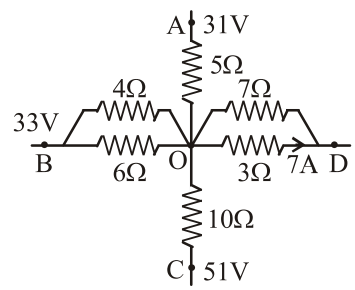


The energy dissipated (In μ sec.) when the connections in the commutator are interchanged from 1 and 2 to 2 and 1, making the positive plate of C negative is found to be 10n μJ. Find the integer n? (Given E = 12 v., C = 15μF)

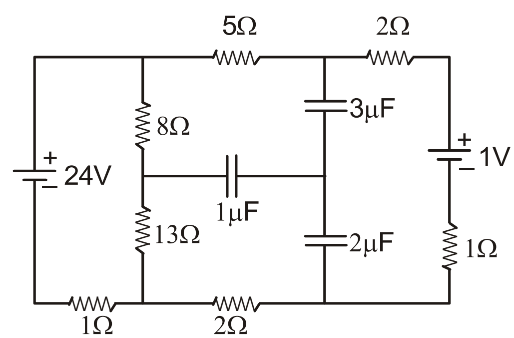
Q.126 A capacitor of capacitance C_1 is discharged through a resistance R_2. When the discharge current attains the value I_o the key K is opened. The amount of heat Q liberated in the resistor starting from this moment is found to be 5n J. Find the integer n ? (C_1 = 2F, C_2 = 3F, I_0 = 10 A, R = 1Ω)



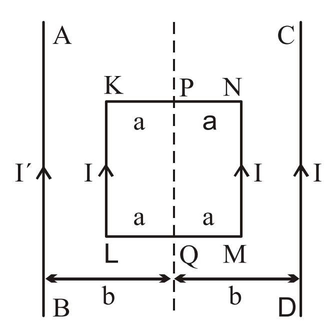
Q.127 The four terminal network is part of a larger circuit. The potentials of the points A, B, C are respectively 31 V, 33 V and 51 V. The current through the 3 ohm resistor is 7A. The potential of the point D is found to be 7n volt. Find the integer n ?



Q.128 The circuit, shown in Fig is in steady state. Total electrostatic potential energy stored in the three capacitors is 11n μJ. Find the integer n?



Q.129 A square frame carrying a current I = 0.9 A is located in the same plane as a long straight wire AB carrying a currentI' = 5A. The frame side has length 2a = 8 cm. The axis of the frame PQ passing through midpoints of opposite sides is parallel to AB and its distance from AB is b = 3a. The force which is acting on the frame in $\beta \times 10^{-n}$ N, where 1 < β < 10. Find the integer n ?



ANSWER KEY

1. SINGLE CORRECT OPTION TYPE QUESTIONS

1. (B)	**2.** (B)	**3.** (C)	**4.** (C)
5. (B)	**6.** (D)	**7.** (A)	**8.** (B)
9. (A)	**10.**(D)	**11.**(B)	**12.**(C)
13. (C)	**14.**(A)	**15.**(D)	**16.**(A)
17. (B)	**18.**(D)	**19.**(B)	**20.**(C)
21.(B)	**22.**(A)	**23.**(C)	**24.**(B)
25.(A)	**26.**(D)	**27.** (D)	**28.** (A)

2. MULTIPLE CORRECT TYPE QUESTIONS

29. (A),(B), (C), (D)	**30.** (A), (B), (C), (D)
31. (B), (D)	**32.** (A),(B),(C)
33. (A), (B), (C), (D)	**34.** (B), (C)
35. (B),(D)	**36.** (A),(B),(C)
37. (A), (B), (C)	**38.** (A), (C), (D)
39. (A), (B), (C)	**40.** (A), (B), (C), (D)
41.(B),(C)	**42.**(B), (C), (D)
43. (A),(B), (C)	**44.** (B),(C)

3. PASSAGE BASED QUESTIONS

45. (D)	**46.** (A)	**47.** (C)
48. (A)	**49.** (B)	**50.** (D)
51. (D)	**52.** (D)	**53.** (D)
54. (C)	**55.** (C)	**56.** (A)
57. (A)	**58.** (D)	**59.** (D)
60. (A)	**61.** (B)	**62.** (B)
63. (D)	**64.** (C)	**65.** (B)
66. (C)	**67.** (B)	**68.** (D)
69. (B)	**70.** (B)	**71.** (B)
72. (D)	**73.** (D)	**74.** (B)
75.(A)	**76.** (A)	**77.** (D)
78.(B)	**79.** (A),(B)	**80.** (B)
81.(A)	**82.** (D)	**83.** (C)
84. (A)	**85.** (A)	**86.** (B)
87. (C)	**88.** (C)	**89.** (B)
90. (C)	**91.** (B)	**92.** (A)
93. (A)	**94.** (B)	**95.** (A)
96. (B)	**97.** (A)	**98.** (B)
99. (D)	**100.** (D)	**101.** (B)
102. (B)	**103.** (B)	**104.** (A)
105. (C)	**106.** (B)	**107.** (D)

4. COLUMN MATCHING QUESTIONS

108. (A)	**109.** (D)	**110.** (D)
111. (B)	**112.** (C)	**113.** (C)
114. (D)	**115.** (C)	

116. $A \to P$ $B \to Q,R$ $C \to Q,R$ $D \to Q,R,S$

117. $A \to R$ $B \to Q$ $C \to S$ $D \to P$

118. $A \to Q$ $B \to Q$ $C \to PD \to P,Q,R,S$

119. $A \to$ Does not match $B \to Q$
$C \to P,Q,S$ $D \to P,S$

120. $A \to P,Q,R,S$ $B \to$ Does not Match
$C \to R$ $D \to P,Q,R,S$

121. $A \to Q$ $B \to P$ $C \to S$ $D \to S$

5. NUMERICAL RESPONSE TYPE QUESTIONS

122. [6]	**123.** [4]	**124.** [5]	**125.** [6]
126. [6]	**127.** [3]	**128.** [3]	**129.** [7]
130. [5]	**131.** [4]		

UNIT 1

Hints & Solutions

Topic : Electrostatics, Capacitance, Current Electricity, Magnetic Effect of Current, Electromagnetic Induction.

1.SINGLE CORRECT OPTION TYPE SOLUTIONS

Sol.1[B] $V_1 = \dfrac{q_1}{4\pi\varepsilon_o r}$, $V_2 = \dfrac{q_2}{4\pi\varepsilon_o r}$ and

$$U = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r}$$

$U_1 = q_2V_1$ and $U_2 = q_1 V_2$

$$U = \frac{1}{2}(U_1 + U_2) = \frac{1}{2}(q_1 V_2 + q_2 V_1)$$

Sol.2[B] When thread is burnt, positively charged sphere accelerated downward due to two forces-

(i) Weight mg of upper sphere

(ii) Force of attraction exerted by lower sphere.

During this process spring elongates and tension in it increases. Upper sphere continues to accelerate till tension becomes equal to sum of weight and electric force. At this instant velocity of upper sphere is maximum. Therefore instant of maximum elongation of spring does not correspond to equilibrium of forces but is corresponds to instantaneous rest of sphere .

Let maximum elongation be x . According to law of conservation of energy.

Loss of Electric and gravitational P.E. = energy stored in spring.

$$\therefore \frac{1}{4\pi\varepsilon_o}\left[\frac{-q^2}{r_o} - \frac{(-q^2)}{(r_o - x)}\right] + mgx = \frac{1}{2}kx^2$$

or = x = 0.10 m or 10 cm

Sol.3[C] Interaction energy between two sphere having uniformly distributed charges q_1 and q_2 is given by

$U = \dfrac{1}{4\pi\varepsilon_o}\dfrac{q_1 q_2}{r}$ The right sphere has a cavity.

This sphere can be assumed to be result of superposition of two solid spheres one of radius R having a positive charge density ρ and other of radius R/2 having a charge density (-ρ).

(i) Interaction energy U_1 of left sphere and a solid sphere of radius R and having charge density ρ. Separation between centre of these spheres is r.

$$\therefore U_1 = \frac{1}{4\pi\varepsilon_o}\frac{\left[\frac{4}{3}\pi R^3\rho\right]\left[\frac{4}{3}\pi R^3\rho\right]}{r} = \frac{4\pi\rho^2R^6}{9\varepsilon_0 r}$$

(ii) U_2 = Interaction energy between left sphere and solid sphere of radius R/2

$$U_2 = \frac{1}{4\pi\varepsilon_o} \text{ x } \frac{\left(\frac{4}{3}\pi R^3\rho\right)\left(\frac{4}{3}\pi\left(\frac{R}{2}\right)^3(-\rho)\right)}{(r - R/2)}$$

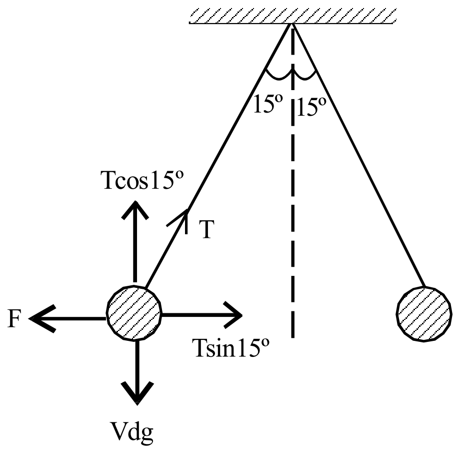
$$= \frac{-\pi\rho^2R^6}{9\varepsilon_o(2r - R)}$$

∴ required interaction energy

$$U = U_1 + U_2 = \frac{\pi\rho^2R^6(7r - 4R)}{9\varepsilon_0 r(2r - R)}$$

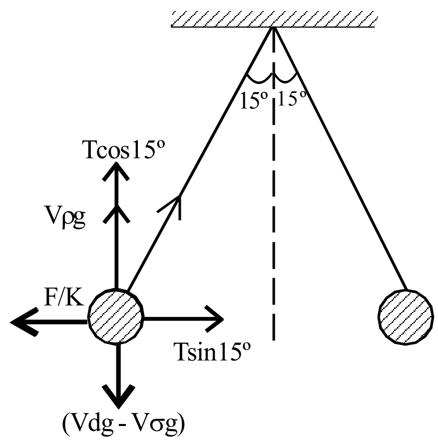
Sol.4[C] A, D & E get potential difference equal to emf B & C get less than emf.

Sol.5[B] When charged spheres are immersed in liquid the downward force decreases from Vdg to (Vdg - Vσg) where d is the density of sphere and σ is the density of liquid . Since on immersing the balls in the liquid, the angle which the string makes with the vertical does not change, it is clear that all the three forces acting on the ball viz. downward force due to gravity, electrical force due to repulsion and tension should decrease in the same ratio Hence.



$F = T \sin 15^\circ$

$Vdg = T \cos 15^\circ$, $\dfrac{F}{Vdg} = \tan 15^\circ$



$T \cos 15^\circ + V\rho g = Vdg$

$T \sin 15^\circ = \dfrac{F}{k}$

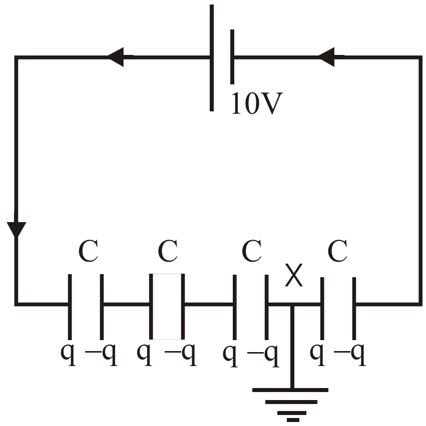
$\tan 15^\circ = \dfrac{F}{k(Vdg - V\rho g)}$

$\therefore \dfrac{F}{Vdg} = \dfrac{F}{k(Vdg - V\rho g)}$

$$k = \frac{d}{d-\rho} = 2$$

Sol.6[D] As 5 Ω resistor is shorted, 1A current flows from b to a.

Sol.7[A]

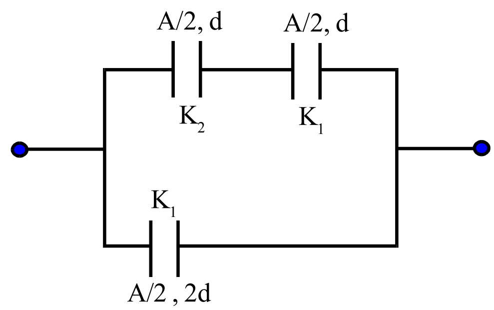


All the four capacitor are in series. point X has zero volt.
Potential across each capacitor is

$$\frac{10}{4} = 2.5 \text{ Volt}$$

$\therefore$ Potential of A = 2.5 + 2.5 + 2.5 = 7.5 Volt

Sol.8[B] Given arrangement is equivalent to



$$C_{eff} = \frac{1}{\dfrac{d}{k_2\varepsilon_0 A/2} + \dfrac{d}{k_1\varepsilon_0 A/2}} + \frac{K_1\varepsilon_0(A/2)}{2d}$$

$$C_{eff} = \frac{\varepsilon_0 A}{4d}\left(k_1 + \frac{2K_1K_2}{K_1+K_2}\right)$$

$$C_{eff} = \frac{K_1\varepsilon_0 A}{4d}\left(\frac{K_1+3K_2}{K_1+K_2}\right)$$

Sol.9[A] The total capacity of the system

$$C = C_1 + C_2 = \frac{K\varepsilon_0 bx}{d} + \frac{K\varepsilon_0 b(\ell - x)}{d}$$

$$C = \frac{\varepsilon_0 b}{d}[\ell + (K-1)x]$$

energy stored

$$U = \frac{1}{2}CV^2 = \frac{1}{2}\frac{\varepsilon_0 b}{d}[\ell + (K-1)x]V^2$$

Now if the slab moves through the distance dx
$dU = -Fdx + Vdq = -Fdx + V^2dC$

$$\Rightarrow \frac{1}{2}\ \frac{\varepsilon_0 b}{d}\,[K-1]\ V^2dx$$

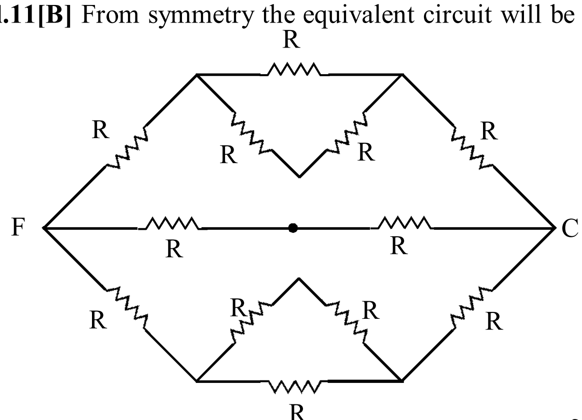
$$= -Fdx + V^2\ \frac{\varepsilon_0 b}{d}\,(K-1)\ dx$$

$$\Rightarrow F = \frac{1}{2}\ \frac{\varepsilon_0 b}{d}\,[K-1]\ V^2$$

Which is independent of ℓ and x.

Sol.10[D] Break the problem into two parts. Consider a mesh with 1A going in at X and 1A coming out at infinity. By symmetry, the wire xy must carry $\frac{1}{6}$ A of current. Alternatively, consider the mesh with 1A going in at infinity and 1A coming out a Y. Again by symmetry $\frac{1}{6}$ A runs through XY. Therefore net current through XY is $\frac{1}{3}$ A.

Sol.11[B] From symmetry the equivalent circuit will be –



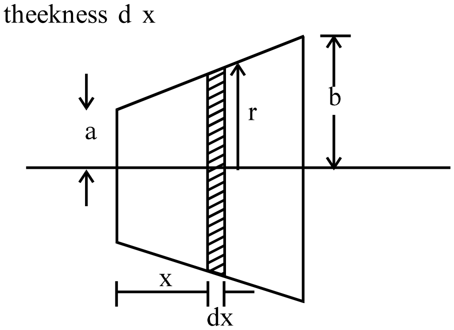
Sol.12[C] $R = \frac{\rho\ell}{A}$, $m = d\ell A$, $A = m/d\ell$, $R = \frac{\rho d\ell^2}{m}$

$$\frac{R_1}{R_2} = \left(\frac{\rho_1}{\rho_2}\right)\left(\frac{d_1}{d_2}\right)\left(\frac{\ell_1}{\ell_2}\right)^2\left(\frac{m_2}{m_1}\right)$$

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

$R_1/R_2 = 1 : 2$

Sol.13[C] Consider an element at a distance x from one end of theekness d x



$$r = \left(\frac{b-a}{\ell}\right) x + a$$

Resistance of small element is

$$dR = \frac{\rho dx}{\pi\left(a + \frac{x}{\ell}(b-a)\right)^2},$$

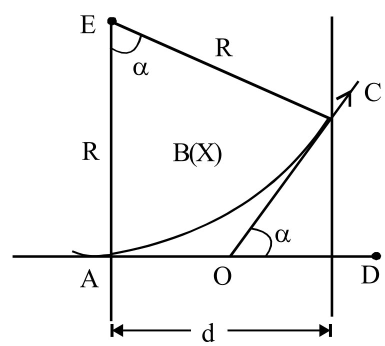
$$\text{So}\ \ R = \int_0^{\ell} dR = \int_0^{\ell} \frac{\rho dx}{\pi\left(a+\frac{x}{\ell}(b-a)\right)^2}$$

$$= \left[-\frac{\rho}{\pi}\frac{\ell}{(b-a)}\frac{1}{\left(a+\frac{x(b-a)}{\ell}\right)}\right]_0^{\ell}$$

$$= \frac{\rho\ell}{\pi(b-a)a} - \frac{\rho\ell}{\pi b(b-a)} = \frac{\rho\ell}{\pi ab}$$

Sol.14[A] From the fig. it is clear that the angle of deflection is given by $\alpha = \angle COD = \angle BEA$

therefore $\sin\alpha = \frac{AB}{EB} = \frac{d}{R}$ where R is the radius of circular path taken by the protons in the magnetic

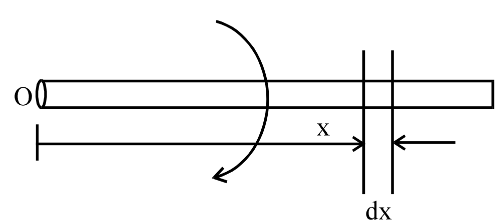


field then $R = \frac{mv}{qB}$ but $\frac{1}{2}\ mv^2 = qV$,

$$\sin\alpha = \frac{d}{R} = \frac{qBd}{mv}$$

$$\Rightarrow \alpha = \sin^{-1}\left(dB\sqrt{\frac{q}{2mv}}\right)$$

Sol.15[D] Taking element at a distance x charge on this element



$dq = \frac{Q}{L} \times dx$

This elemental charge is rotating about O.

$\therefore$ This can be treated as a current carring loop of current $= \frac{dq}{T} = \frac{dq\omega}{2\pi}$

magnetic moment

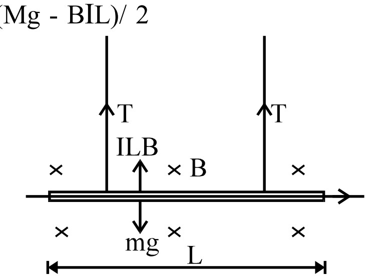
$$dm = \frac{\pi x^2 \times dq\omega}{2\pi}$$

Total moment $\int_O^L dm = \int_O^L \frac{Q}{L}\frac{1}{2}\omega x^2 \, dx = \frac{Q\omega L^2}{6}$

Sol.16[A] If we complete the loop by joining end C to end A, the net force on loop will be zero. This shows that the force acting on the bent wire is equal but opposite in direction to the force acting on straight imaginary wire CA. As the length of CA is ℓ, the force on imaginary wire CA is I(ℓ x B) and this is also the magnitude of the force on the bent wire.

Sol.17[B] If we consider FBD of the rod 2T + BIL = Mg

T = (Mg - BIL)/ 2



Sol.18[D] No. of turns per unit radial width $n = \frac{N}{(b-a)}$

consider a concentric circular ring of radius x and radial thickness

No. of turns in this ring = n .dx

flux $\phi = \pi x^2$ B emf induced in this ring = n . dx

$$\left(\frac{d\phi}{dt}\right) = ndx\left(\pi x^2 \frac{dB}{dt}\right) = \pi n\alpha x^2 dx$$

Total emf induced in the spiral coil

$$e = \int_{x=a}^{x=b} (\pi n\alpha x^2 dx) = \frac{1}{3}\pi n\alpha\,(b^3 - a^3) = \frac{1}{3}\pi N\alpha$$

$(a^2 + b^2 + ab)$

Sol.19[B] Due to semi circular part, B_1 at centre $B_1 = \frac{\mu_o I}{4R}$ (inward) due to straight conductor

$B_2 = \frac{\mu_o I}{4\pi r}(\sin\alpha + \sin\beta)$ here,

r = R cos30 and $\alpha = \beta = 30$

$\therefore B_2 = \frac{\sqrt{3}\mu_o I}{6\pi R}$ (inward)

$\therefore B_{resultant} = B_1 + 3B_2 = \frac{\mu_o I}{4\pi R}(\pi + 2\sqrt{3})$

Area of smaller loop = πr^2

flux linked with it = $\pi r^2 B = \frac{\pi(\mu_o I)(\pi + 2\sqrt{3})r^2}{4\pi R}$

$\therefore$ Magnitude of induced emf

$$= \left|\frac{d\phi}{dt}\right| = \frac{\mu_o(\pi + 2\sqrt{3})\ell^2\alpha}{4R}$$

Sol.20[C] Consider a long element parallel to b of width dx at a distance x from the long conductor

$$d\phi = \frac{\mu_0}{4\pi}\frac{2I}{x} Nbdx$$

ϕ_1 = total flux before rotation = $\int_{x=r}^{x=r+a} \frac{\mu_0}{4\pi}\frac{2I}{x}$

$Nbdx = \frac{\mu_0}{4\pi}\frac{2I}{x} Nb \log \frac{r+a}{r}$

ϕ_2 = total flux in coil afer rotation

$$-\phi_1 = -\frac{\mu_0}{4\pi} 2I\, bN \log\left(\frac{r+a}{r}\right)$$

$$\Delta\phi = \phi_2 - \phi_1 = -\frac{2\mu_0}{4\pi} 2I\, bN \log\left(\frac{r+a}{r}\right),$$

$$\Delta Q = \frac{\Delta\phi}{R} = -\frac{2}{R}\frac{\mu_o}{4\pi} 2I\, bN \log\frac{r+a}{r}$$

Sol.21[B] $E = \int_0^a B\omega dx = \frac{1}{2}B\omega a^2$

$i = E/R = \frac{B\omega a^2}{2R}$ $\tau = (iaB)\frac{a}{2} = \frac{B^2\omega a^4}{4R}$

Sol.22[A] Let the original inductance of the solenoid be L_o and R_o its resistance. The resistance and inductance of each half would be $R_1 = R_o/2$ and $L_1 = L/2$. Since they are connected in parallel the effective inductance is given by .

$$\frac{1}{L} = \frac{1}{L_1} + \frac{1}{L_1} = \frac{2}{L_1} = \frac{2}{L_o/2} = \frac{4}{L_o}$$

$$\Rightarrow L = \frac{L_0}{4}$$

Similarly the effective resistance $R = \frac{R_0}{4}$

Time constant $= \frac{L}{R} = \frac{L_0}{R_0} = \frac{1.8\times10^{-4}}{6} = 0.3\times 10^{-4}$S,

current $I = \frac{E}{R} = \frac{4E}{R_o} = \frac{4\times12}{6} = 8$A