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## TARGET : JEE (Advanced) 2015

**Course: VIJETA & VIJAY (ADP & ADR)** **Date : 14-04-2015**

**PHYSICS**
# DPP
**DAILY PRACTICE PROBLEMS**
**NO. 03**

**TEST INFORMATION**

**TEST : PART TEST (PT)-1 (3 HOURS)** (**Test Date : 15-04-2015**)

**Syllabus :** Geometrical Optics, Electrostatics, Gravitation, Kinematics, Newton's laws of motion, Friction.

**This DPP is to be discussed (17-04-2015)**

**PT-1 to be discussed (17-04-2015)**

## DPP No. # 03

| | | |
|---|---|---|
| **Total Total Marks : 151** | **Max. Time : 116½ min.** | |
| **Single choice Objective (–1 negative marking) Q. 1 to 15** | **(3 marks 2½ min.)** | **[45, 37½]** |
| **Multiple choice objective (–1 negative marking) Q. 16 to 20** | **(4 marks, 3 min.)** | **[20, 15]** |
| **Single Digit Subjective Questions (no negative marking) Q.21 to Q.27** | **(4 marks 2½ min.)** | **[28, 17½]** |
| **Double Digits Subjective Questions (no negative marking) Q. 28 to 29** | **(4 marks 2½ min.)** | **[8, 5]** |
| **Three Digits Subjective Questions (no negative marking) Q. 30 to 31** | **(4 marks 2½ min.)** | **[8, 5]** |
| **Comprehension (–1 negative marking) Q.32 to 42** | **(3 marks 2½ min.)** | **[33, 27½]** |
| **Match Listing (–1 negative marking) Q.43 to Q.45** | **(3 marks, 3 min.)** | **[9, 9]** |

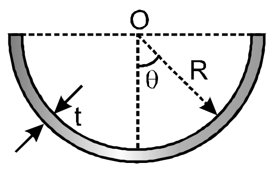
**1.** Consider two infinite large parallel current carrying sheet. Current per unit width in both sheets is $\frac{1}{\sqrt{\pi}}$ A/m. If direction of current in both sheets is same than force per unit area on each sheet will be :

(A) $10^{-7}$ N/m$^2$ (B) $0.5 \times 10^{-7}$ N/m$^2$ (C) $2 \times 10^{-7}$ N/m$^2$ (D) $10^{-5}$ N/m$^2$

**2.** Consider two uniformly charged concentric and coaxial rings of radii R and 2R. Total charge on inner ring is $Q_1$ and that on outer ring is $Q_2$. Both rings are revolving in same sense with same angular velocity about its axis. If net magnetic induction at a distance R from the centre of the rings, on axis of rings is zero then $\frac{Q_1}{Q_2}$ is :

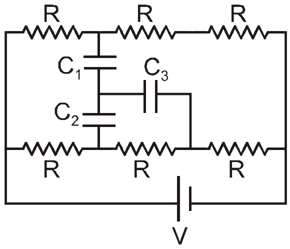
(A) – 1 (B) $-\frac{2\sqrt{2}}{5\sqrt{5}}$ (C) $-\frac{8\sqrt{2}}{5\sqrt{5}}$ (D) $-\frac{4\sqrt{2}}{3\sqrt{3}}$

**3.** Conductor of length $\ell$ has shape of a semi cylinder of radius R (<< $\ell$). Cross section of the conductor is shown in the figure. Thickness of the conductor is t (<< R) and conductivity of its material varies with angle $\theta$ according to the law $\sigma = \sigma_0\cos\theta$ where $\sigma_0$ is a constant. If a battery of emf $\varepsilon$ is connected across its end faces (across the semi–circular cross-sections), the magnetic induction at the mid point O of the axis of the semi-cylinder is :



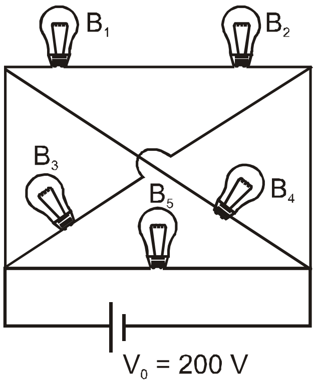

(A) $\frac{\mu_0\sigma_0\varepsilon t}{8\ell}$ (B) $\frac{\mu_0\sigma_0\varepsilon t}{4\ell}$ (C) $\frac{\mu_0\sigma_0\varepsilon t}{\ell}$ (D) $\frac{2\mu_0\sigma_0\varepsilon t}{\ell}$

**4.** In the shown circuit, all three capacitor are identical and have capacitance C $\mu$F each. Each resistor has resistance of R $\Omega$. An ideal cell of emf V volts is connected as shown. Then the magnitude of potential difference across capacitor $C_3$ in steady state is :



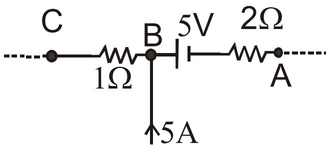

(A) $\frac{V}{3}$ (B) $\frac{V}{2}$ (C) $\frac{2}{9}V$ (D) $\frac{3}{4}V$

**5.** Five bulbs $B_1$, $B_2$, $B_3$ and $B_4$ each of rating 60W / 200V and $B_5$ of rating 120W / 400V are connected as shown in circuit. Total power consumption by all the bulbs is :



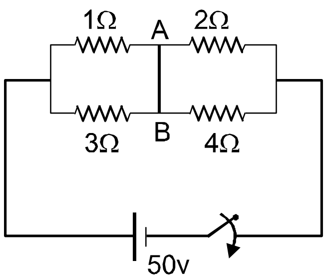

(A) 240 W (B) 270 W (C) 90 W (D) 180 W

**6.** If an ideal cell of emf 5 volt shown in the figure gives a power of 10 W , find the powers consumed by the resistors 2 $\Omega$ and 1 $\Omega$.



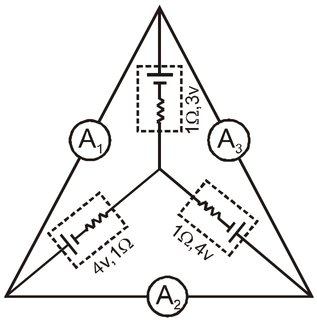

(A) 2W, 18W (B) 8W, 49W (C) 8W, 18W (D) 2W, 49W

**7.** Four resistances are connected by an ideal battery of emf 50 volt, circuit is in steady state then the current in wire AB is :




(A) 1A (B) 2A (C) 3A (D) 4 A

8. Three batteries are connected as shown in figure. Reading of ideal ammeters $A_1$ ,$A_2$ & $A_3$ are :



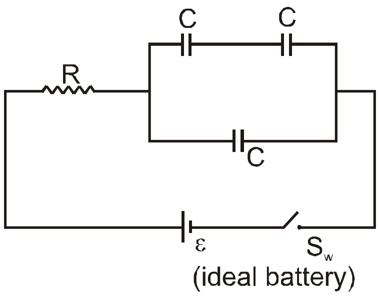

(A) $\frac{1}{3}$A, 0,$\frac{1}{3}$A

(B) 0.5 A, 0.5 A & 1A respectively

(C) zero, 0.5 A & zero respectively

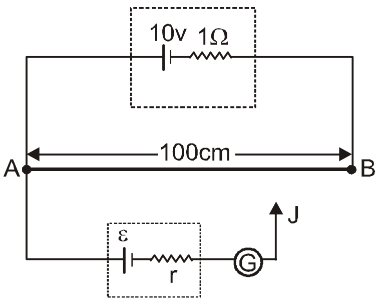
(D) zero, zero & 1A respectively

9. The time when the voltage across the resistor drops to nearly 37% of the value just after the switch $S_w$ is closed : (R = 100 kΩ, C = 1μF) is :




(A) 0.15 s (B) 0.30 s (C) 0.45 s (D) 0.60 s

10. AB is potentiometer wire of resistance per unit length 0.09 Ω/cm and ε is an unknown emf of a battery to be measured. ε cannot be measured using the potentiometer shown if the value of ε is (select the most appropriate answer)



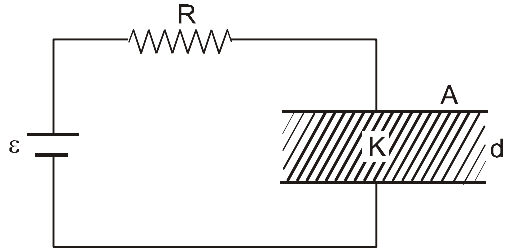

(A) greater than 8.0 V

(B) greater than 8.5 V

(C) greater than 9.0 V

(D) greater than 9.5 V

**11.** In the circuit diagram a capacitor which is initially uncharged is connected to an ideal cell of emf $\varepsilon$ through a resistor 'R'. A leaky dielectric fills the space between the plates of dielectric. The capacitance of the capacitor with dielectric is C. Resistance of the dielectric is $R' = R$.



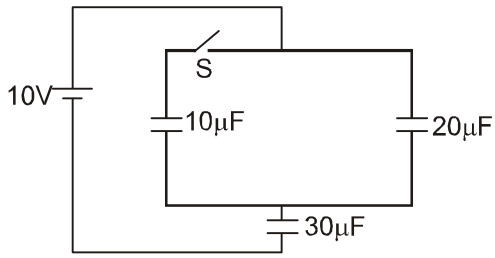

(A) Charge on the capacitor as function of time t is $\frac{\varepsilon C}{2}\left[1-e^{-\frac{2t}{RC}}\right]$

(B) Maximum charge on the capacitor is $\frac{\varepsilon C}{2}$ .

(C) When charge on the capacitor is maximum, then current in the circuit is $\frac{\varepsilon}{2R}$

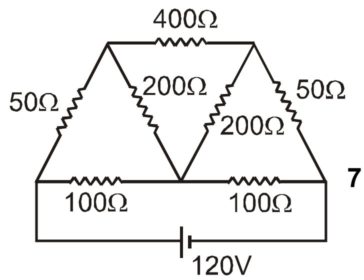
(D) All of the above options are true

**12.** Charge flown through the battery after closing the switch is (initially all capacitors are uncharged) :




(A) 20mC (B) 30mC (C) 120mC (D) 150mC

**13.** Electric current through 400Ω resistor is :



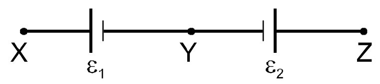

7

(A) 0.8 A (B) 0.6 A (C) 0.4 (D) 0.2 A

**14.** Two coaxial long solenoids of equal lengths have current, $i_1$, $i_2$, number of turns per unit length $n_1$, $n_2$ and radius $r_1$, $r_2$ respectively. If $n_1 i_1 = n_2 i_2$ and the two solenoids carry current in opposite sense, the magnetic energy stored per until length is $[r_2 > r_1]$

(A) $\frac{\mu_0}{2} n_1^2 i_1^2 \pi (r_2^2 - r_1^2)$ (B) $\mu_0 n_1^2 i_1^2 \pi (r_2^2 - r_1^2)$ (C) $\frac{\mu_0}{2} n_1^2 i_1^2 \pi r_1^2$ (D) $\frac{\mu_0}{2} n_2^2 i_2^2 \pi r_2^2$

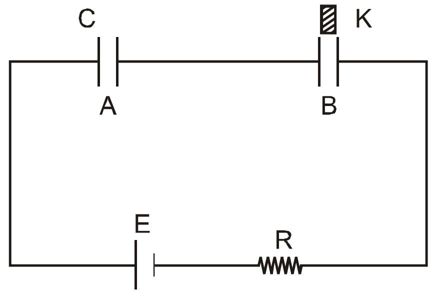
15. Two cells of emf $\varepsilon_1$ and $\varepsilon_2$ ($\varepsilon_2 < \varepsilon_1$) are joined as shown in figure :




When a potentiometer is connected between X and Y it balances for 300 cm length against $\varepsilon_1$. On connecting the same potentiometer between X and Z it balances for 100 cm length against $\varepsilon_1$ and $\varepsilon_2$. Then the ratio $\frac{\varepsilon_2}{\varepsilon_1}$ is :

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

16. In the figure shown capacitors A and B of capacitance C are in steady state. A dielectric slab of dielectric constant K = 2 and dimensions equal to the inner dimensions of the capacitor is inserted in the space between the plates of the capacitor B. In stedy state choose the correct options



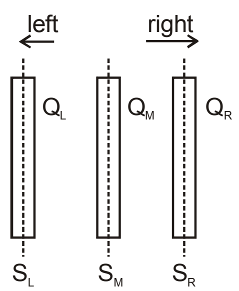

(A) Charge on each capacitor will increase by $\frac{CE}{6}$.

(B) In the process of inserting the dielectric, energy of the battery decreases by an amount of $\frac{CE^2}{6}$.

(C) In the process of inserting the dielectric, energy of the battery increases by an amount of $\frac{CE^2}{6}$.

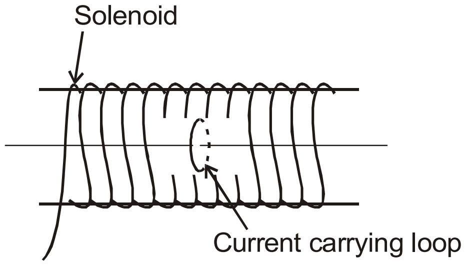
(D) In the process of inserting the dielectric, energy in the capacitor A increases by an amount of $\frac{7CE^2}{72}$.

17. Three large identical conducting plates of area A are closely placed parallel to each other as shown (the area A is perpendicular to plane of diagram). The net charge on left , middle and right plates are $Q_L$, $Q_M$ and $Q_R$ respectively. Three infinitely large parallel surfaces $S_L$,$S_M$ and $S_R$ are drawn passing through middle of each plate such that surfaces are perpendicular to plane of diagram as shown. Then pick up the correct option(s).



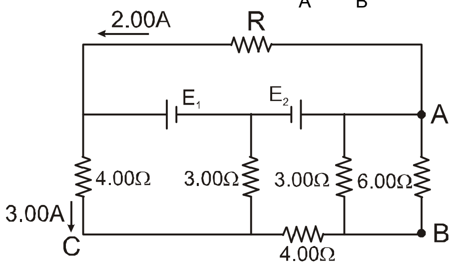

(A) The net charge on left side of surface $S_L$ is equal to net charge on right side of surface $S_R$.
(B) The net charge on left side of surface $S_L$ is equal to net charge on right side of surface $S_M$.
(C)The net charge on left side of surface $S_L$ is equal to net charge on right side of surface $S_L$.
(D) The net charge on right side of surface $S_L$ is equal to net charge on left side of surface $S_R$.

**18.** A single circular loop of wire with radius 0.02 m carries a current of 8.0 A. It is placed at the centre of a solenoid that has length 0.65 m, radius 0.080 m and 1300 turns.



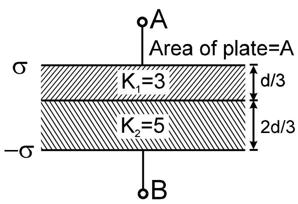

(A) The value of the current in the solenoid so that the magnetic field at the centre of the loop becomes zero, is equal to 44 mA.
(B) The value of the current in the solenoid so that the magnetic field at the centre of the loop becomes zero, is equal to 100 mA.
(C) The magnitude of the total magnetic field at the centre of the loop (due to both the loop and the solenoid) if the current in the loop is reversed in direction from that needed to make the total field equal to zero tesla, is $8\pi \times 10^{-5}$ T.
(D) The magnitude of the total magnetic field at the centre of the loop (due to both the loop and the solenoid) if the current in the loop is reversed in direction from that needed to make the total field equal to zero tesla, is $16\pi \times 10^{-5}$ T.

**19.** In the circuit shown in figure, $E_1$ and $E_2$ are two ideal sources of unknown emfs. Some currents are shown. Potential difference appearing across $6\Omega$ resistance is $V_A - V_B = 10V$. Choose correct options.




(A) The current in the 4.00 $\Omega$ resistance between C & B is 5A.
(B) The unknown emf $E_1$ is 36 V.
(C) The unknown emf $E_2$ is 54 V.
(D) The resistance R is equal to 9 $\Omega$.

**20.** In the figure shown



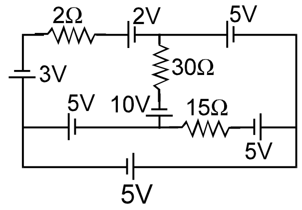

(A) the ratio of energy density in Ist dielectric to second dielectric is $\frac{5}{3}$

(B) the ratio of energy density in Ist dielectric to second dielectric is $\frac{1}{1}$

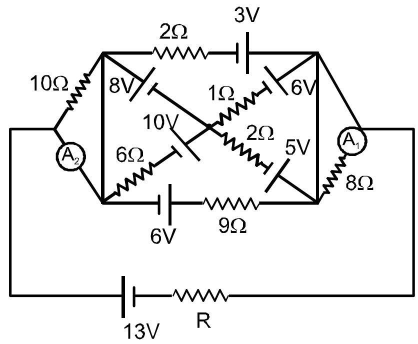
(C) total induced surface charge on the interface of the two dielectric is $\frac{2\sigma}{15}$

(D) total induced surface charge on the interface of the two dielectric is $-\frac{2\sigma}{15}$

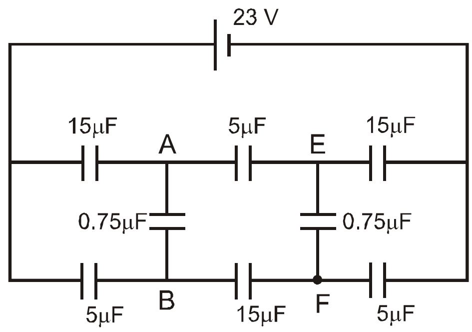
**21.** In the circuit shown, current through the resistance 2Ω is $i_1$ and current through the resistance 30Ω is $i_2$. Find the ratio $\frac{i_1}{i_2}$.



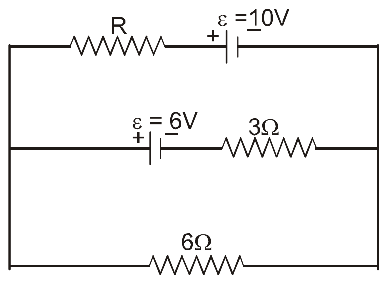

**22.** Find the value of R (in Ω) so that there is no current through 5V cell. All the cells & ammeters are ideal in the circuit shown.




**23.** Find the potential difference (in volt) between the points A and B of the circuit shown in figure.

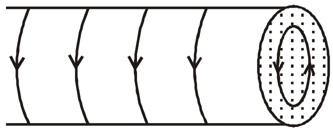



**24.** In the given circuit if the internal resistance of the batteries are negligible, then for what value of resistance R (in Ω)will the thermal power generated in it be maximum.

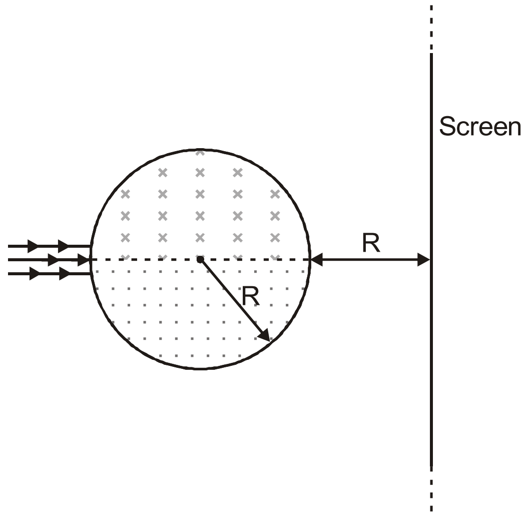



**25.** A long straight wire is carrying current $I_1$ = *2/5 A* in +*z* direction. The *x - y* plane contains a closed circular loop carrying current $I_2$ = 5/2 A and not encircling the straight wire, then the force (in newton) on the loop will be ? (radius of the circular loop R = 3/4m).

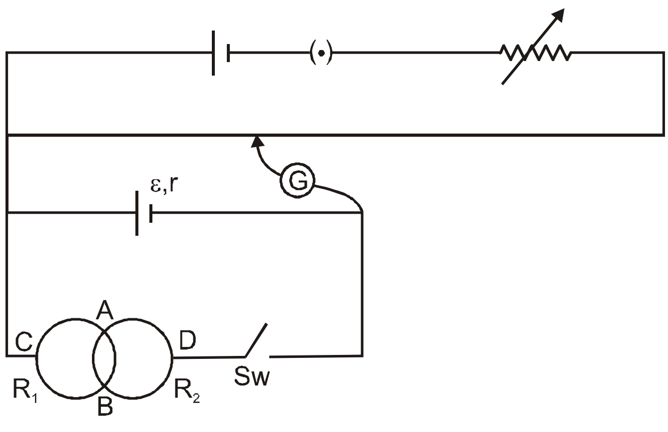
**26.** Magnetic field is uniform and has a magnitude B in the interior of a very long solenoid far from its ends. One of the ends of the solenoid is closed with a thin flat plastic cover. A single small electrical loop of radius R lies on the cover so that its center is on the axis of the solenoid. The electrical current flowing in the loop in $I$. If the mechanical tension in the loop's wire is $\frac{BIR}{x}$, then value of x:



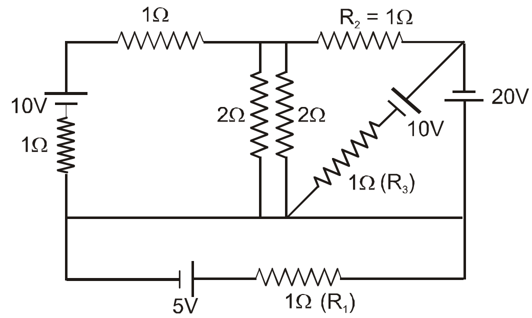
**27.** Figure shows circular region of radius $R = \sqrt{3}$ m in which upper half has uniform magnetic field $\vec{B} = 0.2(-\hat{k})$ T and lower half has uniform magnetic field $\vec{B} = 0.2\hat{k}$ T. A very thin parallel beam of point charges each having mass m = 2gm, speed v = 0.3 m/sec and charge q = +1mC are projected along the diameter as shown in figure. A screen is placed perpendicular to initial velocity of charges as shown. If the distance between the point on screen where charges will strike is 4X meters, then calculate X.




**28.** Internal resistance of a cell is r = 5Ω & is connected in potentiometer (wire length = 1m) circuit arrangement as shown in figure, which shows two circular conducting rings $R_1$ & $R_2$ each having radii 20 cm cross each other at conducting joints A & B. Section AB subtends 120º at the center of each ring. Resistance per unit length of $R_1$ & $R_2$ are $\frac{3}{\pi}$ Ω/cm & $\frac{6}{\pi}$ Ω/cm respectively. Cell is connected across points C & D of rings lying on perpendicular bisector of AB. Now when switch Sw remains closed, balancing length at null point is 48 cm. Find the balancing length (in cm.) when switch Sw is opened.



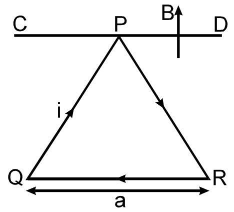
**29.** Find the sum of magnitude of current (in Amp.) through $R_1$, $R_2$ and $R_3$. All cells are ideal




**30.** A parallel plate capacitor is to be designed which is to be connected across 1 kV potential difference. The dielectric material which is to be filled between the plates has dielectric constant K = $6\pi$ and dielectric strength $10^7$ V/m.
For safety the electric field should never exceed 10% of the dielectric strength. With such specifications, if we want a capacitor of capacitance 50 pF, what minimum area (in $mm^2$) of plates is required for safe working?

(use $\varepsilon_0 = \frac{1}{36\pi} \times 10^{-9}$ in MKS)

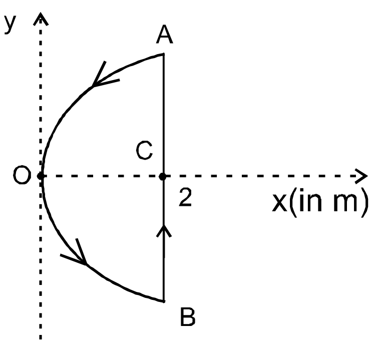
**31.** A loop PQR formed by three identical uniform conducting rods each of length a = 20 cm is suspended from one of its vertices (P) so that it can rotate about horizontal fixed smooth axis CD. Initially plane of loop is in vertical plane. A constant current i = 10 A is flowing in the loop. Total mass of the loop is m = 60 gm. At t = 0, a uniform magnetic field of strength B directed vertically upwards is switched on. Find the minimum value of B in mT so that the plane of the loop becomes horizontal (even for an instant) during its subsequent motion.




## COMPREHENSION - 1

A conducting wire is bend into a loop as shown in the figure. The segment AOB is parabolic given by the equation $y^2 = 2x$, while segment BA is a straight line x = 2.

The magnetic field in the region $\vec{B} = -8\hat{k}$ tesla and the current in wire is 2A.




**32.** The torque on the loop will be :

(A) $16\sqrt{2}\text{N}-\text{m}$ (B) $16\text{N}-\text{m}$ (C) $18\sqrt{2}\text{N}-\text{m}$ (D) zero

**33.** The magnetic field created by the current in the loop at point C will be

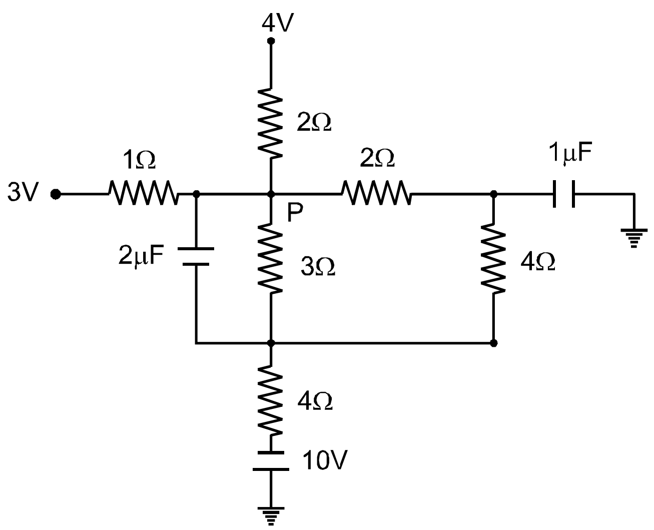
(A) $-\frac{\mu_0}{4\pi}\hat{k}$ (B) $-\frac{\mu_0}{8\pi}\hat{k}$ (C) $-\frac{\mu_0\sqrt{2}}{\pi}\hat{k}$ (D) none

**34.** If the loop were rotated about the z-axis with an angular speed of 1rad/sec. Then magnitude of emf induced across the straight segment AC will be

(A) 32V (B) 8V (C) 16V (D) 4V

## COMPREHENSION - 2

The figure shown is part of the circuit at steady state.




**35.** The potential of point P is :

(A) 1V (B) 2V (C) 3V (D) 4V

**36.** The charge on 2μF capacitor is :

(A) 2μc (B) 4μc (C) 6μc (D) 8μc

**37.** The current flowing from 3Ω resistor is :

(A) 2 A (B) $\frac{4}{3}$ A (C) $\frac{2}{3}$ C (D) None of these

## COMPREHENSION - 3

A galvanometer measures current which passes through it. A galvanometer can measure typically current of order of mA. To be able to measure currents of the order of amperes of main current, a shunt resistance 'S' is connected in parallel with the galvanometer.


Figure-I

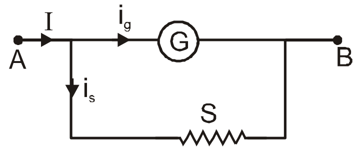



Figure-II

**38.** The resistance of the shunt 'S' and resistance 'G' of the galvanometer should have the following relation.

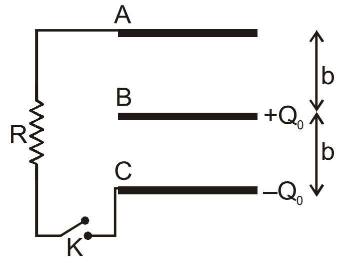
(A) S = G (B) S >> G (C) S << G (D) S < G

**39.** If resistance of galvanometer is $10\Omega$ and maximum current $i_g$ is 10mA then the shunt resistance required so that the main current '$I$' can be upto 1A is (in $\Omega$)

(A) $\frac{99}{10}$ (B) $\frac{10}{99}$ (C) 990 (D) $\frac{99}{1000}$

## COMPREHENSION - 4

Three identical metal plates of area S are at equal distances b as shown. Initially metal plate A is uncharged, while metal plates B and C have respective charges $+Q_0$ and $-Q_0$ initially as shown. Metal plates A and C are connected by switch K through a resistor of resistance R. The key K is closed at time t = 0




**40.** Then the magnitude of current in amperes through the resistor at any later time t is :

(A) $\frac{Q_0 b}{RS\varepsilon_o} e^{\frac{-bt}{RS\varepsilon_o}}$ (B) $\frac{Q_0 b}{RS\varepsilon_o} e^{\frac{-2bt}{RS\varepsilon_o}}$ (C) $\frac{Q_0 b}{2RS\varepsilon_o} e^{\frac{-2bt}{RS\varepsilon_o}}$ (D) $\frac{Q_0 b}{2RS\varepsilon_o} e^{\frac{-bt}{RS\varepsilon_o}}$

**41.** After the steady state is achieved, the charge on plate A is :

(A) $\frac{Q_0}{2}$ (B) $-\frac{Q_0}{2}$ (C) $\frac{Q_0}{3}$ (D) $-\frac{Q_0}{3}$

**42.** The total heat produced dissipiated by resistor of resistance R is :

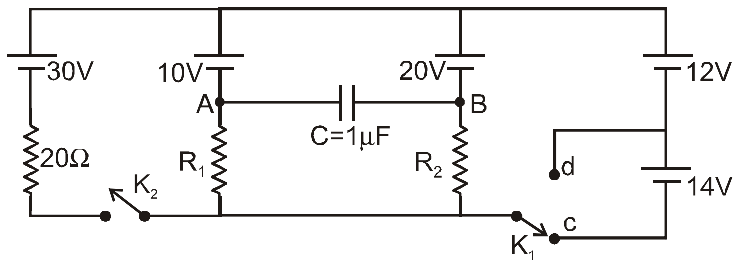
(A) $\frac{Q_0^2 b}{4S\varepsilon_0}$ (B) $\frac{Q_0^2 b}{8S\varepsilon_0}$ (C) $\frac{Q_0^2 b}{2S\varepsilon_0}$ (D) $\frac{3Q_0^2 b}{4S\varepsilon_0}$

**43.** Column I gives certain situations in which capacitance of a capacitor is changed by different means. Column II gives resulting effect under different conditions. Match the proper entries from column-2 to column-1 using the codes given below the columns,

| Column I | Column II |
|---|---|
| (P) The plates of a plane parallel capacitor are slowly pulled apart. Then the magnitude of electric field intensity inside the capacitor. | (1) Increases if the capacitor is maintained at constant charge. |
| (Q) The plates of a plane parallel plate capacitor are slowly pulled apart. Then the potential energy stored in the capacitor. | (2) Decreases if the capacitor is maintained at constant charge |
| (R) The capacitance of an air filled plane parallel plate capacitor on insertion of dielectric | (3) Increases if the capacitor is maintained at constant potential difference. |
| (S) A dielectric slab is inserted inside an air filled plane parallel plate capacitor. The potential energy stored in the capacitor. | (4) Decreases if the capacitor is maintained at constant potential difference. |

| | (P) | (Q) | (R) | (S) |
|---|---|---|---|---|
| (A) | 1 | 2 | 4 | 3 |
| (B) | 4 | 1 | 3 | 2 |
| (C) | 1 | 2 | 3 | 4 |
| (D) | 4 | 1 | 2 | 3 |

**44.** A circuit involving five ideal cells , three resistors ($R_1$, $R_2$ and $20\Omega$) and a capacitor of capacitance C = 1 $\mu$F is shown. At steady state match the proper entries from column-2 to column-1 using the codes given below the columns,




| Column-I | Column-II |
|---|---|
| (P) $K_2$ is open and $K_1$ is in position C | (1) Potential at point A is greater than potential at B |
| (Q) $K_2$ is open and $K_1$ is in position D | (2) Current through $R_1$ is downward |
| (R) $K_2$ is closed and $K_1$ is in position C | (3) Current through $R_2$ is upward |
| (S) $K_2$ is closed and $K_1$ is in position D | (4) Charge on capacitor is 10$\mu$C. |

| | (P) | (Q) | (R) | (S) |
|---|---|---|---|---|
| (A) | 4 | 3 | 1 | 2 |
| (B) | 3 | 1 | 4 | 2 |
| (C) | 3 | 2 | 1 | 4 |
| (D) | 1 | 4 | 3 | 2 |

**45.** Column I lists the field in a region and Column II lists the path of a charge *q* and mass *m* on which the particle can move. Match the proper entries from column-2 to column-1 using the codes given below the columns, [Consider all fields to be uniform]

| Column I | Column II |
|---|---|
| (P) Only electric field $\vec{E}$ is present | (1) The particle can move on a straight line |
| (Q) Only magnetic field $\vec{B}$ is present | (2) The particle can move on a circle |
| (R) Only gravitational field $\vec{g}$ is present | (3) The particle can move on parabolic path |
| (S) Both electric field $\vec{E}$ and magnetic field $\vec{B}$ are present | (4) The particle can remain in rest |

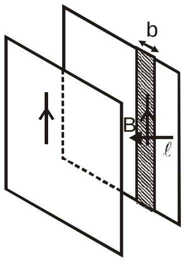
| | (P) | (Q) | (R) | (S) |
|---|---|---|---|---|
| (A) | 4 | 3 | 1 | 2 |
| (B) | 3 | 1 | 4 | 2 |
| (C) | 3 | 2 | 1 | 4 |
| (D) | 1 | 2 | 3 | 1 |

## ANSWER KEY OF DPP No. # 02

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1.** | (A) | **2.** | (C) | **3.** | (D) | **4.** | (A) | **5.** | (B) | **6.** | (B) | **7.** | (B) |
| **8.** | (D) | **9.** | (A) | **10.** | (B) | **11.** | (B) | **12.** | (D) | **13.** | (C) | **14.** | (C) |
| **15.** | (C) | **16.** | (B) | **17.** | (C) | **18.** | (A,C,D) | **19.** | (A,B,D) | **20.** | (C,D) | | |
| **21.** | (B,D) | **22.** | (A,D) | **23.** | (B,C,D) | **24.** | (A,B,C) | **25.** | 6 | **26.** | $\alpha$ = 4 | | |
| **27.** | 10 sec | **28.** | 125 | **29.** | 3 | **30.** | 5 | **31.** | 3 | **32.** | (C) | **33.** | (D) |
| **34.** | (A) | **35.** | (D) | **36.** | (A) | **37.** | (B) | **38.** | (A) | **39.** | (D) | | |
| **40.** | (A) – p,s ; (B) – p,t ; (C) – q,s ; (D) – q, s | | | | | **41.** | (B) | **42.** | (A) | | | | |

## PHYSICS

**1.** Magnetic field due to one of the sheet




B = $\frac{\mu_0 K}{2}$ Parallel to second sheet

Force on section of width b

$F = bK\ell \frac{\mu_0 K}{2}$

Force per unit area

$P = \frac{B}{\ell b} = \frac{\mu_0 K^2}{2}$

$P = 4\pi \times 10^{-7} \frac{1}{2\pi}$

**2.** Magnetic field due to circular current carrying loop on axis of loop is :

$B = \frac{\mu_0}{4\pi} \frac{2I\pi R^2}{(R^2 + x^2)^{3/2}}$ , I = Qf

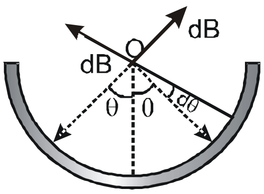
$B_1 + B_2 = 0$

$\frac{Q_1 R^2}{(R^2 + R^2)^{3/2}} + \frac{Q_2 4R^2}{(4R^2 + R^2)^{3/2}} = 0$

$\frac{Q_1}{2\sqrt{2}} + \frac{Q_2 4}{5\sqrt{5}} = 0$

$\frac{Q_1}{Q_2} = -\frac{8\sqrt{2}}{5\sqrt{5}}$

**3.**




$dB = \frac{\mu_0 d\iota}{2\pi R} = \frac{\mu_0 \times \frac{\varepsilon}{\ell}(\sigma_0 \cos\theta) R d\theta \times t}{2\pi R}$

$B = \int_0^{\pi/2} 2 dB \cos\theta = \frac{\mu_0 \sigma_0 \varepsilon t}{4\ell}$

**4.** No current passes through capacitors in steady state. Assume potential at point '4' to be zero.

Then points '1' and '2' are at same potential $\frac{2V}{3}$.

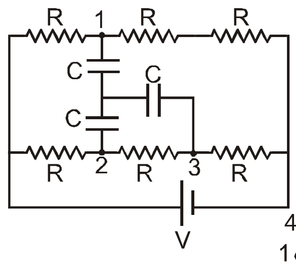
Hence $C_1$ and $C_2$ can be taken in parallel.

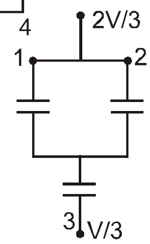
The potential at point 3 is $\frac{V}{3}$.

$\therefore$ Equivalent circuit of all three capacitors is shown

Hence potential difference across capacitor $C_3$ is

$$= \frac{2C}{2C+C} \times \left(\frac{2V}{3} - \frac{V}{3}\right) = \frac{2V}{9}$$




**5.** $P_{B_1 + B_2} = 30$ W

$P_{B_3} = 60$ W, $P_{B_4} = 60$ W

$$P_{B_5} = \frac{(200)^2}{\frac{400^2}{120}} = \frac{120}{4} = 30W$$

$P_{total} = 180W$

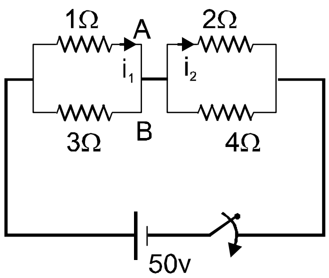
**6.** Since the cell gives out a power of 10W, a current 2A must flow through the cell towards left.

$\therefore$ Power consumed in $2\Omega$ resistor = $2^2$ x 2 = 8W

Total current flowing in $1\Omega$ = 7Amp.

$\therefore$ Power consumed by $1\Omega$ = $7^2$ x 1 = 49 W

**7.**



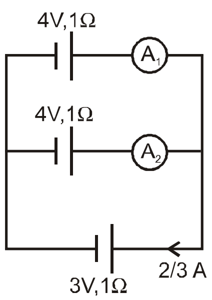

$$R_{eq} = \frac{3}{4} + \frac{8}{6} = \frac{25}{12} \Rightarrow \quad i_0 = \frac{V}{R_{eq}} = 24 \text{ Amp.}$$

$i_1 = \frac{3}{4} \times 24 = 18$ Amp., $i_2 = \frac{4}{6} \times 24 = 32$ Amp.

Current in the branch AB

$\Delta i = 2$ Amp.

**8.**



**9.** $\tau = RC = \frac{3}{20}$ s

voltage in capacitor rises to 63% of maximum value.

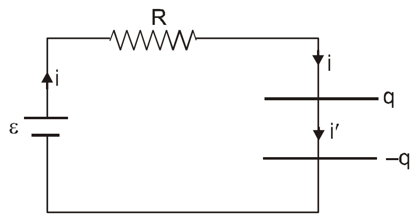
$0.63 = (1 - e^{-t/\tau})$

t = 0.15 s

**10.** Potential on AB wire is 9V.

Hence $\varepsilon$ greater then 9v cannot be measured.

**11.** **(i)** At t > 0




i′ = current through dielectric

$= \frac{q}{C.R.}$ ...(i)

By K.V.L. $\varepsilon - iR - \frac{q}{C} = 0$ ...(2)

$i = i' + \frac{dq}{dt} = \frac{q}{RC} + \frac{dq}{dt}$ ...(3)

By (2) and $\varepsilon - \left(\frac{q}{RC} + \frac{dq}{dt}\right) R - \frac{q}{C} = 0$

$\Rightarrow \quad \varepsilon C - 2q - RC\frac{dq}{dt} = 0$

$\Rightarrow \quad \varepsilon C - 2q = RC\frac{dq}{dt} \Rightarrow \int_0^q \frac{dq}{\varepsilon C - 2q} = \int_0^t \frac{dt}{RC}$

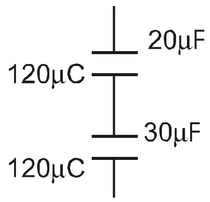
$\Rightarrow \quad -\frac{1}{2}\ \ell n\ \frac{\varepsilon C - 2q}{\varepsilon C} = \frac{t}{RC} \Rightarrow \quad q = \frac{\varepsilon C}{2}\left(1 - e^{-\frac{2t}{RC}}\right)$

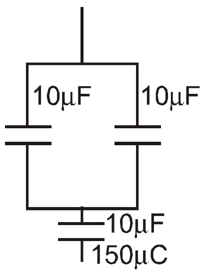
**(ii)** $q_{max} = \frac{\varepsilon C}{2}$ as $t \to \infty$

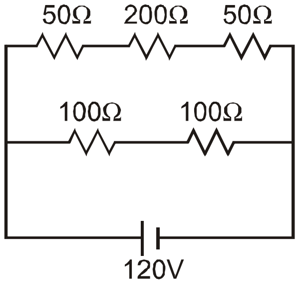
and by (2) $\varepsilon - iR - \frac{\varepsilon}{2} = 0$

$\Rightarrow \quad i = \frac{\varepsilon}{2R}$ at that time.

**12.**



**13.** 


**14.** Magnetic field is non zero only in the region between the two solenoids , where $B = \mu_0 n_2 i_2$

$\therefore$ energy stored per unit volume = $\dfrac{B^2}{2\mu_0} = \dfrac{\mu_0 n_2^{\,2} i_2^{\,2}}{2}$

The energy per unit length. = energy per unit volume × area of cross section where $B \neq 0$

$= \dfrac{\mu_0 n_2^2 i_2^{\,2}}{2}\,[\pi\,(r_2^{\,2} - r_1^{\,2})] \qquad = \dfrac{\mu_0 n_1^2 i_1^2}{2}[\pi(r_2^{\,2} - r_1^{\,2})$, since $n_1 i_1 = n_2\, i_2$

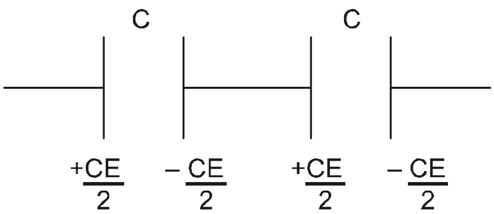
**15.** $\varepsilon_1 = 300\,\alpha$ ..........(i)

$-\,\varepsilon_2 + \varepsilon_1 = 100\,\alpha$ ..........(ii)

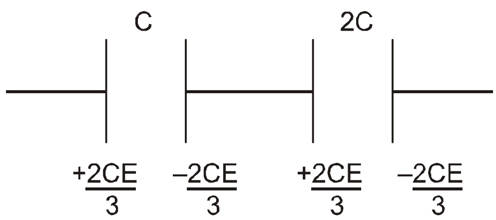
where, $\alpha$ is the potential gradient

$\therefore \quad \dfrac{\varepsilon_2}{\varepsilon_1} = \dfrac{2}{3}$.

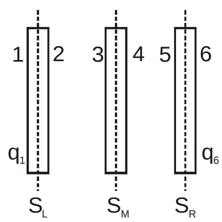
**16.** Initial




Final




**17.** Since electric field on plate at surface $S_L$ is zero, net charge on left side of $S_L$ is equal to net charge on right side of $S_L$. Further net charge between any two dotted surfaces (out of $S_L$, $S_M$ and $S_R$) is zero from Gauss theorem.
$\therefore$ Charge on left most surface $q_1$ is equal to charge on right most surface $q_6$, that is, $q_1 = q_6$
Hence all statements are true.



**18.** For given condition :

Magnitude of $B_{solienoid}$ = Magnitude of $B_{loop}$

$$\mu_0 ni = \frac{\mu_0 I}{2R} \qquad \text{here } n = \frac{\text{Total no. of turn}}{\text{Total length}} = \frac{1300}{0.65}$$

$$i = \frac{I}{2R} \times \frac{1}{n} = \frac{8 \times 0.65}{2 \times 0.02 \times 1300} = 100 \text{ mA.}$$

For given condition :

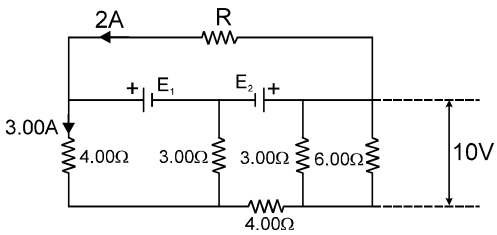
Total magnetic field at the centre of loop

$$= |B_{loop}| + |B_{solenoid}| \qquad \because \quad |B_{loop}| = ||B_{solenoid}|$$

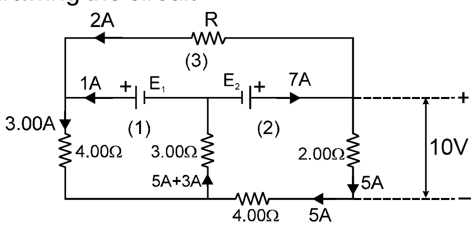
$$= 2|B_{loop}| = 2 \times \frac{\mu_0 I}{2R}$$

$$= \frac{2 \times 4\pi \times 10^{-7} \times 8}{2 \times 0.02} = 16\,\pi \times 10^{-5} \text{ T.}$$

**19.**




after redrawing the circuit




(a) $I_4 = 5A$

(b) From loop (1) to (1)

$-8(3) + E_1 - 4(3) = 0 \quad \Rightarrow \quad E_1 = 36$ volt

from loop (2) to (2)

$+4(5) + 5(2) - E_2 + 8(3) = 0$

$E_2 = 54$ volt

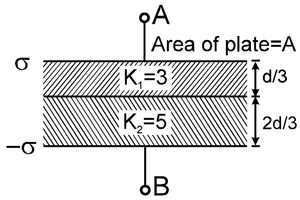
(c) from loop (3) to (3)

$-2R - E_1 + E_2 = 0$

$$R = \frac{E_2 - E_1}{2} = \frac{54}{2} - 36 = 9\ \Omega$$

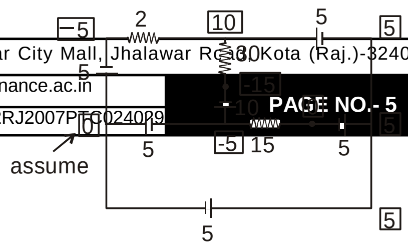
**Ans.** (a) 5.00 A (b) 36.0 V, 54.0 V (c) 9.00 Ω

**20.** (i) $\dfrac{e_1}{e_2} = \dfrac{\in_1 E_1^2}{\in_2 E_2^2} = \dfrac{k_1 E_1^2}{k_2 E_2^2} = \left(\dfrac{k_1}{k_2}\right)\left(\dfrac{k_2}{k_1}\right)^2 = \dfrac{k_2}{k_1} = \dfrac{5}{3}$




(ii) $\sigma_B = \sigma\left(1 - \dfrac{1}{k_1}\right) - \sigma\left(1 - \dfrac{1}{k_2}\right) = \sigma\left(\dfrac{1}{k_2} - \dfrac{1}{k_1}\right) = -\dfrac{2\sigma}{15}$

**21.** Potentials are indicated in figure



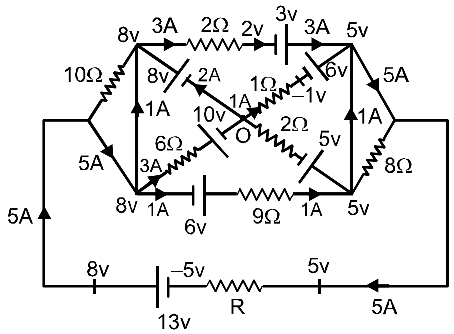
Current in $2\Omega$ $= \frac{10-(-5)}{2} = \frac{15}{2}$ = **7.5 A, leftwards**

Current in $30\ \Omega$ $= \frac{10-(-15)}{30} = \frac{25}{30} = \frac{5}{6}$ **A, downwards**

$\frac{i_1}{i_2}$ **= 9**

**22.** Let the junction located at the center of rectangular portion of circuit be at zero potential .Then potentials of many other points can be shown as in figure . Now current can be written in every branch satisfying KCL.

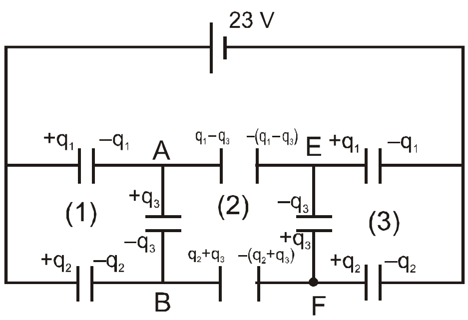
So, $R = \frac{5-(-5)}{5} = 2\Omega$ **Ans.**




Reading of $A_1 = 0$ **Ans**

& reading $A_2 = 5$ A **Ans.**

**23.**




The distribution of charge is shown in figure $\frac{-q_2}{5} + \frac{q_3}{0.75} + \frac{q_1}{15} = 0$

$\Rightarrow$ $q_1 - 3q_2 + 20q_3 = 0$ ..........(i)

$$-\left(\frac{q_2+q_3}{15}\right) - \frac{q_3}{0.75} + \frac{q_1-q_3}{5} - \frac{q_3}{0.75} = 0$$

$\Rightarrow$ $3q_1 - q_2 - 44q_3 = 0$ ..........(ii)

$$23 - \frac{q_2}{5} - \left(\frac{q_2+q_3}{15}\right) - \frac{q_2}{5} = 0$$

$345 = 7q_2 + q_3$ ..........(iii)

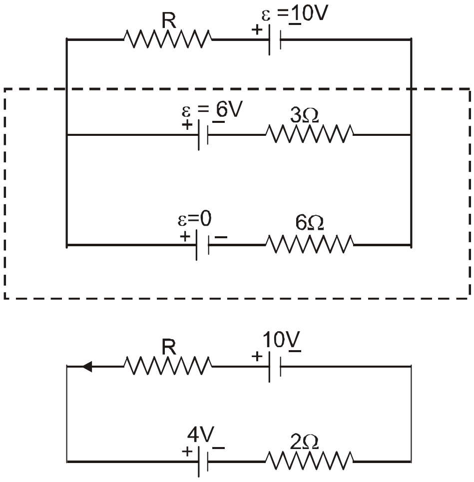
From eq.(i), (ii), (iii)

$$q_1 = \frac{19\times 345}{92},\ q_2 = \frac{13\times 345}{92},\ q_3 = \frac{345}{92}$$

Potential difference between A and B = $\frac{q_3}{0.75}$ = 5V **...Ans.**

**24.** Given circuit can be simplified as dotted part can be replaced as

$$\varepsilon_{eq} = \frac{\frac{6}{3}+\frac{0}{6}}{\frac{1}{3}+\frac{1}{6}} = 4V$$




$$\frac{1}{r_{eq}} = \frac{1}{3}+\frac{1}{6} \quad \Rightarrow \quad r_{eq} = 2\Omega$$

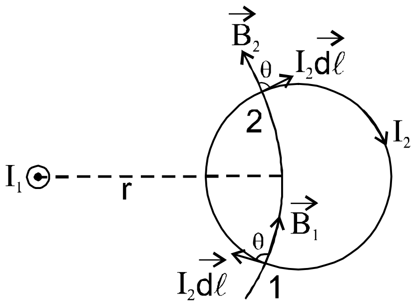
then current $I = \frac{10-4}{2+R} = \frac{6}{2+R}$

Power in R, $P = \left(\frac{6}{2+R}\right)^2 R = \frac{36R}{(2+R)^2}$,

for P to be maximum $\frac{dP}{dR} = 0$

on solving R = 2Ω

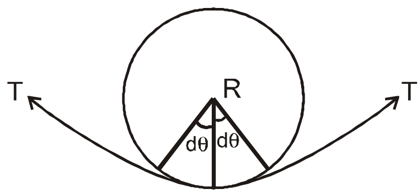
**25.**




The force on current elements 1 and 2 is equal in magnitude and opposite in direction

$\Rightarrow \quad F_{net} = 0$

**26.** B at end = $\frac{1}{2}$ B at interior = $\frac{1}{2}$ B



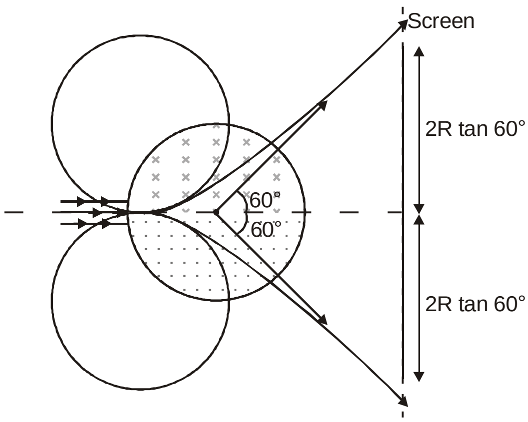

$IdL\left(\frac{B}{2}\right) = 2T \sin d\theta$

$dL = R(2d\theta)$

$I\,R.2d\theta\,\frac{B}{2} = 2T\,d\theta$

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

**27.**




Required d = 4R tan 60° = 4 $(\sqrt{3})\sqrt{3}$ = 12

**28.** $R_{AC} = R_{CB} = \dfrac{2\pi \times 20}{3} \times \dfrac{3}{\pi} = 40\ \Omega$

& $R_{AD} = R_{BD} = \dfrac{2\pi \times 20}{3} \times \dfrac{6}{\pi} = 80\ \Omega$

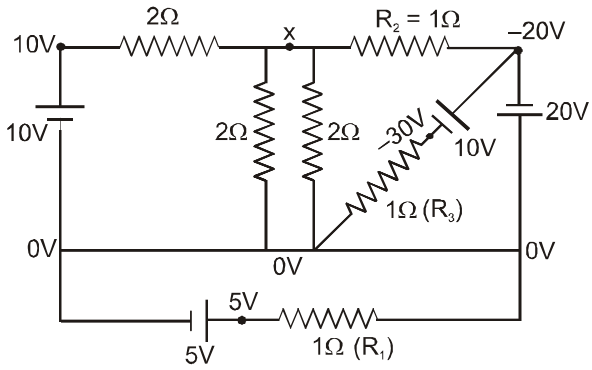
$\Rightarrow$ Balanced W.S.B $\Rightarrow$ $R_{CD} = \dfrac{120}{2} = 60\ \Omega$

$\varepsilon \times \left(\dfrac{60}{60+5}\right) = 48\ x$

& $\varepsilon = x\ \ell$

$\Rightarrow$ $\ell \times \dfrac{60}{65} = 48$ $\Rightarrow$ $\ell = 52$ cm

**29.**




Potential of different points are shown.

(i) current in $R_1$

$I_1 = \dfrac{\Delta V}{R_1} = \dfrac{5-0}{1}$ A = 5A from left to right.

(ii) current in $R_3$

$I_3 = \dfrac{\Delta V}{R_3} = \dfrac{30}{1}$ A = 30 A from lower to higher.

(iii) For current in $R_2$
using KCL

$$\frac{10-x}{2} + \frac{0-x}{2} + \frac{0-x}{2} + \frac{-20-x}{1} = 0$$

$\Rightarrow$ $\dfrac{10}{2} - 20 = \dfrac{3x}{2} + x \Rightarrow$ $x = -6V$

$\therefore$ $I_2 = \dfrac{20-6}{1}$ A = 14 A.

**30.** $E < 10^6$ $\Rightarrow$ $\dfrac{10^3}{d} < 10^6$

$d > 10^{-3}$ m $\Rightarrow$ $C = \dfrac{k\varepsilon_0 A}{d}$

$d = \dfrac{k\varepsilon_0 A}{C} > 10^{-3}$

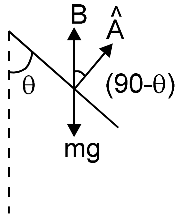
$A > \dfrac{10^{-3}\ x\ C}{k\varepsilon_0}$ $\Rightarrow$ $A > \dfrac{10^{-3}\ x\ 50\ x\ 10^{-12}}{(6\pi)\ x \left(\dfrac{1}{36\pi} x10^{-9}\right)} = 300\ mm^2$

**31.** Applying Energy conservation, initially kinetic energy = 0
gravitational P.E. = 0 (say) & Magnetic P.E. = μB

where, μ = magnetic moment of the loop = i. $\left(\frac{\sqrt{3}a^2}{4}\right)$

Finally when the loop becomes horizontal, Kinetic energy = 0

gravitational P.E.=mg$\left(\frac{a}{\sqrt{3}}\right)$ (because mg acts on the centre of mass)




magnetic P.E. = 0

$\Rightarrow \quad 0 + 0 + \mu B = 0 + \frac{mga}{\sqrt{3}} + 0 \Rightarrow \quad B = \frac{mga}{\sqrt{3}\mu} = \frac{4mg}{3ia}$

using values, B = 400 mT

**32.** Since $\vec{M} \parallel^r$ to $\vec{B}$

$\therefore$ torque zero.

**33.** at C direction must be along $t\hat{k}$ direction.

**34.** The emf is the difference between emf across straight segment OA and OC.

**36.** $V_P = x$

$\frac{3-x}{1} = \frac{x-4}{2} + \frac{x+10}{6}$

Solve

q = 2 × 4 = 8μc

**38.** The current through the galvanometer is ~ $\frac{1}{1000}$ of total current, the S << G.

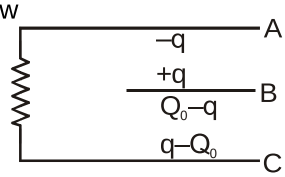
**39.** Potential difference across galvanometer = Potential difference across S.

$\Rightarrow \quad i_g \cdot G = (I - i_g) \cdot S$

$\Rightarrow \quad 10 \times 10^{-3} \cdot 10 = (1 - 10 \times 10^{-3}) \cdot S \quad \Rightarrow \quad R_S = \frac{10^{-1}}{1-10^{-2}} = \frac{10}{99}\,\Omega$

**40.** At any time t, the charge on right capacitor be q. Applying Kirchoff's law

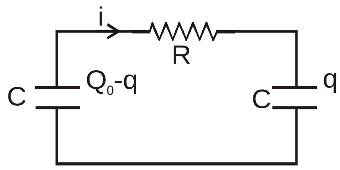
$\frac{Q_0 - q}{C} = iR + \frac{q}{C} \qquad \therefore \quad \frac{Q_0 - 2q}{2CR} = \frac{dq}{dt}$




integrating and evaluating the constant we get

Hence $q = \frac{Q_0}{2}(1 - e^{-\frac{2t}{RC}})$

or $i = \frac{dq}{dt} = \frac{Q_0}{RC}e^{-\frac{2t}{RC}}$




**41.** At steady state charges on both the capacitor will be equal. Hence charge on plate A is $-Q_0/2$.

**42.** Finally the charge on either capacitor is $Q_0/2$. Hence heat produced is = initial P.E. – final P.E.

$= \frac{Q_0^2}{2C} - \frac{(Q_0/2)^2}{2C} - \frac{(Q_0/2)^2}{2C} = \frac{Q_0^2 b}{4S\varepsilon_0}$

**43.** (A) At constant charge, the electric field within the capacitor remains same when plate separation is changed. The electric field in capacitor is $E = \frac{V}{d}$. Hence at constant potential difference the electric field decreases with increase in d.

(B) $U = \frac{1}{2}\frac{Q^2}{C}$. Hence at constant charge U increases with decrease in C.

$U = \frac{1}{2}CV^2$. Hence at constant potential difference U decreases with decrease in C.

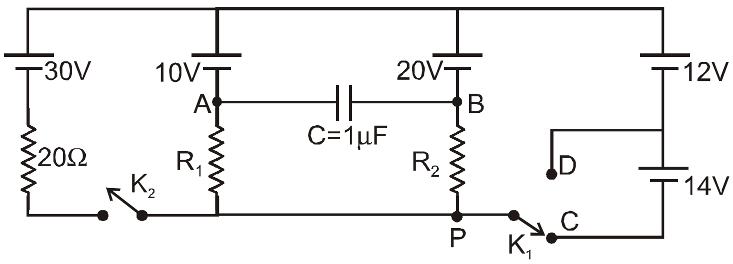
(C) Capacitance increases on insertion of dielectric.

(D) As a result of insertion of dielectric the capacitance increases

$U = \frac{1}{2}\frac{Q^2}{C}$. Hence at constant charge U decreases with increase in C.

$U = \frac{1}{2}CV^2$. Hence at constant potential difference U increases with increase in C.

**44.** The state of key $K_2$ has no effect on current through $R_1$ and $R_2$ as well has no effect on charge in the capacitor. Also position of key $K_1$ has no effect on potential difference between points A and B, that is $V_A - V_B$ = 10 volts under all conditions. Hence charge on capacitor under all cases is 10μC.




Assume the potential at point P to be zero,

When Key $K_1$ is in position C: $V_A$ = 16 Volt and $V_B$ = 6 volts. Hence current in both $R_1$ and $R_2$ will flow downwards.

When Key $K_1$ is in position D: $V_A$ = 2 Volt and $V_B$ = – 8 volts. Hence current through $R_1$ will flow downwards and through $R_2$ will flow upwards.