EXERCISE

2.1 Two charges 5×10^{-8} C and -3×10^{-8} C are located 16 cm apart. At what point(s) on the line joining the two charges is the electric potential zero? Take the potential at infinity to be zero.

2.2 A regular hexagon of side 10 cm has a charge 5 µC at each of its vertices. Calculate the potential at the centre of the hexagon.

2.3 Two charges 2 µC and –2 µC are placed at points A and B 6 cm apart.

(a) Identify an equipotential surface of the system.

(b) What is the direction of the electric field at every point on this surface?

2.4 A spherical conductor of radius 12 cm has a charge of 1.6×10^{-7}C distributed uniformly on its surface. What is the electric field

(a) inside the sphere

(b) just outside the sphere

(c) at a point 18 cm from the centre of the sphere?

2.5 A parallel plate capacitor with air between the plates has a capacitance of 8 pF (1pF = 10^{-12} F). What will be the capacitance if the distance between the plates is reduced by half, and the space between them is filled with a substance of dielectric constant 6?

2.6 Three capacitors each of capacitance 9 pF are connected in series.

(a) What is the total capacitance of the combination?

(b) What is the potential difference across each capacitor if the combination is connected to a 120 V supply?

2.7 Three capacitors of capacitances 2 pF, 3 pF and 4 pF are connected in parallel.

(a) What is the total capacitance of the combination?

(b) Determine the charge on each capacitor if the combination is connected to a 100 V supply.

2.8 In a parallel plate capacitor with air between the plates, each plate has an area of 6×10^{-3} m^2 and the distance between the plates is 3 mm. Calculate the capacitance of the capacitor. If this capacitor is connected to a 100 V supply, what is the charge on each plate of the capacitor?

2.9 Explain what would happen if in the capacitor given in Exercise 2.8, a 3 mm thick mica sheet (of dielectric constant = 6) were inserted between the plates,

(a) while the voltage supply remained connected.

(b) after the supply was disconnected.

2.10 A 12pF capacitor is connected to a 50V battery. How much electrostatic energy is stored in the capacitor?

2.11 A 600pF capacitor is charged by a 200V supply. It is then disconnected from the supply and is connected to another uncharged 600 pF capacitor. How much electrostatic energy is lost in the process?

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Exercise

3.1 Here $\varepsilon = 12V$, $r = 0.4\,\Omega$

The current drawn from the battery will be max when the external resistance in the circuit is zero $R=0$

$$\therefore \quad I_{max} = \frac{\varepsilon}{r} = \frac{12}{0.4} = 30A$$

3.2 As $I = \dfrac{\varepsilon}{R+r} \Rightarrow R+r = \dfrac{\varepsilon}{I}$

$$\therefore \quad R = \frac{\varepsilon}{I} - r = \frac{10}{0.5} - 3 = 17\,\Omega$$

Terminal voltage,

$$V = IR = 0.5 \times 17 = 8.5V$$

3.3 i) $R_S = R_1 + R_2 + R_3 = 6\,\Omega$

ii) Current in the circuit, $I = \dfrac{\varepsilon}{R_S} = \dfrac{12}{6} = 2A$

$\therefore$ Potential drop across different resistors are

$V_1 = IR_1 = 2 \times 1 = 2V$

$V_2 = IR_2 = 2 \times 2 = 4V$

$V_3 = IR_3 = 2 \times 3 = 6V$

3.4 i) $\dfrac{1}{R_P} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3} = \dfrac{1}{2} + \dfrac{1}{4} + \dfrac{1}{5} = \dfrac{19}{20}\,\Omega$

ii) Current drawn through different resistors are

$I_1 = \dfrac{\varepsilon}{R_1} = \dfrac{20}{2} = 10A$, $I_2 = \dfrac{\varepsilon}{R_2} = \dfrac{20}{4} = 5A$.

$I_3 = \dfrac{\varepsilon}{R_3} = \dfrac{20}{5} = 4A$

Total current drawn from the battery,

$I = I_1 + I_2 + I_3 = 10 + 5 + 4 = 19A$.

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3.5 Here $R_1 = 100\,\Omega$, $R_2 = 117\,\Omega$, $t_1 = 27^\circ C$

$\alpha = 1.70 \times 10^{-4}\ {}^\circ C^{-1}$

As $\alpha = \dfrac{R_2 - R_1}{R_1(t_2 - t_1)}$

$\therefore t_2 - t_1 = \dfrac{R_2 - R_1}{R_1 \alpha} = \dfrac{117 - 100}{100 \times 1.70 \times 10^{-4}} = 1000$

$\therefore t_2 = 1000 + t_1 = 1000 + 27 = 1027^\circ C$

3.6

Here $l = 15\,m$, $A = 6.0 \times 10^{-7}\,m^2$, $R = 5.0\,\Omega$

Respectively $\rho = \dfrac{RA}{l} = \dfrac{5.0 \times 6.0 \times 10^{-7}}{15}$

$= 2.0 \times 10^{-7}\,\Omega m$

3.7 $R_1 = 2.1\,\Omega$, $t_1 = 27.5^\circ C$, $R_2 = 2.7\,\Omega$, $t_2 = 100^\circ C$

Temperature coefficient of resistivity of silver,

$\alpha = \dfrac{R_2 - R_1}{R_1(t_2 - t_1)}$

$= \dfrac{2.7 - 2.1}{2.1(100 - 27.5)} = \dfrac{0.6}{2.1 \times 72.5}$

$= 0.00394^\circ C^{-1}$

3.8 Here $V = 230\,V$, $I_1 = 3.2A$,
$I_2 = 2.8A$, $\alpha = 1.70 \times 10^{-4}\,{}^\circ C^{-1}$

Resistance at room temperature,
$$R_1 = \frac{V}{I_1} = \frac{230}{3.2} = 71.875\,\Omega$$

Resistance at steady temperature,
$$R_2 = \frac{V}{I_2} = \frac{230}{2.8} = 82.143\,\Omega$$

Now $$\alpha = \frac{R_2 - R_1}{R_1(t_2 - t_1)}$$

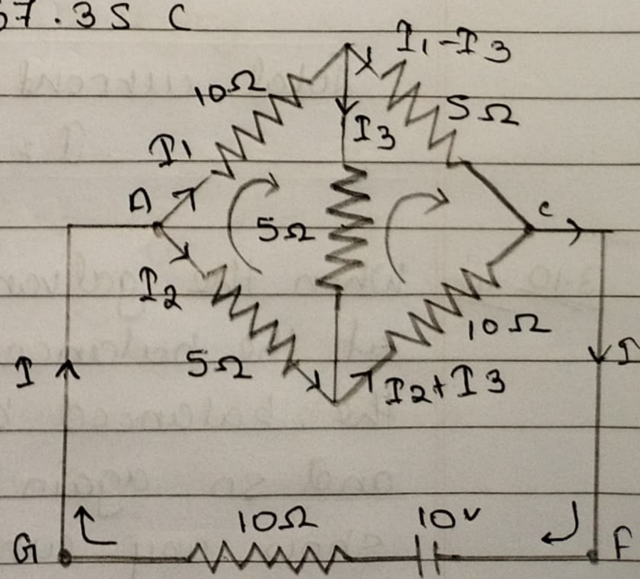
$$\therefore t_2 - t_1 = \frac{R_2 - R_1}{R_1 \alpha}$$

$$= \frac{82.143 - 71.875}{71.875 \times 1.70 \times 10^{-4}}$$

$$= \frac{10.268 \times 10^4}{71.875 \times 1.7} = 840.35\,{}^\circ C$$

$\therefore$ Steady temperature of element,
$$t_2 = 840.35 + 27 = 867.35\,{}^\circ C$$

3.9 let I, I_1, I_2, I_3 be the current as shown. we apply kirchhoff's second rule to different loops.



From loop ABDA,

$$10I_1 + 5I_3 - 5I_2 = 0$$

For loop BCDB,

$$5(I_1 - I_3) - 10(I_2 + I_3) - 5I_3 = 0$$

For loop ADCFGA,

$\Rightarrow 5I_2 + 10(I_2 + I_3) + 10(I_1 + I_2) = 10$

$\Rightarrow 10I_1 - 5I_2 + 5I_3 = 0 \quad - (i)$

$5I_1 - 10I_2 - 20I_3 = 0 \quad - (ii)$

$10I_1 + 25I_2 + 10I_3 = 10 \quad - (iii)$

solving eq. (1), (2), (3), we get

$$I_1 = \frac{4}{17} A, \; I_2 = \frac{6}{17} A, \; I_3 = \frac{-2}{17} A$$

Current in different branches are

$I_{AB} = I_1 = \frac{4}{17} A \qquad I_{BC} = I_1 - I_3 = \frac{6}{17} A$

$I_{DC} = I_2 + I_3 = \frac{4}{17} A \qquad I_{DA} = I_2 = \frac{6}{17} A$

$I_{BD} = I_3 = \frac{-2}{17} A$

Total current,

$$I = I_1 + I_2 = \frac{10}{17} A$$

3.10 iii When the galvanometer and cell are interchanged at the balanced point, the conditions of the balanced bridge are still satisfied and so again the galvanometer will not show any current.

3.10 Here $l = 35.9$ cm , $R = X = 7$, $S = Y = 12.5\Omega$

As $S = \frac{100 - l}{l} \times R$ $\therefore 12.5 = \frac{100 - 39.5}{39.5} \times R$

or $R = \frac{12.5 \times 39.5}{60.5} = 8.16\Omega$

Connection are ~~maid~~ made by thick copper stick to minimise the resistances of connections which are not accaunted for in the above formula.

ii) When x & Y are interchanged,

$R = Y = 12.5\Omega$, $S = X = 8.16\Omega$, $l = ?$

As, $S = \frac{100 - l}{l} \times R$ $\therefore 8.16 = \frac{100 - l}{l} \times 12.5$

$= 8.16 l = 1250 - 12.5 l$

$= l = \frac{1250}{20.66} = 60.5\Omega$, From the end A.

3.11 When the storage battery of 8.0 volt is charged with a dc supply of 120 V, the net emf in the circuit will be $\varepsilon' = 120 - 8.0 = 112V$

current in the circuit during charging

$I = \frac{\varepsilon'}{R + r} = \frac{112}{15.5 + 0.5} = 7A$

The terminal voltage of the battery during charging,

$V = \varepsilon + Ir = 8.0 + 7 \times 0.5 = 11.5V$

The series resistor limits the current drawn from the external source. In its absence, the current will be dangerously high.