Physics
Test question $
Answer

Q1 (a) using relevant equations, Define the following terms
(i) current
(ii) Resistance
(iii) Electromotive force

soln.

(i) current is the rate of flow of electric charge on the quantity of electrons passing a given point, which can be mathematically express as;

$$I = \frac{Q}{t} \quad (A)$$

(ii) Resistance is the oposition flow of charge measured in ohm's (Ω). which can be mathematically express as;

$$R = \frac{\rho L}{A} \quad (\Omega)$$

(iii) Electromotive force: It is the Potential difference of a cell when its not connected to any external circuit. which can be mathematically express as;

$$\mathcal{E} = \bar{I}R + \bar{I}r$$

(Q1b) An electricity supply cable consists of a steel core of cross sectional area of $50mm^2$ with six other aluminum conductors of the same cross sectional area arrange around it. cal. the resistance of 120 m length of the cable (Take density of steel $= 9.0\times10^{-6}$ and density of Al $= 2.5\times10^{-8}\,\Omega m$)

soln

Resistance of steel cable R_s,

$$R_s = \frac{\rho L}{A} = \frac{9\times10^{-6}\times120}{50\times10^{-6}} = 21.$$

Resistance of 6 aluminium cable

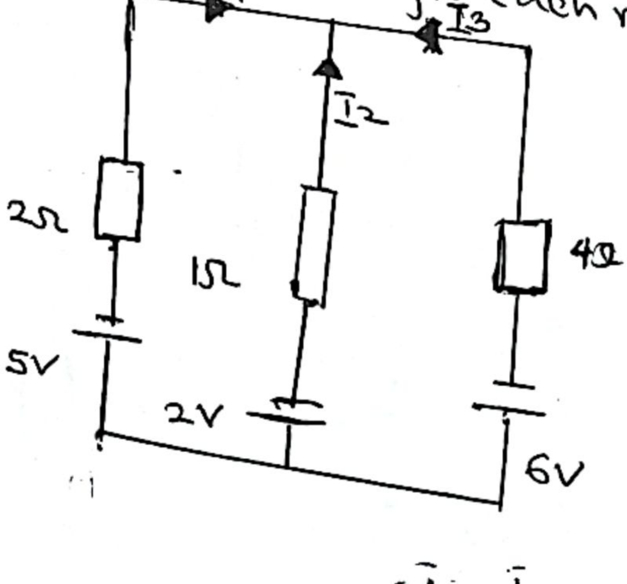
$$R_A = \frac{\rho L}{A} = \frac{2.5\times10^{-8}\times120}{6\times50\times10^{-6}} = 0.01$$

effective Resistance of the cable R_c;

$$\frac{1}{R_c} = \frac{1}{R_s} + \frac{1}{R_A}$$

$$\frac{1}{R_c} = \frac{1}{21.6} + \frac{1}{0.01} = 100\Omega$$

Q2. Using nodal analysis. cal. the current through each resistor



Soln.

$$\frac{V_1 - V_A}{R_1} + \frac{V_2 - V_A}{R_2} + \frac{V_3 - V_A}{R_3}$$

$$\frac{(-5 - V_A)}{R_1} + \frac{(-2 - V_A)}{R_2} + \frac{(-6 - V_A)}{R_3}$$

$$\frac{(-5 - V_A)}{2} + \frac{(-2 - V_A)}{1} + \frac{(-6 - V_A)}{4}$$

$$2(-5 - V_A) + 4(-2 - V_A) + (-6 + V_A)$$

$$-10 - 2V_A - 8 - 4V_A - 6 - V_A$$

$$-24 - 7V_A = 0$$

$$\frac{-24}{7} = \frac{7V_A}{7} \quad V_A = -3.4V$$

$$I_1 = \frac{-5 - (-3.4)}{2} = -0.8A$$

$$I_2 = \frac{-2 - (-3.4)}{1} = 1.4A$$

$$I_3 = \frac{-6 - (-3.4)}{4} = -0.6A$$

Proof. $I_1 + I_2 + I_3 = 0$

$-0.8 + 1.4 + (-0.6) = 0$

(2bi) Show that for a pure Ind circuit, the voltage leads the current by $\pi/2$.

Soln.

$I = I_0 \sin 2\pi f t$

$V = V_0 \sin(2\pi f + \pi/2)$

voltage lead by $\pi/2$

(2bii) obtain the corresponding expression for inductive reactance X_L and rms current I_{rms}.

Soln.

$X_L = 2\pi f L$ - Inductive reactance

$I_{rms} = I = \frac{I_0}{\sqrt{2}}$

3a. A coil has an inductance of 0.3H. Determine the values of the peak voltage and current in the circuit of 240V and 50H

Soln.

Peak voltage $= V = \frac{V_0}{\sqrt{2}}$

$= 240 = \frac{V_0}{\sqrt{2}}$

$V_0 = 240 \times \sqrt{2}$

$V_0 = 339.4v$

Peak current $= I = \frac{I_0}{\sqrt{2}}$

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(2)

7. An ac voltage whoose peak value is 80 volts is connected across 60Ω resistor. The values of I_{rms} and V_{rms} are?

Soln.

$V_0 = I_0 R \quad = \frac{V_0}{R} = \frac{I_0 R}{R}$

$I_0 = \frac{V_0}{R} = \frac{80}{60} = 1.33A$

$I_{rms} = \frac{I_0}{\sqrt{2}} = \frac{1.33}{\sqrt{2}}$

~~$I_{rms} \times \sqrt{2} = I_0$~~

~~$1.33 \times \sqrt{2} = 1.88$~~ $= 0.94$

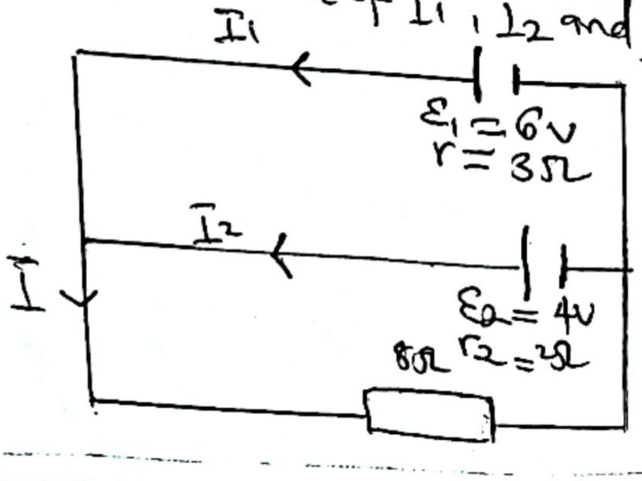
$V_{rms} = \frac{80}{\sqrt{2}} = 56.56$

8. In a Pure capacitive circuit, the current lags the voltage by 90°.

9. For a Series RLC circuit, the expression for Impedance. 2

$= Z = \sqrt{R^2 + (X_L - X_C)}$

10. Use the below figure and determine the value of I_1, I_2 and I



Soln. (4)

$I = I_1 + I_2$ — (1)

$\varepsilon_1 = IR + I_1 r_1$

$6 = (I_1 + I_2) 8 + I_1 3$

$6 = 8I_1 + 8I_2 + 3I_1$

$6 = 11I_1 + 8I_2$ — (2)

$\varepsilon_2 = IR + I_2 r_2$

$4 = (I_1 + I_2) 8 + I_2 2$

$4 = 8I_1 + 8I_2 + 2I_2$

$4 = 8I_1 + 10I_2$ — (3)

$6 = 11I_1 + 8I_2 \times 8$

$4 = 8I_1 + 10I_2 \times 11$

$48 = 88I_1 + 64I_2$

$44 = 88I_1 + 110I_2$

$4 = 0 - 46I_2$

$\frac{4}{-46} = \frac{-46I_2}{-46}$

$I_2 = \frac{4}{-46} = -0.087A$

Sub the value in eqn (2)

$6 = 11I_1 + 8(-0.087)$

$6 = 11I_1 - 0.696$

$6 + 0.696 = 11I_1$

$6.696 = 11I_1 \quad I_1 = \frac{6.696}{11} = 0.6$

~~6.696~~ $\frac{6.696}{11} = \frac{11I}{11}$

... ?

$V = IR$

$I = \frac{V}{R}$

where R: $X_L = 2\pi f L$

$= 2\pi(50)(0.3)$

$R = 94.26$

$I = \frac{240}{94.26} = 2.55A$

$I = \frac{I_0}{\sqrt{2}} = 2.55 = \frac{I_0}{\sqrt{2}}$

$I_0 = 2.55 \times \sqrt{2}$

$= 3.6A$

3b. list the four (4) types of transformers and state their respective applications.

Soln.

i) Step-up transformers
ii) Step-down transformers
iii) Isolation transformers
iv) Air core ,,

Applications

=> Step-up transformers: Power distribution
=> Step-down tranformers: power transmition
=> Isolation transformers: safety purpose Insulation barrier
=> Air core transformer: Radio frequency application

4. The relation ... between ... sectional area and the resistance of the material is given as: $\rho = \frac{RA}{L}$

5. A 12kΩ and 8kΩ resistors are connected in series to a 9v battery. The p.d across the 12kΩ resistor is?

Soln.

~~$V = IR$ $R_T = R_1 + R_2 + R_n$~~

$9 = I$

$R_T = R_1 + R_2 .. R_n$

$R_T = 12 + 8$

$R_T = 20k\Omega$

$V = IR$

$9 = I20$

$\frac{9}{20} = \frac{I20}{20}$ $I = 9/20 = 0.45$

The p.d across 12kΩ

$V = IR$

$V = 0.45 \times 12$

$V = 5.4v$

6. Kirchhoff's second law states that; The algebraic sum of the Emf is equal to the algebraic sum of the product of the current and resistance.

$\Sigma \varepsilon = \Sigma(IR)$

$\bar{I} = ?$

$v = IR$

$I = \frac{v}{R}$

where $R = X_L = 2\pi f L$
$= 2\pi(50)(0.3)$
$R = 94.26$

$I = \frac{240}{94.26} = 2.55A$

$\bar{I} = \frac{I_0}{\sqrt{2}} = 2.55 = \frac{I_0}{\sqrt{2}}$

$I_0 = 2.55 \times \sqrt{2}$
$= 3.6A$

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=> Step-up transformers: Power distribution
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=> Isolation transformers: safety Purpose Insulation barrier
=> Air core transformer: Radio frequency application..

4. The relationship between length, l cross sectional area, A and the resistance of the material is given as: $\rho = \frac{RA}{L}$

5. A 12kΩ and 8kΩ resistors are connected in series to a 9V battery. The p.d across the 12kΩ resistor is?

Soln.

$V = IR$ $R_T = R_1 + R_2 + R_n = 12 + 8$

$9 = I$

$R_T = R_1 + R_2 .. R_n$

$R_T = 12 + 8$

$R_T = 20k\Omega$

$V = IR$

$9 = I20$

$\frac{9}{20} = \frac{I20}{20}$ $I = 9/20 = 0.45A$

The p.d across 12kΩ

$V = IR$

$V = 0.45 \times 12$

$V = 5.4V$

6. Kirchhoff's second law states that; The algebraic sum of the Emf is equal to the algebraic sum of the product of the current and resistance.

$\Sigma \varepsilon = \Sigma (IR)$

$I = I_1 + I_2$

$I = 0.609 + (-0.087)$

$I = 0.609 - 0.087$

$I = 0.522$

$\because$ $I = 0.522A$

$I_1 = 0.609A$

$I_2 = -0.087A$

11. A 100uf capacitor is connected to a 12V battery, a frepuency of 50Hz. The values of X_C and I_C are?

Soln.

$$X_C = \frac{1}{2\pi fC}$$

$$X_C = \frac{1}{2 \times 3.142 \times 50 \times 100 \times 10^{-6}}$$

$$X_C = 31.82\Omega$$

$$I_C = \frac{V}{X_C} = \frac{12}{31.82} = 0.377A$$