BEEE Digital Assignment -1

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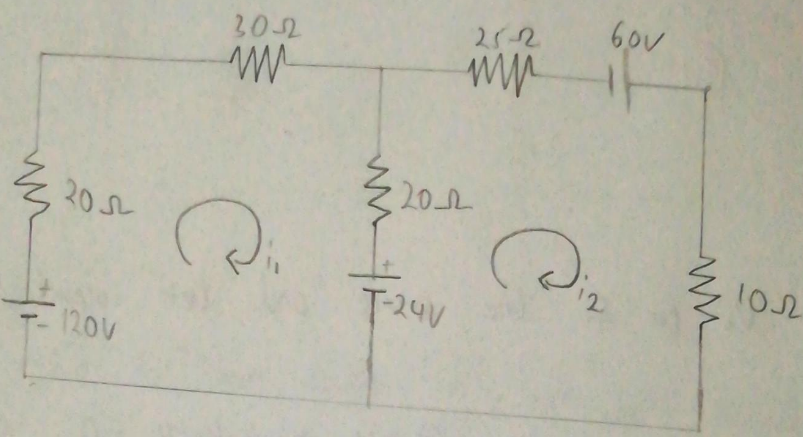
1.



Mesh 1:

Let i_1 be the current flowing through mesh 1:

$$120 - 20i_1 - 30i_1 - 20(i_1 - i_2) - 24 = 0$$
$$= -70i_1 + 20i_2 = -96 \rightarrow ①$$

Mesh 2:

Let i_2 be the current flowing through mesh 2:

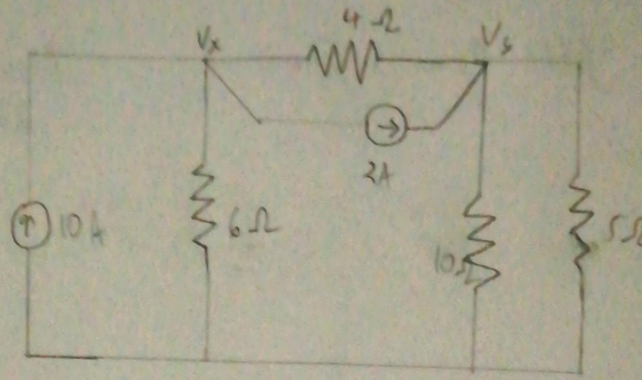
$$24 - 20(i_2 - i_1) - 25i_2 + 60 - 10i_2 = 0 \rightarrow ②$$

Solving equations ① and ②, we get:

$i_1 = 2.017\,A$
$i_2 = 2.260\,A$

∴ Current flowing through the 10Ω resistor $= i_2 = 2.260\,A$

2.



Assume V_x to be the source and let current be flowing out of it

$\therefore$ Equation at x node: $-10 + \frac{V_x}{6} + 2 + \frac{V_x - V_y}{4} = 0$

$= -240 + 4V_x + 48 + 6V_x - 6V_y = 0$

$= 10V_x - 6V_y = 192 \rightarrow (1)$

Next, assume V_y to be the source and let current be flowing out of it.

$\therefore$ Equation at y node $= \frac{V_y - V_x}{4} - 2 + \frac{V_y}{10} + \frac{V_y}{5} = 0$

$= 5V_y - 5V_x - 40 + 2V_y + 4V_y = 0$

$= -5V_x + 11V_y = 40 \rightarrow (2)$

Solving equations (1) and (2), we get:

$V_x = \underline{\underline{29.4V}}, \; V_y = \underline{\underline{17V}}$

$\therefore$ Current flowing through resistors:

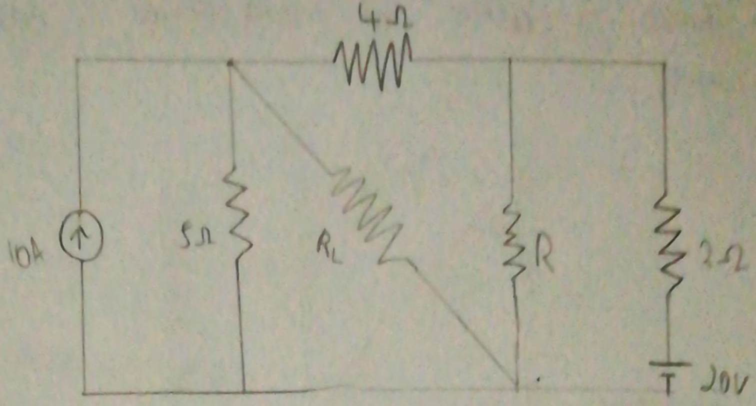
i) $6\Omega = \frac{V_x}{6} = \frac{29.4}{6} = \underline{\underline{4.9A}}$

ii) $4\Omega = \frac{V_x - V_y}{4} = \frac{12.4}{4} = \underline{\underline{3.1A}}$

iii) $10\Omega = \frac{V_y}{10} = \frac{17}{10} = \underline{\underline{1.7A}}$

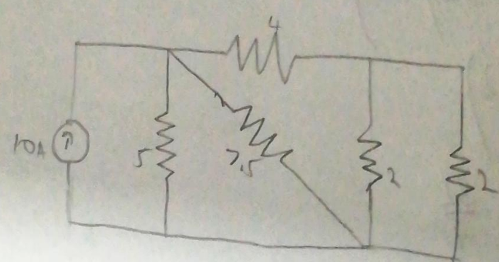
iv) $5\Omega = \frac{V_y}{5} = \frac{17}{5} = \underline{\underline{3.4A}}$

3.



Since the value for the resistor 'R', we will assume its value to be 2Ω

i) When current source is active and voltage source is shorted.



2Ω || 2Ω

$\therefore \cancel{R_{eq}}\ R_{eq} = \left(\frac{1}{2} + \frac{1}{2}\right)^{-1} = \underline{1\Omega}$

~~1Ω~~ 1Ω in series with 4Ω

$\therefore R_{eq} = 1 + 4 = 5\Omega$

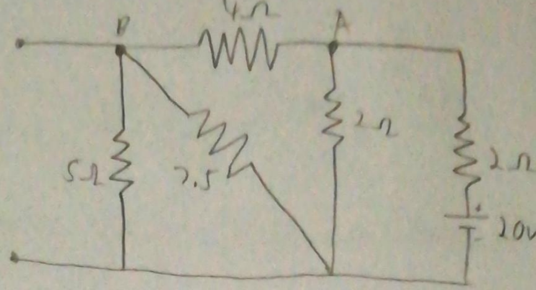
~~5||5~~ 5Ω || 5Ω

$\therefore R_{eq} = \left(\frac{1}{5} + \frac{1}{5}\right)^{-1} = \frac{5}{2} = 2.5\Omega$

Since 2.5Ω || 7.5Ω (R_L), we can apply current division rule:

$i_1 = \frac{I \times 2.5}{2.5 + 7.5} = = \frac{10 \times 2.5}{10} = \underline{2.5A} \rightarrow (1)$

i) Voltage source is active and current source is made into an open circuit.



We have to find equivalent resistance - R_{eq}

$$R_{eq} = 2 + \left(\left(4 + 7.5 \,||\, 5 \right) || \, 2 \right)$$

$$= 2 + \left(\left(4 + 3 \right) || \, 2 \right)$$

$$= 2 + \left(7 \,||\, 2 \right)$$

$$= 2 + \frac{14}{9} = \frac{32}{9} \, \Omega$$

$\therefore$ Current $= I = \dfrac{V}{R} = \dfrac{20}{\left(\frac{32}{9}\right)} = \dfrac{5 \times 9}{8} = 5.625\text{A}$

At point A, the current going through $4\Omega = I_A$

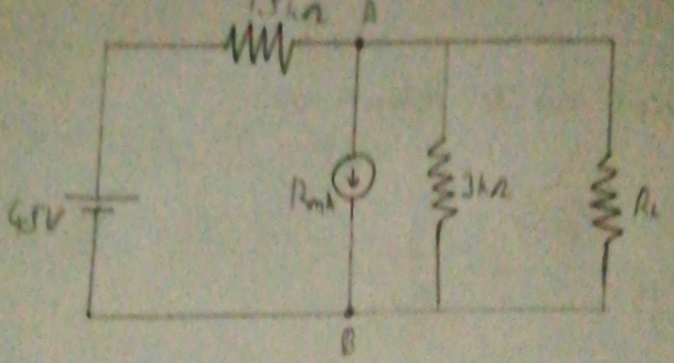
$$I_A = \frac{I \times 2}{7+2} = \frac{5.625 \times 2}{9} = 1.25\text{A}$$

At point B, the current going through $7.5\Omega = I_2$

$$I_2 = \frac{I_A \times 5}{5 + 7.5} = \frac{1.25 \times 5}{12.5} = 0.5\text{A} \rightarrow (2)$$

$\therefore$ Total current going through $R_L = I_1 + I_2 = 2.5 + 0.5 = \underline{3\text{A}}$

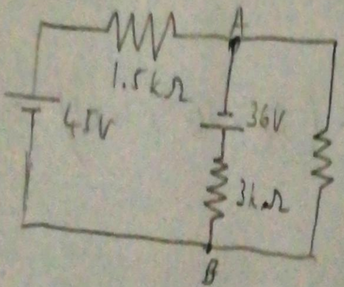
4.



To find thevenin's voltage (V_{TH}), we source transform the current source between A and B.

$V = IR$

$= 12 \times 10^{-3} \times 3 \times 10^{3} = 36V$



When we do mesh analysis

$45 - I \times 1.5 \times 10^{3} + 36 - I \times 3 \times 10^{3} = 0$

$81 = 4.5 \times 10^{3} \times I$

$I = 18 \times 10^{-3} = 18mA$

$\therefore$ Voltage drop at A: $IR = 18 \times 10^{-3} \times 1.5 \times 10^{3} = 27V$

$V_A = 45 - 27 = 28V$

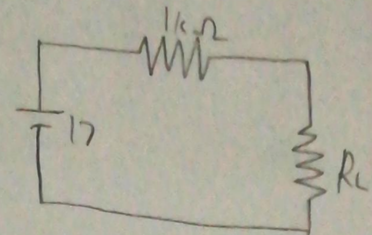
$V_B = 28 + 36 - (18 \times 10^{-3} \times 3 \times 10^{3}) = 64 - 54 = 10V$

$\therefore$ Voltage across AB $= V_A - V_B = 27 - 10 = 12V$

$\therefore V_{TH} = 12V$

$$R_{TH} = \left(\frac{1}{3 \times 10^{3}} + \frac{1}{1.5 \times 10^{3}}\right)^{-1} = \left(\frac{3}{3 \times 10^{3}}\right)^{-1} = 1k\Omega$$

Therefore, the circuit can be redrawn as:



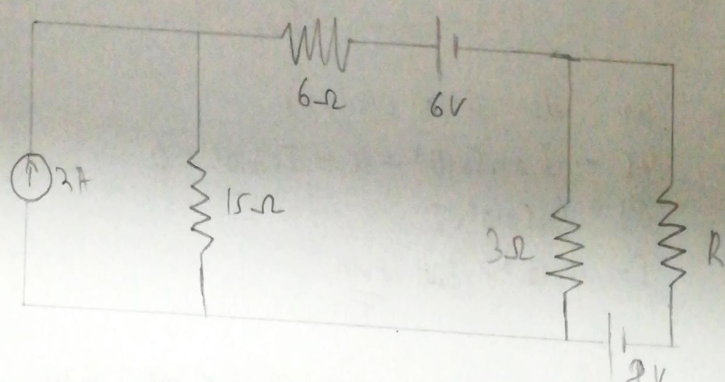
When $R_L = 2k\Omega$,

$R_{eq} = 1k + 2k = \underline{\underline{3k\Omega}}$

$\therefore$ Current $I = \frac{V}{R} = \underline{\underline{\frac{17}{3}}}$ mA

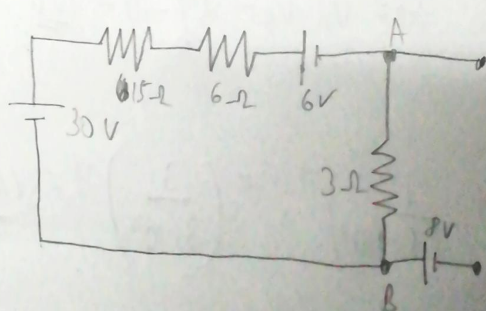
Voltage across $R_L = 17 - \left(\frac{17}{3} \times 10^{-3} \times 1\times10^{3}\right) = \underline{\underline{11.333...}}$ V

5.



Using source transformation, we can transform the current source to a voltage source.

$V = IR = 2 \times 15 = 30V$



Using mesh analysis:

$30 - 15i - 6i - 6 - 3i = 0$

$24 - 24i = 0$

$i = \underline{1A}$

$\therefore$ ~~Volty~~ Voltage drop at $A = 30 - (15\times1 + 6\times1 + 6) = \underline{3V}$

$V_A = 3V$

$V_B = 0 - 8$ (Since an 8V voltage source opposes current)

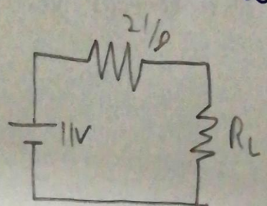
$= \underline{-8V}$

$\therefore V_{AB} = V_A - V_B = 3 - (-8) = \underline{11V}$

$\therefore V_{TH} = 11V$

$$R_{TH} = \left(\frac{1}{3} + \frac{1}{15+6}\right)^{-1} = \left(\frac{1}{3} + \frac{1}{21}\right)^{-1} = \underline{\frac{21}{8}\,\Omega}$$

$\therefore$ The circuit can be redrawn as:



For maximum power, $R_L = R_{TH}$

$\therefore R_L = \underline{21/8\,\Omega}$

$$\text{Maximum power: } \frac{V_{TH}^2}{4R_{TH}} = \frac{121}{4\times\frac{21}{8}} = \frac{121}{\left(\frac{21}{2}\right)} = \frac{121\times2}{21} = \underline{11.523\,W}$$

6. We know that for a sinusoidal AC, $V_{rms} = 0.707\, V_{max}$
$\omega = 2\pi f = 2\pi \times 50 = 100\pi$ rad/s, $V_{max} = 1.414 \times 200 = 282.8V$

$\therefore$ Instantaneous voltage $= v = 282.8 \sin(100\pi t)$

V at $t = 0.0125s$ $= 282.8 \sin(100\pi \times 0.0125)$
$= 282.8 \sin\left(\frac{5\pi}{4}\right)$
$= -282.8 \times \frac{1}{\sqrt{2}} = -\underline{\underline{200V}}$

For $V = 141.4V$, $\sin(\omega t) = \frac{1}{2}$ since $282.8 \times \frac{1}{2} = 141.4V$

$\therefore$ ~~at~~ ~~at~~ $\omega t = 100\pi t = \frac{\pi}{6}$

$\therefore t = \frac{1}{600} = 0.00\underline{\underline{1666}}\ldots s$

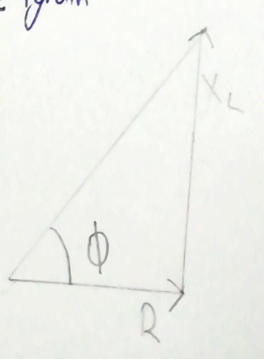
$\therefore$ The maximum positive value of instantaneous voltage will be 141.4V at $t = 0.00\underline{\underline{166}}s$.

7. $R = 5\Omega$, $L = 31.8\,mH = \frac{100}{\pi}\,mH$
$X_L = L\omega = \frac{100}{\pi} \times 10^{-3} \times 2\pi \times 50 = 10\Omega$

$Z = \sqrt{R^2 + X_L^2} = \sqrt{25 + 100} = \sqrt{125} = 11.1\underline{\underline{80}}\,\Omega$

$\therefore$ Current $= \frac{V}{Z} = \frac{200}{11.180} = \underline{\underline{17.889A}}$

Vector diagram



When a non-inductive resistance of 10Ω is connected in series with the coil.

$R = 5 + 10 = 15\Omega$, $X_L = 10\Omega$

$Z = \sqrt{R^2 + X_L^2} = \sqrt{15^2 + 10^2} = 18,027\Omega$

$I = \frac{V}{Z} = \frac{200}{18.027} = 11.094\ A$

~~Power ϕ = $\tan^{-1}\left(\frac{X_L}{R}\right)$ =~~

Power factor $= \cos\phi = \frac{R}{Z} = 0.554$