# SOLUTIONS

## ASSIGNMENT-I

Date of issue - 13/9/19 Date of Submission - 19/9/19

1. Refer to class notes.

2. Refer to class notes.

3. given $f = 50\,Hz$ $I_{rms} = 20\,A$
instantaneous equation, $i = I_{max} \sin(2\pi f t)$
$i = \sqrt{2} I_{rms} \sin(2\pi \times 50 \times t) = 20\sqrt{2}\sin(100\pi t)$ Ans

a) at $t = 0.0025$ sec, $i = ?$ after passing through a positive maximum value.
~~$i = 20\sqrt{2}\sin(100\pi \times 0.0025)$~~
hence instantaneous equation becomes
$$i = 20\sqrt{2}\sin\left(100\pi t + \frac{\pi}{2}\right) = 20\sqrt{2}\cos(100\pi t)$$
$$\therefore\ i = 20\sqrt{2}\cos(100\pi \times 0.0025) = 20\,A \text{ Ans}$$

b) at $t = 0.0125$ sec $i = ?$
$$\therefore\ i = 20\sqrt{2}\cos(100\pi \times 0.0125) = -20\,A$$
Now $i = 14.14$, measured from +ve max. value $t = ?$
$$\therefore\ 14.14 = 20\sqrt{2}\cos(100\pi t)$$
$$t = \frac{1}{100\pi}\cos^{-1}\left(\frac{14.14}{20\sqrt{2}}\right) = \frac{1}{100\pi}\cos^{-1}\left(\frac{1}{2}\right) = \frac{1}{100\pi} \times \frac{\pi}{3} = \frac{1}{300} \text{ sec or } 3.33 \times 10^{-3} \text{ sec Ans}$$

4. Since wave form given is non-symmetrical and sinusoidal function.
$\therefore$ $v = 100\sin\theta$ is the instantaneous equation
$$\text{Avg value, } V_{avg} = \frac{1}{\pi}\int_0^{\pi} 100\sin\theta\, d\theta = \frac{100}{\pi}\int_0^{\pi}\sin\theta\, d\theta = \frac{100}{\pi}\left[-\cos\theta\right]_0^{\pi}$$
$$V_{avg} = \frac{100}{\pi}\left[-\cos\pi + \cos 0\right] = \frac{100}{\pi}\left[1+1\right] = \frac{200}{\pi} = 63.66 \text{ volts Ans}$$
$$\text{RMS value, } V_{rms} = \sqrt{\frac{1}{\pi}\int_0^{\pi}(100\sin\theta)^2 d\theta} = \sqrt{\frac{100^2}{\pi}\int_0^{\pi}\sin^2\theta\, d\theta}$$
using $\cos 2\theta = 1 - 2\sin^2\theta$, $\sin^2\theta = \frac{1-\cos 2\theta}{2}$
$$V_{rms} = \sqrt{\frac{100^2}{\pi}\int_0^{\pi}\left(\frac{1-\cos 2\theta}{2}\right)d\theta} = \sqrt{\frac{100^2}{2\pi}\int_0^{\pi}\left(\frac{1-\cos 2\theta}{\cancel{2}}\right)d\theta}$$

$$V_{rms} = \sqrt{\frac{100^2}{2\pi}\left\{\int_0^{\pi} 1\, d\theta - \int_0^{\pi} \cos 2\theta\, d\theta\right\}} = \sqrt{\frac{100^2}{2\pi}\left\{\left[\theta\right]_0^{\pi} - \left[\frac{\sin 2\theta}{2}\right]_0^{\pi}\right\}}$$

$$V_{rms} = \sqrt{\frac{100^2}{2\pi}\left\{(\pi - 0) - \left(\frac{\sin 2\pi}{2} - \frac{\sin 0^\circ}{2}\right)\right\}} = \sqrt{\frac{100^2}{2\cancel{\pi}}(\cancel{\pi})}$$

$V_{rms} = \frac{100}{\sqrt{2}} = 70.71$ volts <u>Ans</u>

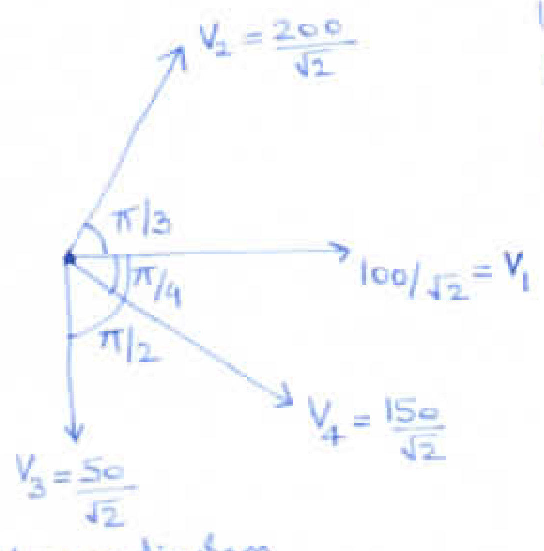
form factor, $K_f = \frac{V_{rms}}{V_{avg}} = \frac{70.71}{63.66} = 1.11$ <u>Ans</u>

5. given: $v_1 = 100 \sin 500t$ , $\phi_1 = 0^\circ$

$v_2 = 200 \sin\left(500t + \frac{\pi}{3}\right)$ , $\phi_2 = \frac{\pi}{3}$

$v_3 = -50 \cos 500t = 50 \sin\left(500t - \frac{\pi}{2}\right)$ , $\phi_3 = -\frac{\pi}{2}$

$v_4 = 150 \sin\left(500t - \frac{\pi}{4}\right)$ , $\phi_4 = -\pi/4$




phasor diagram

X-component,

$V_x = 100 \cos 0^\circ + 200 \cos(\pi/3) + 50 \cos\left(-\frac{\pi}{2}\right) + 150 \cos\left(-\frac{\pi}{4}\right)$

$V_x = 100 \times 1 + 200 \times 1/2 + 50 \times 0 + 150 \times 1/\sqrt{2} = 306.066$ volts

Y-component,

$V_y = 100 \sin 0^\circ + 200 \sin(\pi/3) + 50 \sin(-\pi/2) + 150 \sin(-\pi/4)$

$V_y = 100 \times 0 + 200 \times \frac{\sqrt{3}}{2} - 50 \times 1 - 150 \times 1/\sqrt{2} = 17.139$ volts

Resultant magnitude, $V_{R_{max}} = \sqrt{V_x^2 + V_y^2} = \sqrt{(306.066)^2 + (17.139)^2}$

$V_{R_{max}} = 306.545$ volts

$\therefore$ RMS value, $V_{rms} = \frac{V_{R_{max}}}{\sqrt{2}} = \frac{306.545}{\sqrt{2}} = 216.76$ volts <u>Ans</u>

⑥ given: $i_1 = 10\sin 314t$, $\phi_1 = 0^\circ$

$i_2 = 7.5\sin\left(314t - \frac{\pi}{3}\right)$, $\phi_2 = -\frac{\pi}{3}$

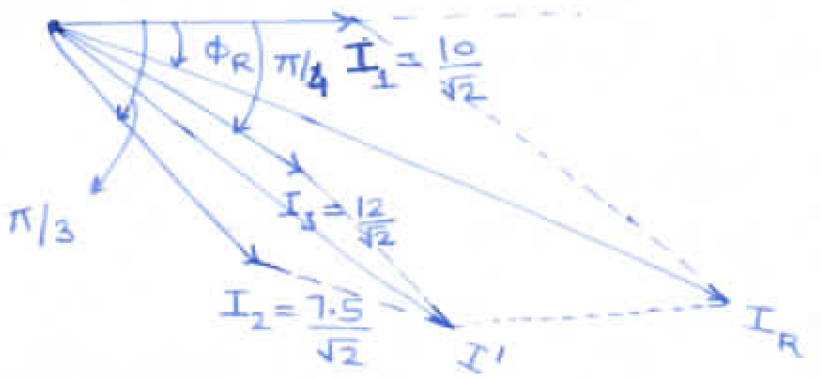
$i_3 = 12\sin\left(314t - \frac{\pi}{4}\right)$, $\phi_3 = -\frac{\pi}{4}$

X-component, $I_x = 10\cos 0^\circ + 7.5\cos\left(-\frac{\pi}{3}\right) + 12\cos\left(-\frac{\pi}{4}\right)$

$= 10\times 1 + 7.5\times\frac{1}{2} + 12\times\frac{1}{\sqrt{2}} = 22.235$ amp

Y-component, $I_y = 10\sin 0^\circ + 7.5\sin\left(-\frac{\pi}{3}\right) + 12\sin\left(-\frac{\pi}{4}\right)$

$= 10\times 0 + \left(-7.5\times\sqrt{3}/2\right) - 12\times 1/\sqrt{2} = -14.98$ amp



phasor diagram

Resultant magnitude, $I_{R_{max}} = \sqrt{I_x^2 + I_y^2} = \sqrt{(22.23)^2 + (-14.98)^2}$

$I_{R_{max}} = 26.80$ amp

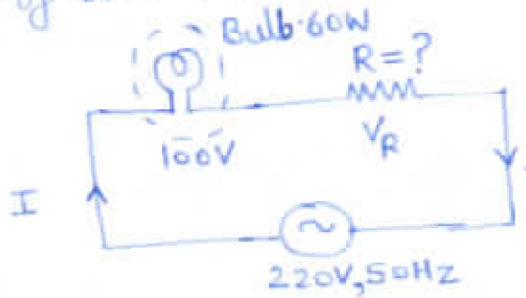
Resultant phase angle $\phi_R = \tan^{-1}\left(\frac{V_y}{V_x}\right) = \tan^{-1}\left(\frac{-14.98}{22.23}\right) = -0.592$ rad

instantaneous equation of resultant current, $i = 26.80\sin(314t - 0.592)$ Ans

rms value of resultant current, $I_{rms} = \frac{I_{R_{max}}}{\sqrt{2}} = \frac{26.80}{\sqrt{2}} = 18.95$ Amp Ans

⑦ please refer class notes. Topic Purely Inductive and purely capacitive circuit of unit-2.

⑧ soln:




current taken by bulb, $I = \frac{60}{100} = \frac{P}{V}$

$I = 0.6$ A

voltage across unknown resistance 'R'

$V_R = V - V_{bulb} = 220 - 100 = 120$V

(because bulb is considered purely resistive)

phasor diagram

Unknown resistance, $R = \frac{V_R}{I} = \frac{120}{0.6}$

$R = 200\,\Omega$ Ans

(9) Soln: $v = 50\sin(314t + 55^\circ)$, $\phi_1 = 55^\circ$

$i = 10\sin(314t + 325^\circ)$ $\phi_2 = 325^\circ$

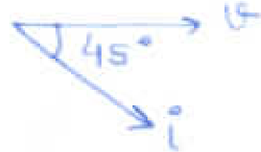
phase difference between voltage and current $\phi = \phi_1 - \phi_2$

$\phi = 55 - 325 = -270^\circ$

$\therefore$ Power drawn $P = VI\cos\phi = \frac{50}{\sqrt{2}} \times \frac{10}{\sqrt{2}}\cos(270^\circ) = 0$ Ans

(10) Soln: given $v = 283\sin 314t$ $\phi_1 = 0^\circ$

$i = 4\sin(314t - 45^\circ)$ $\phi_2 = -45^\circ$




$\therefore \omega = 314$, $f = \frac{314}{2\pi} = 50\,Hz$

phase angle,

$\phi = \phi_1 - \phi_2 = 0 - (-45) = 45^\circ$

power factor, $\cos\phi = \cos(45) = \frac{1}{\sqrt{2}} = 0.707$ lagging Ans ($\because \phi$ is +ve) or current is lagging)

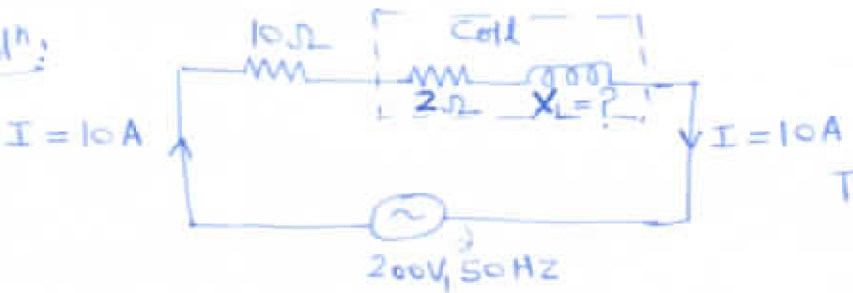
Resistance $R = Z\cos\phi = \frac{V_{max}}{I_{max}}\cos\phi = \frac{283}{4} \times 0.707$

$R = 50.02\,\Omega$ Ans

Inductive reactance, $X_L = Z\sin\phi = \frac{283}{4}\sin(45^\circ) = 50.02\,\Omega$

$\therefore X_L = 2\pi f L \Rightarrow L = \frac{X_L}{2\pi f} = \frac{X_L}{\omega} = \frac{50.02}{314} = 0.159\,H$ Ans

(11) Soln:




$Z = \frac{V}{I} = \frac{200}{10} = 20\,\Omega$

Total resistance $= 10 + 2 = 12\,\Omega$

Impedance of the circuit, $Z = \sqrt{(10+2)^2 + X_L^2} = \sqrt{(12)^2 + X_L^2}$

$20 = \sqrt{(12)^2 + X_L^2} \Rightarrow X_L = \sqrt{(20)^2 - (12)^2} = 16\,\Omega$

Inductance of coil,

i) $\therefore L = \frac{X_L}{2\pi f} = \frac{16}{2\pi \times 50} = 0.0509\,H$ Ans

Impedance of coil, $Z_{coil} = \sqrt{R_{coil}^2 + X_L^2} = \sqrt{(2)^2 + (16)^2} = 16.124\,\Omega$

ii) power factor of coil, $\cos\phi_{coil} = \frac{R_{coil}}{Z_{coil}} = \frac{2}{16.124} = 0.1240$ (lagging) Ans

power factor of circuit, $\cos\phi = \frac{R_{Total}}{Z} = \frac{12}{20} = 0.6$ lagging Ans

iii) quality factor of coil, $Q\text{-factor} = \frac{\omega L}{R_{coil}} = \frac{X_L}{R_{coil}} = \frac{16}{2} = 8$ Ans

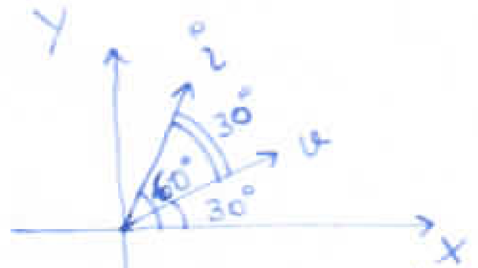
iv) voltage across coil, $V_{coil} = I Z_{coil} = 10 \times 16.124 = 161.24$ volts Ans

(13) given: $v = 100\sin(\omega t + 30^\circ)$ $\phi_1 = 30^\circ$

$i = 20\sin(\omega t + 60^\circ)$ $\phi_2 = 60^\circ$

phase angle, $\phi = \phi_1 - \phi_2 = 30 - 60 = -30^\circ$

Since $\phi$ is "−ve" hence current is leading.



current is leading

impedance, $Z = \frac{V_{max}}{I_{max}} = \frac{100}{20} = 5\,\Omega$ Ans

resistance $R = Z\cos\phi = 5\cos(30) = 5 \times \frac{\sqrt{3}}{2} = 4.33\,\Omega$ Ans

reactance $X = Z\sin\phi = 5\sin(30) = 5 \times \frac{1}{2} = 2.5\,\Omega$ (capacitive) Ans
($\because$ current is leading)

power factor, $\cos\phi = \cos(30^\circ) = \frac{\sqrt{3}}{2} = 0.866$ (leading) Ans

power, $P = VI\cos\phi = \frac{100}{\sqrt{2}} \times \frac{20}{\sqrt{2}} \times 0.866 = 866$ watts Ans

(14) given: $R = 10\,\Omega$, $L = 0.1\,H$, $C = 50\,\mu F$, $v(t) = 141.4\cos(100\pi t)$.

from voltage equation, $\omega = 100\pi$ rad/sec.

Now, ii) $X_L = \omega L = 100\pi \times 0.1 = 31.415\,\Omega$ Ans

iii) $X_C = \frac{1}{\omega C} = \frac{1}{100\pi \times 50 \times 10^{-6}} = 63.661\,\Omega$ Ans

Impedance of the circuit, $Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{(10)^2 + (31.415 - 63.661)^2}$

$Z = 33.76\,\Omega$

phase angle of the circuit, $\phi = \tan^{-1}\left(\frac{X_C - X_L}{R}\right)$

$$\phi = \tan^{-1}\left(\frac{63.661 - 31.415}{10}\right) = 72.77^\circ$$

$\therefore$ expression for instantaneous current,

$$i = \frac{V_{max}}{Z}\cos(100\pi t + 72.77^\circ) = \frac{141.4}{33.76}\cos(100\pi t + 72.77^\circ)$$

i) $i = 4.188\cos(100\pi t + 72.77^\circ)$ amp Ans

ii) power factor of circuit, $\cos\phi = \cos(72.77^\circ) = 0.2962$ (leading) Ans
(because $X_C > X_L$)

iv) voltage drop across resistance, $V_R = IR = \frac{4.188}{\sqrt{2}} \times 10 = 29.61$ volts Ans

voltage drop across inductance, $V_L = IX_L = \frac{4.188}{\sqrt{2}} \times 31.415 = 93.03$ volts Ans

voltage drop across capacitor, $V_C = IX_C = \frac{4.188}{\sqrt{2}} \times 63.661 = 188.52$ volts Ans

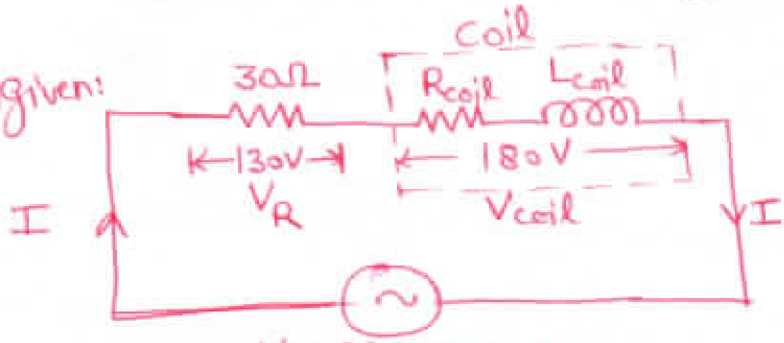
v) Active, Power $= VI\cos\phi = \frac{141.4}{\sqrt{2}} \times \frac{4.188}{\sqrt{2}} \times 0.2962 = 87.702$ watts Ans

Reactive power $= VI\sin\phi = \frac{141.4}{\sqrt{2}} \times \frac{4.188}{\sqrt{2}} \times \sin(72.77)$

$= 282.804$ VAR Ans

Apparent power, $= VI = \frac{141.4}{\sqrt{2}} \times \frac{4.188}{\sqrt{2}} = 296.091$ VA Ans

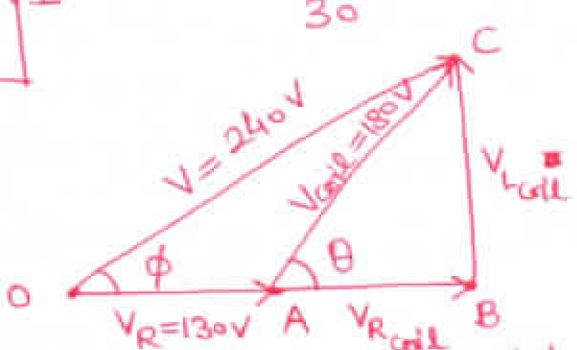
(12) given:




$V = 240V, 50HZ$

current in circuit,

$$I = \frac{130}{30} = 4.33\text{ A}$$




phasor diagram of the ckt

from phasor diagram,

$$OC^2 = OB^2 + BC^2$$

$$OC^2 = (OA + AB)^2 + BC^2$$

$$(240)^2 = (130 + 180\cos\theta)^2 + (180\sin\theta)^2$$

(16) given: $v = 100\sin(314t - \pi/4)$ volts

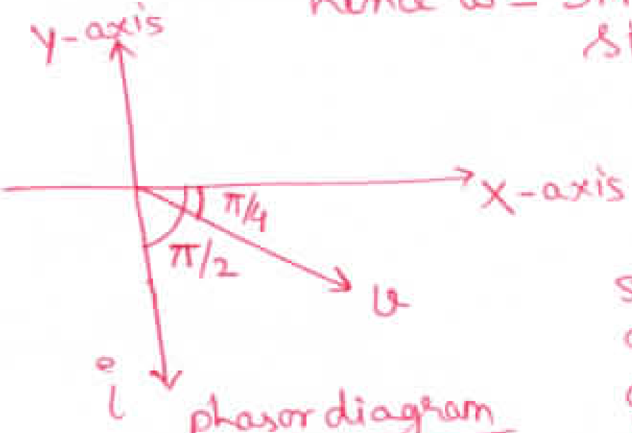
$i = 20\sin(314t - 90^\circ) = 20\sin(314t - \pi/2)$ amps.

hence $\omega = 314$ rad/sec

since phase angle $\phi = -\frac{\pi}{4} - \left(-\frac{\pi}{2}\right)$

$\phi = -\frac{\pi}{4} + \frac{\pi}{2} = \frac{-2\pi + \pi}{4}$

$\phi = \pi/4 = 45^\circ$




phasor diagram

since phase angle is 45° and is positive and also phase diagram shows that current is lagging behind voltage by $\pi/4$ rad. Hence circuit has two elements namely resistance and inductance.

$\therefore Z = \frac{V_{max}}{I_{max}} = \frac{100}{20} = 5\,\Omega$

$\therefore R = Z\cos\phi = 5\cos(45) = 5 \times 1/\sqrt{2} = 3.53\,\Omega$ Ans

& $X_L = Z\sin\phi = 5\sin(45) = 3.53\,\Omega$

$\because X_L = 2\pi f L$, $L = \frac{X_L}{2\pi f} = \frac{X_L}{\omega} = \frac{3.53}{314} = 0.0112\,H$

or $L = 11.2$ mH Ans

since $\omega = 2\pi f = 314$

$\therefore f = \frac{\omega}{2\pi} = \frac{314}{2\pi} = 50$ Hz Ans

(17) given: $R_{coil} = 8\,\Omega$ $L_{coil} = 0.12\,H$, $C = 140\,\mu F = 140 \times 10^{-6}\,F$

$V = 230$ volts, $f = 50$ Hz.

$X_L = 2\pi f L_{coil} = 2\pi \times 50 \times 0.12 = 37.69\,\Omega$

$X_C = \frac{1}{2\pi f C} = \frac{1}{2\pi \times 50 \times 140 \times 10^{-6}} = 22.73\,\Omega$

i) $Z = \sqrt{R_{coil}^2 + (X_L - X_C)^2} = \sqrt{(8)^2 + (37.69 - 22.73)^2} = 16.96\,\Omega$ Ans

ii) $I_{condenser} = \frac{V}{Z} = \frac{230}{16.96} = 13.55$ Amp Ans

iii) $\cos\phi = \frac{R_{coil}}{Z} = \frac{8}{16.96} = 0.4716$ lagging ($\because X_L > X_C$) Ans

$$(240)^2 = (130)^2 + (180)^2 \cos^2\theta + 2\times130\times180\cos\theta + (180)^2\sin^2\theta$$

$$(240)^2 = (130)^2 + (180)^2[\cos^2\theta + \sin^2\theta] + 2\times130\times180\cos\theta$$

$$(240)^2 = (130)^2 + (180)^2 + 46800\cos\theta$$

$$46800\cos\theta = (240)^2 - \{(130)^2 + (180)^2\}$$

$$468\cancel{00}\cos\theta = 83\cancel{00}$$

$$\cos\theta = \frac{83}{468} = 0.17735$$

or $\theta = \cos^{-1}(0.177) = 79.78^\circ$

$\therefore V_{R_{coil}} = 180\cos\theta = 180\times0.177 = 31.92$ volts

$\therefore R_{coil} = \frac{V_{R_{coil}}}{I} = \frac{31.92}{4.33} = 7.37\,\Omega$

i) power consumed by the coil, $P_{coil} = V_{coil} I_{coil} \cos\phi_{coil}$

or $P_{coil} = I^2 R_{coil} = (4.33)^2 \times 7.37 = 138.22$ watts Ans

ii) Power factor of the whole circuit,

$\cos\phi = \frac{R_T}{Z} = \frac{30+7.37}{55.43} = 0.6741$ Ans lagging $\quad \because Z = \frac{V}{I} = \frac{240}{4.33} = 55.4\,\Omega$

(15) given: $L = 50\,mH = 50\times10^{-3}\,H$ ; $Z = 20\,\Omega$ ; $\cos\phi = 0.5$ lagging.

as we know that, $R = Z\cos\phi = 20\times0.5 = 10\,\Omega$

$\therefore$ Resistance of coil $R = 10\,\Omega$ Ans $\quad \because \cos\phi = 0.5 \quad \sin\phi = \sqrt{1-(0.5)^2}$

$\phi = 60^\circ \quad \sin\phi = \sqrt{3}/2$

since $X_L = Z\sin\phi = 20\times\sin 60^\circ = 20\times\sqrt{3}/2$

$X_L = 17.32\,\Omega$

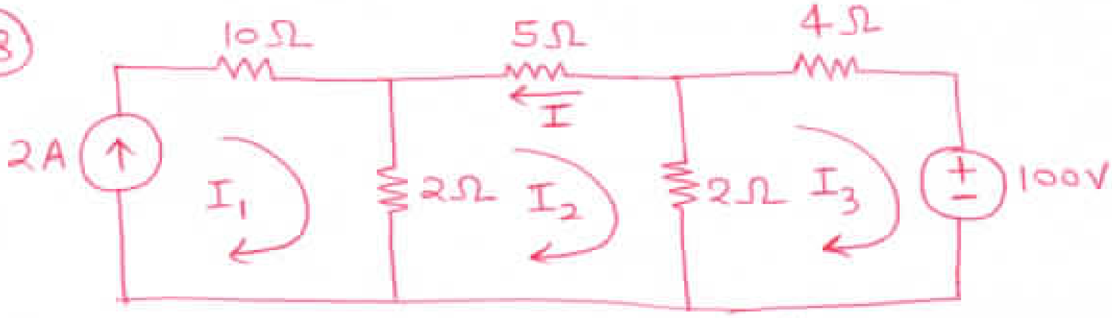
as we know that, $X_L = \omega L$

$\therefore \omega = \frac{X_L}{L} = \frac{17.32}{50\times10^{-3}} = 346.41$ rad/sec Ans

iv) voltage across condenser, $V_c = I X_c = 13.55 \times 22.73$

$V_c = 307.99$ volts. Ans

(18)



~~since $I_1 = +2$~~ since $I_1 = 2A$ (given)

KVL equation of mesh II

$-2(I_2 - 2) - 5I_2 - 2(I_2 - I_3) = 0$

$0I_1 - 9I_2 + 2I_3 = -4$ —— (I)

KVL equation of mesh III

$-2(I_3 - I_2) - 4I_3 - 100 = 0$

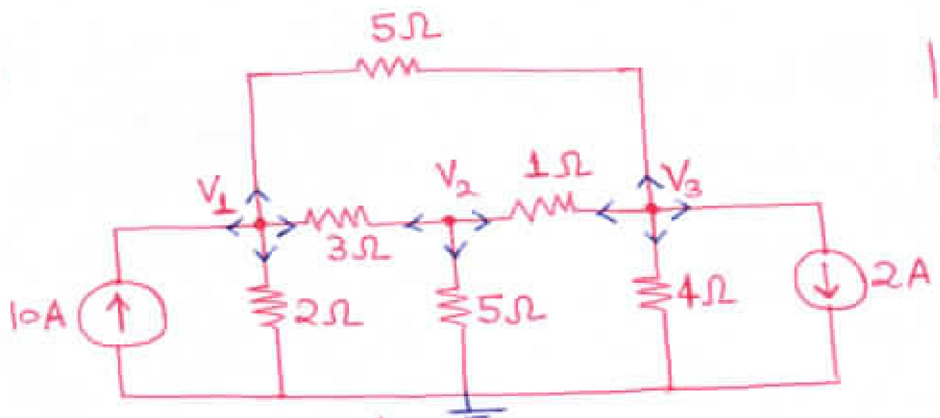
$2I_2 - 6I_3 = 100$ —— (II)

Solving eq. (I) & eq. (II) we get,

$I_2 = -3.52A \quad I_3 = -17.84A$

$I = -I_2 = 3.52A$ Ans

(19)



applying KCL at node-1

$-10 + \frac{V_1}{2} + \frac{V_1 - V_2}{3} + \frac{V_1 - V_3}{5} = 0$

$\frac{-300 + 15V_1 + 10V_1 - 10V_2 + 6V_1 - 6V_3}{30} = 0$

$31V_1 - 10V_2 - 6V_3 = 300$ —— (1)

applying KCL at node-2

$\frac{V_2 - V_1}{3} + \frac{V_2}{5} + \frac{V_2 - V_3}{1} = 0$

$\frac{5V_2 - 5V_1 + 3V_2 + 15V_2 - 15V_3}{15} = 0$

$-5V_1 + 23V_2 - 15V_3 = 0$ —(2)

applying KCL at node-3

$\frac{V_3 - V_1}{5} + \frac{V_3 - V_2}{1} + \frac{V_3}{4} + 2 = 0$

$\frac{4V_3 - 4V_1 + 20V_3 - 20V_2 + 5V_3 + 40}{20} = 0$

$-4V_1 - 20V_2 + 29V_3 = -40$ —(3)

solving eq. ①, ② & ③ we get,

$V_1 = 12.06$ volts ; $V_2 = 5.1$ volts (or 5.1009) ; $V_3 = 3.8$ volts

Now from circuit diagram:

$$I_1 = \frac{V_1 - V_3}{5} = \frac{12.06 - 3.8}{5} = 1.652\text{ A} \quad \underline{\underline{\text{Ans}}}$$

$$I_2 = \frac{V_1 - V_2}{3} = \frac{12.06 - 5.1}{3} = 2.32\text{ A} \quad \underline{\underline{\text{Ans}}}$$

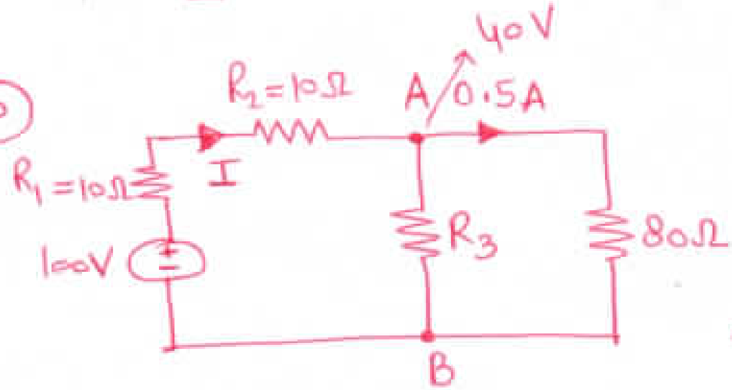
$$I_3 = \frac{V_1}{2} = \frac{12.06}{2} = 6.03\text{ A} \quad \underline{\underline{\text{Ans}}}$$

$$I_4 = \frac{V_2}{5} = \frac{5.1}{5} = 1.02\text{ A} \quad \underline{\underline{\text{Ans}}}$$

$$I_5 = \frac{V_3}{4} = \frac{3.8}{4} = 0.95\text{ A} \quad \text{Ans}$$

$$I_6 = \frac{V_2 - V_3}{1} = 5.1 - 3.8 = 1.3\text{ A} \quad \text{Ans}$$

(20)

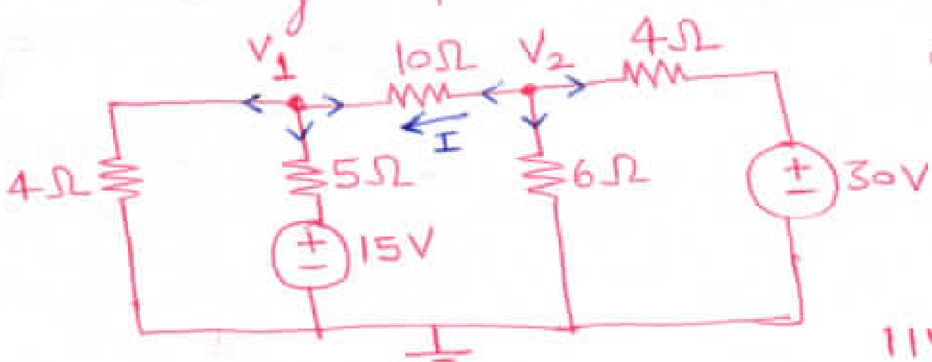



voltage at node A $= 0.5 \times 80 = 40$ V

$$\therefore \text{ current } I = \frac{100 - 40}{10 + 10} = 3\text{ A}$$

$\therefore$ voltage drop across $R_1 = 3 \times 10 = 30$ volts
voltage drop across $R_2 = 3 \times 10 = 30$ volts } $\underline{\underline{\text{Ans}}}$

(21)




applying KCL at node-1

$$\frac{V_1}{4} + \frac{V_1 - 15}{5} + \frac{V_1 - V_2}{10} = 0$$

$$\frac{5V_1 + 4V_1 - 60 + 2V_1 - 2V_2}{20} = 0$$

$$11V_1 - 2V_2 = 60 \quad \text{——} ①$$

applying KCL at node-2

$$\frac{V_2 - V_1}{10} + \frac{V_2}{6} + \frac{V_2 - 30}{4} = 0 \Rightarrow \frac{6V_2 - 6V_1 + 10V_2 + 15V_2 - 450}{60} = 0$$

$6V_2 - 6V_1 + 10V_2 + 15V_2 = 450$

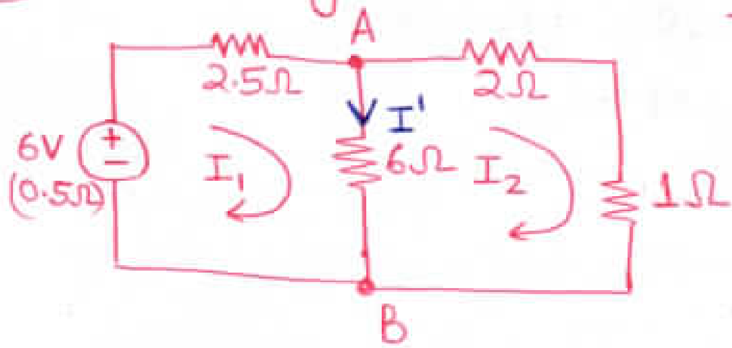
$-6V_1 + 31V_2 = 450$ —— (2)

Solving eq.(1) & eq.(2) we get,

$V_1 = 8.389$ volts ; $V_2 = 16.139$ volts

hence $I = \frac{V_2 - V_1}{10} = \frac{16.139 - 8.389}{10} = 0.7750$ A Ans

(22) Considering 6V source.




KVL equation of mesh-1

$-0.5I_1 + 6 - 2.5I_1 - 6(I_1 - I_2) = 0$

$-9I_1 + 6I_2 = -6$ —— (1)

KVL equation of mesh-2

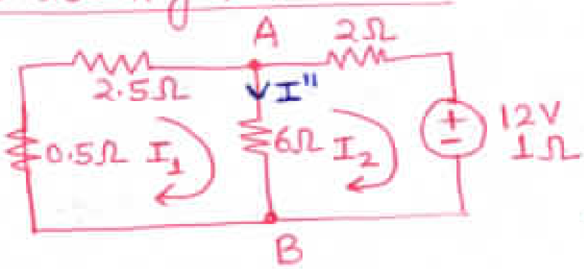
$-6(I_2 - I_1) - 2I_2 - 1I_2 = 0$

$6I_1 - 9I_2 = 0$ —— (2)

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

$I_1 = 1.2A$ , $I_2 = 0.8A$ $\therefore I' = I_1 - I_2 = 1.2 - 0.8 = 0.4A (\downarrow)$

Considering 12V source:




KVL equation of mesh-1

$-0.5I_1 - 2.5I_1 - 6(I_1 - I_2) = 0$

$-9I_1 + 6I_2 = 0$ —— (3)

KVL equation of mesh-2

$-6(I_2 - I_1) - 2I_2 - 12 - 1I_2 = 0$

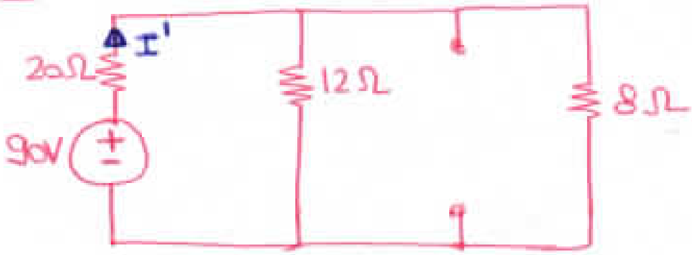
$6I_1 - 9I_2 = 12$ —— (4)

solving eq.(3) and (4) we get,

$I_1 = -1.6A$ ; $I_2 = -2.4A$ ; $\therefore I'' = I_1 - I_2 = -1.6 - (-2.4) = 0.8A(\downarrow)$

Hence current in branch AB, $I = I' + I'' = 0.4A + 0.8A = 1.2A(\downarrow)$ Ans

(23) Consider 90V source:

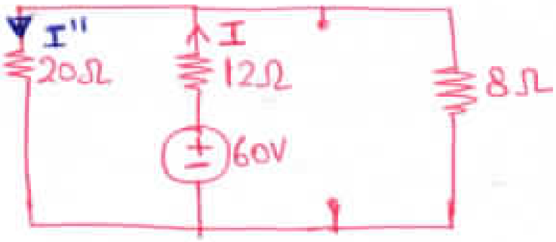



$R_{eq} = (12 \| 8) + 20 = \left(\frac{12 \times 8}{12+8}\right) + 20$

$R_{eq} = 24.8\,\Omega$

$\therefore I' = \frac{90}{24.8} = 3.629\text{ A } (\uparrow)$

Consider 60 V source




$R_{eq}$ for 60V source,

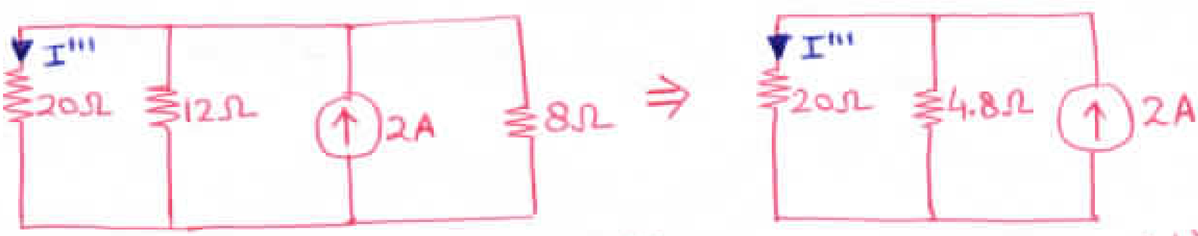
$R_{eq} = (20 \| 18) + 12 = \frac{20 \times 8}{20+8} + 12$

$R_{eq} = 17.71\,\Omega$

$I = \frac{60}{17.71} = 3.38\text{ A}$

$\therefore I'' = I \times \frac{8}{20+8} = 3.38 \times \frac{8}{28} = 0.967\text{ A } (\downarrow)$

Consider 2A source




$(12 \| 8)$

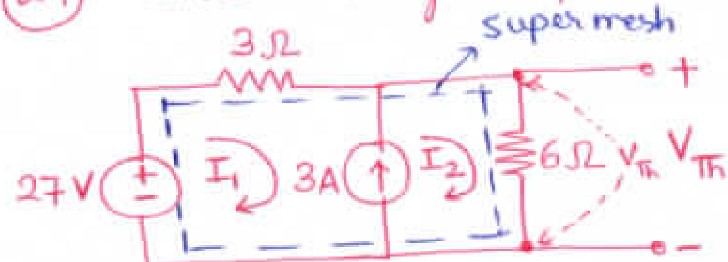
$\frac{12 \times 8}{12+8} = 4.8\,\Omega$

$I''' = 2 \times \frac{4.8}{20+4.8} = 0.387\text{ A } (\downarrow)$

Hence current in 20Ω resistor $= I' - (I'' + I''') = 3.629 - (0.967 + 0.387)$

$= 3.629 - (0.967 + 0.387) = 2.275\text{ A } (\uparrow)$ Ans

(24) Circuit diagram for $V_{Th}$;




First equation; $I_2 - I_1 = 3$

$\Rightarrow -I_1 + I_2 = 3$ —— (1)

Equation of supermesh,

$27 - 3I_1 - 6I_2 = 0$

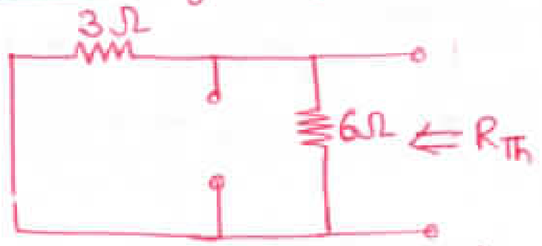
$3I_1 + 6I_2 = 27$ —— (2)

Solving eq. (1) & eq (2) we get,

$I_1 = 1\text{ A}$ , $I_2 = 4\text{ A}$

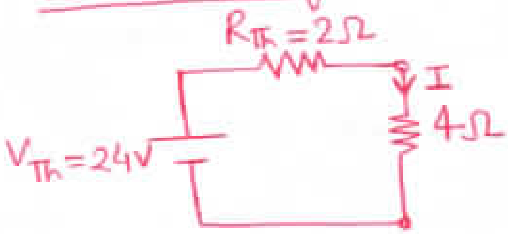
$\therefore$ voltage across 6Ω resistor i.e $V_{Th} = 6I_2 = 6 \times 4 = 24$ volts.

Circuit diagram of $R_{Th}$



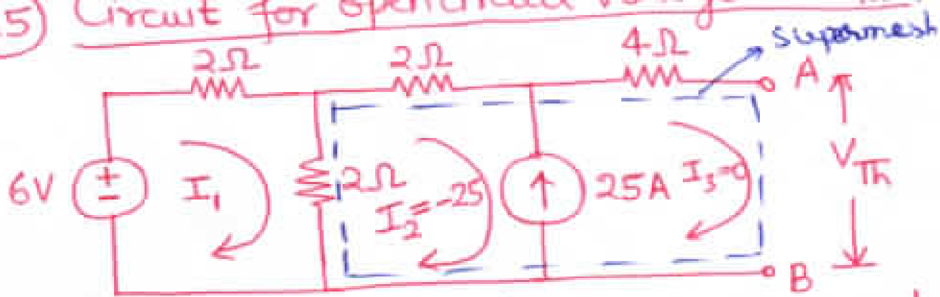

$$R_{Th} = (3 \| 6) = \frac{3 \times 6}{3+6} = \frac{18}{9} = 2\,\Omega$$

Thevenin's Equivalent circuit:




$$\therefore I = \frac{24}{2+4} = 4\,A \quad \text{Ans}$$

(25) Circuit for open circuit voltage i.e $V_{Th}$:




First equation from super mesh,

$I_3 - I_2 = 25$

$0 - I_2 = 25$, $I_2 = -25\,A$

KVL equation for mesh-I

$6 - 2I_1 - 2[I_1 - (-25)] = 0$

$6 - 2I_1 - 2I_1 - 50 = 0$

$-4I_1 - 44 = 0$

$I_1 = -11\,A$

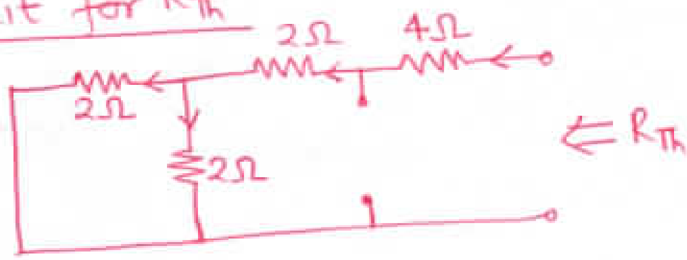
Equation of supermesh:

$-2(-25 - I_1) - 2(-25) - 4(0) - V_{Th} = 0$

$50 + 2(-11) + 50 - V_{Th} = 0$

$V_{Th} = 78$ volts Ans

Circuit for $R_{Th}$

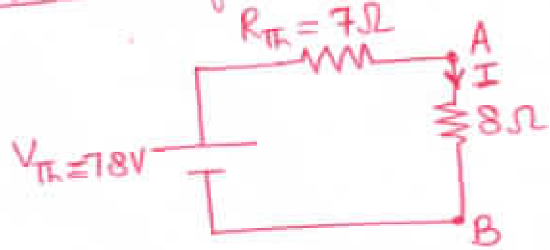



$$R_{Th} = \{(2\|2)\} + (2+4)$$

$$= \left\{\frac{2 \times 2}{2+2}\right\} + 6$$

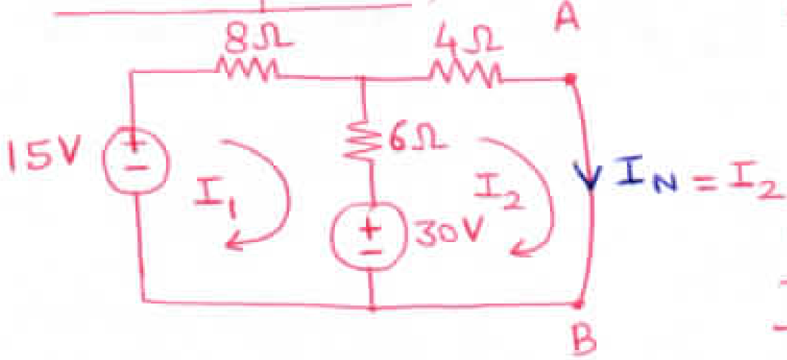
$$R_{Th} = 7\,\Omega \quad \text{Ans}$$

Thevenin's Equivalent circuit;




$$I = \frac{78}{7+8} = 5.2\,A \quad \text{Ans}$$

(26) Circuit for $I_N$;




KVL equation of mesh-1

$$15 - 8I_1 - 6(I_1 - I_2) - 30 = 0$$

$$-14I_1 + 6I_2 = 15 \quad \text{---(1)}$$

KVL equation of mesh-2

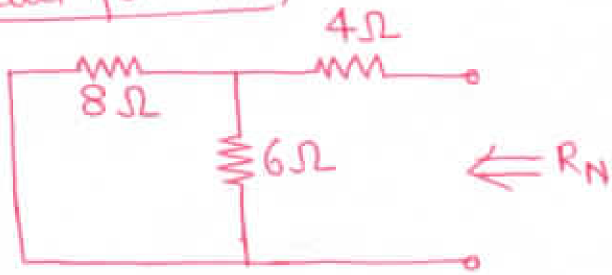
$$-6(I_2 - I_1) - 4I_2 + 30 = 0$$

$$6I_1 - 10I_2 = -30 \quad \text{---(2)}$$

Solving eq. (1) & (2) we get,

$I_1 = 0.288$ A , $I_2 = 3.173$ A Hence $I_N = 3.173$ A

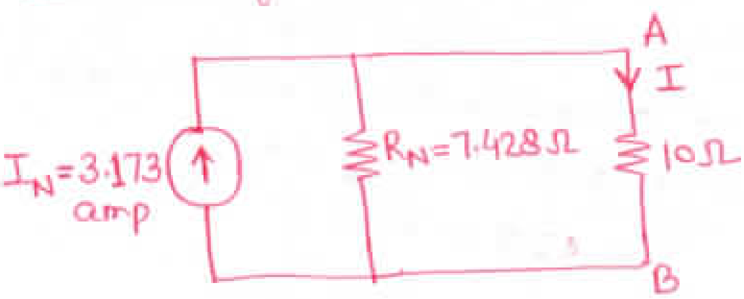
Circuit for $R_N$;




$$R_N = (8 \parallel 6) + 4 = \left(\frac{8 \times 6}{8+6}\right) + 4$$

$$R_N = 7.428\ \Omega$$

Norton's Equivalent Circuit;




$$\therefore I = I_N \times \frac{R_N}{R_N + R_L}$$

$$I = 3.173 \times \frac{7.428}{7.428 + 10}$$

$$I = 1.352 \text{ A} \quad \underline{\underline{\text{Ans}}}$$

(27) Circuit for $I_N$;

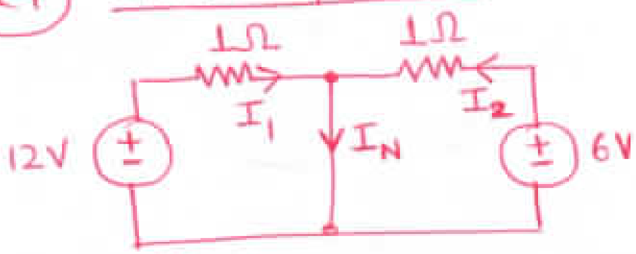
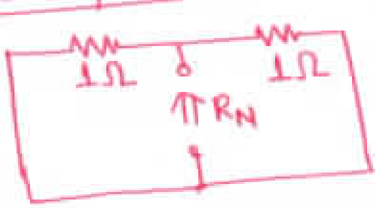



fig (9)

In fig (9): $I_N = I_1 + I_2$

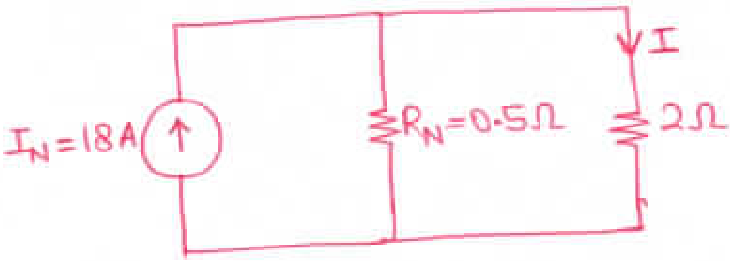
$$I_N = \frac{12}{1} + \frac{6}{1} = 18 \text{ A}$$

Circuit for $R_N$




$$R_N = 1 \parallel 1 = \frac{1}{2} = 0.5\ \Omega$$

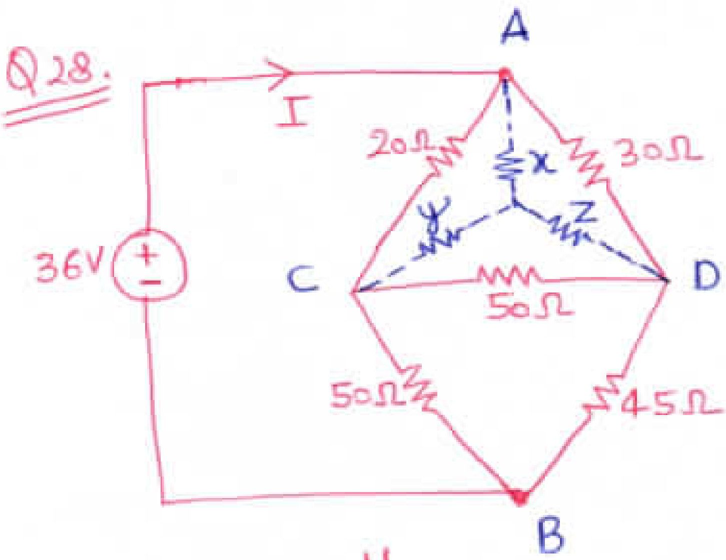
## Norton's Equivalent Circuit ;




$$\therefore I = 18 \times \frac{0.5}{0.5+2}$$

$$I = 3.6\ A \quad \underline{\underline{\text{Ans}}}$$

**Q28.**



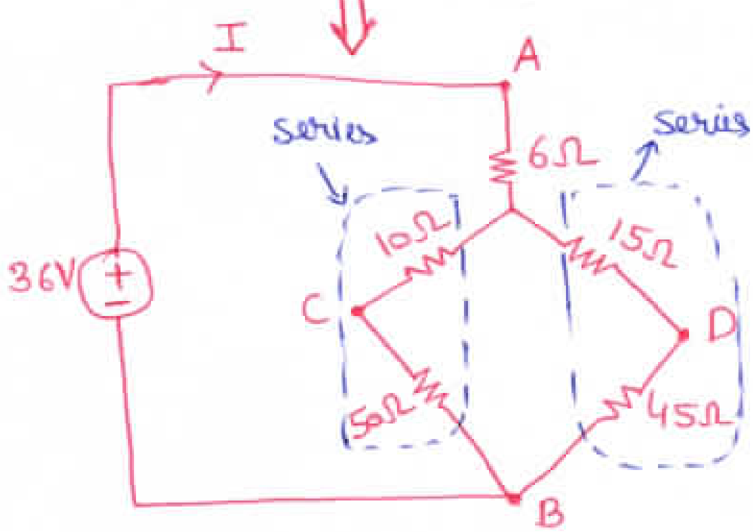

using delta to star conversion in network ADC,

$$x = \frac{20 \times 30}{20+30+50} = 6\,\Omega$$

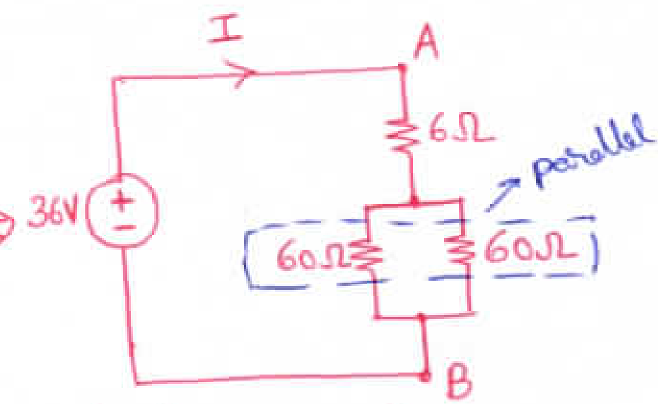
$$y = \frac{20 \times 50}{20+30+50} = 10\,\Omega$$

$$z = \frac{30 \times 50}{20+30+50} = 15\,\Omega$$

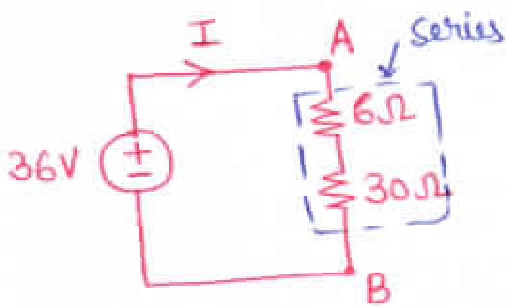
$\Downarrow$




$\Rightarrow$




$(60 \| 60 = 30\Omega)$




$\Rightarrow$

$$I = \frac{36}{36} = 1\ A \quad \underline{\underline{\text{Ans}}}$$