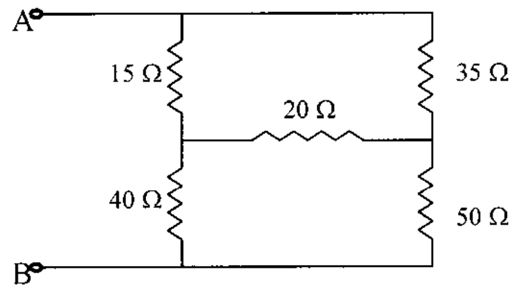
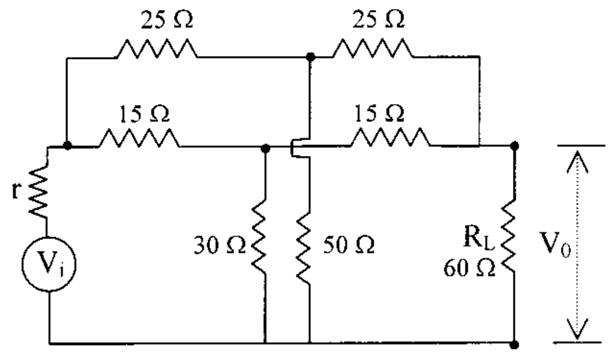
Physics 228
Home Work Chapter I

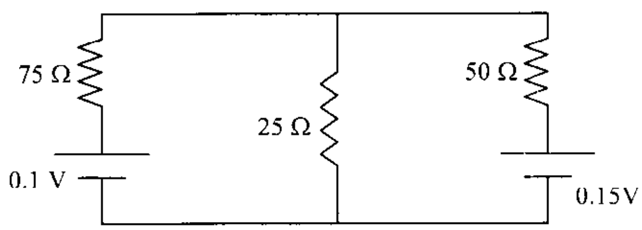
I. Determine the resistance between A and B.



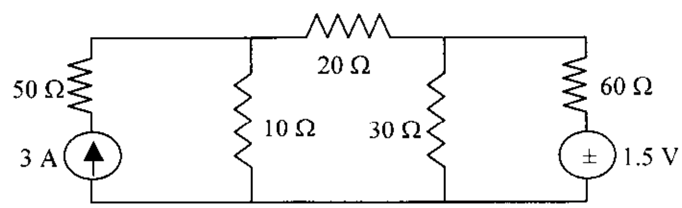
II. The Twin-T circuit is inserted between The power supply with internal resistance r = 60Ω. Determine the insertion loss (V_0/V_i).



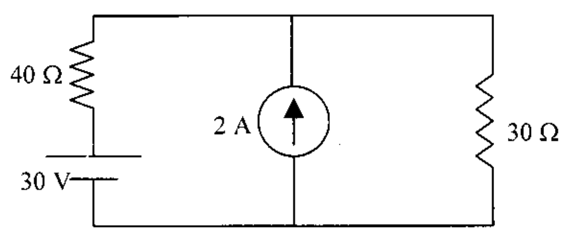
III. Determine the current in each resistor. Calculate the current in the 25 Ω resistor using the principle of superposition.



IV. Determine the power delivered by each source.

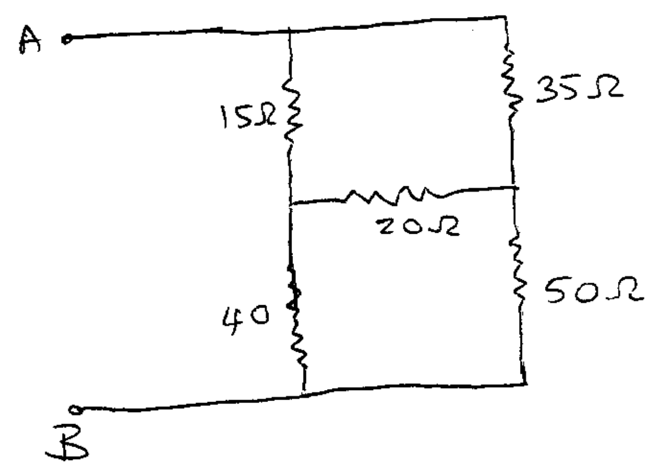


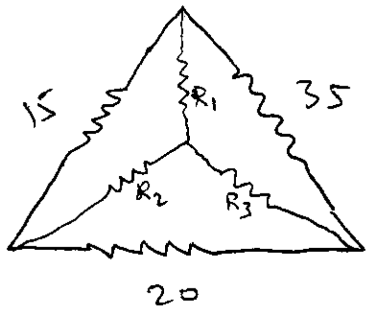
V. Determine the power delivered by each source.



Physics 228,
Solution Set - I.

I. Convert the triangle formed by $(15, 20, 35)\,\Omega$ into a star.



- 

$$R_1 = \frac{15 \times 35}{15+35+20} = \frac{15 \times 35}{70} = 7.5\,\Omega$$

$$R_2 = \frac{15 \times 20}{70} = \ldots = 4.28\,\Omega$$

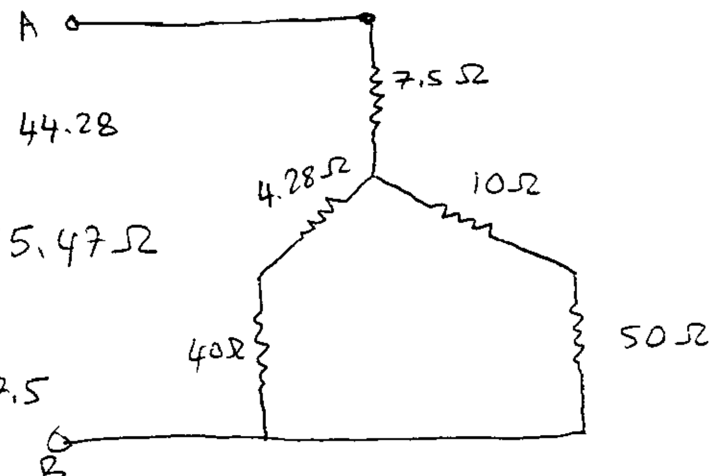
$$R_3 = \frac{20 \times 35}{70} = \ldots = 10\,\Omega$$

- The circuit becomes as follow:

10 in serie with 50 = 60

4.28 in serie with 40 = 44.28

60 // 44.28 ⇒ 25.47 Ω

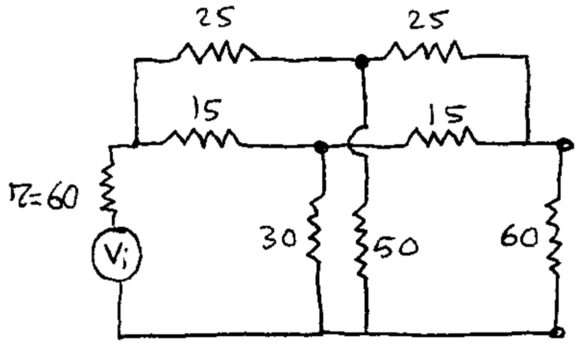


25.47 in serie with 7.5

$$\Rightarrow R_{AB} = 25.47 + 7.5 = 33\,\Omega$$

II - Determine the ratio

$$\left(\frac{V_o}{V_i}\right) = ??$$

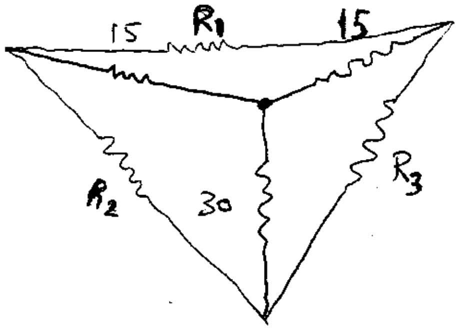


Replace the star "Y" formed by the (30, 15, 15) Ω resistors by a triangle.

- $$R_1 = \frac{15\times15 + 15\times30 + 15\times30}{30} = 37.5\,\Omega$$

$$R_2 = \frac{15\times15 + 15\times30 + 15\times30}{15} = 75\,\Omega$$

$$R_3 = \frac{15\times15 + 15\times30 + 15\times30}{15} = 75\,\Omega.$$

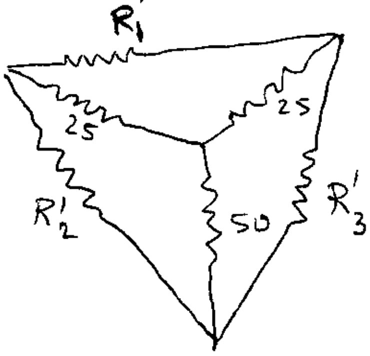


Now convert the star "Y'" formed by the (50, 25, 25) into a triangle

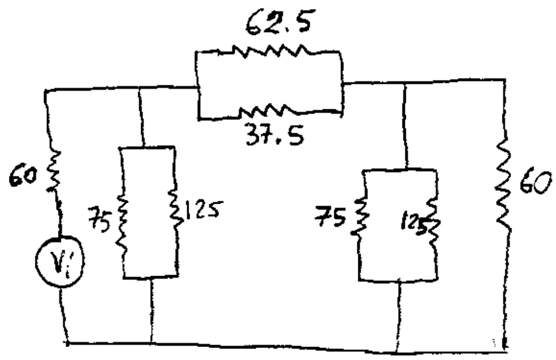
- $$R'_1 = \frac{25\times25 + 25\times50 + 25\times50}{50} = 62.5\,\Omega$$

$$R'_2 = \frac{25\times25 + 25\times50 + 25\times50}{25} = 125\,\Omega$$

$$R'_3 = \frac{25\times25 + 25\times50 + 25\times50}{25} = 125\,\Omega.$$



Now we reconstruct our circuit:

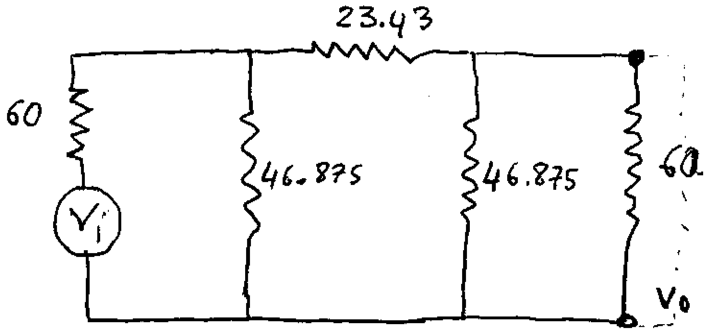


Phys 228 Solution

SET I.

One can easily see that the
$$\begin{cases} 62.5\,\Omega \;//\; 37.5\,\Omega \\ 75\,\Omega \;//\; 125\,\Omega \\ 75\,\Omega \;//\; 125\,\Omega. \end{cases}$$

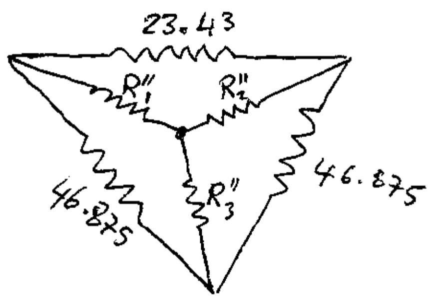
The Equivalent circuit becomes:



Remember that we need the ratio of $\left(\frac{V_0}{V_i}\right)$; Several metho[ds] can lead to this ratio.

I will convert the triangle formed by the (46.875, 46.875, 23.43) into a star "Y"

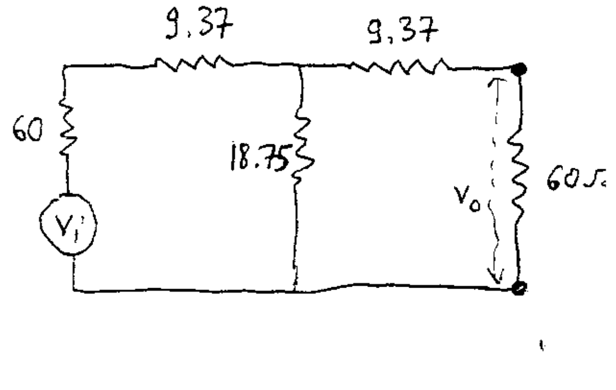
$$R_1'' = \frac{23.43 \times 46.875}{46.875 + 46.875 + 23.43} = 9.37$$



$$R_2'' = \frac{23.43 \times 46.875}{46.875 + 46.875 + 23.43} = 9.37$$

$$R_3'' = \frac{46.875 \times 46.875}{46.875 + 46.875 + 23.43} = 18.75$$

The circuit will becomes:

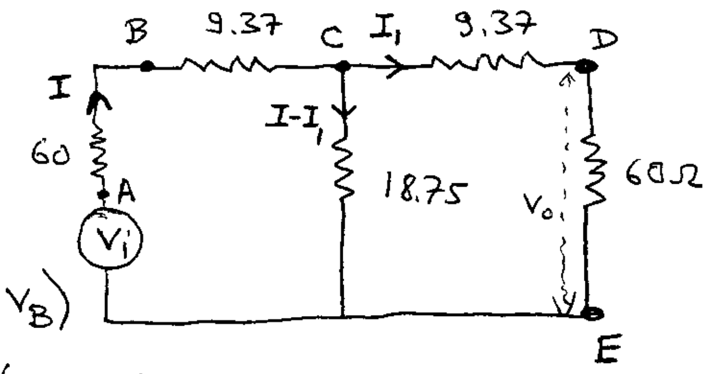


II - Contnd.

Phys 228 Solution

SET I.

Kirchoff's Law. on the large Loop:



$$(V_A - V_E) + (V_E - V_D) + (V_D - V_C) + (V_C - V_B) + (V_B - V_A) = 0$$

- $V_i - V_o - 9.37\, I_1 - 9.37\, I - 60\, I = 0$

$$\Rightarrow \boxed{V_i - V_o - 69.37\, I - 9.37 \frac{V_o}{60} = 0} \quad \text{Eq.(B)}$$

$$\boxed{\frac{V_o}{60} = I_1}$$

The value of I can be determined as follow:

$$I = \frac{V_i}{R_{Eq}}$$

- $60\,\Omega$ and $9.37\,\Omega$ in serie $\Rightarrow 69.37\,\Omega$

the $69.37\,\Omega$ in parallel with $18.75 \Rightarrow \frac{69.37 \times 18.37}{69.37 + 18.37} = 14.7$

the 14.76 in serie with 9.37 and 60 $\Rightarrow$

$$R_{Eq} = 9.37 + 60 + 14.76 = 84.13\,\Omega.$$

$$\Rightarrow I = \frac{V_i}{84.13}$$

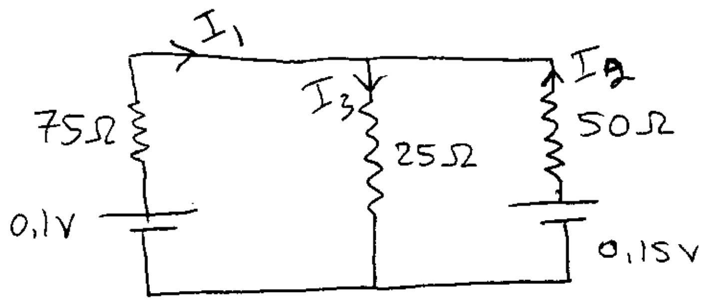
$$\text{Eq (B)} \Rightarrow V_i - V_o - \frac{V_i \times 69.37}{84.13} - \frac{9.37}{60} V_o = 0$$

$$\Rightarrow \boxed{\frac{V_o}{V_i} \simeq 0.15}$$

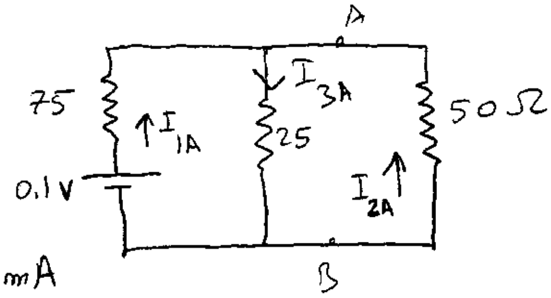
Phys 228 solution SI-5

SET 1.

III - Superposition principle.



$$I_{1A} = \frac{0.1\ V}{R_{Eq}}$$



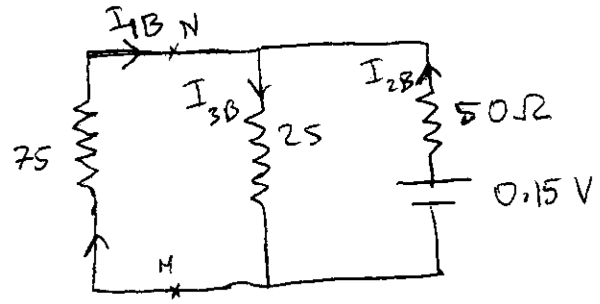
$$R_{Eq} = \frac{50\times\cancel{25}}{\cancel{75}} + 75 = \frac{275}{3}\ \Omega$$

$$\Rightarrow I_{1A} = \frac{0.1\times 3}{275} = \frac{0.3}{275}\ A = 1.09\ mA$$

Now $I_{3A} = \dfrac{0,1-(0,3\times 75/275)}{25} = \dfrac{0,1-0,9/11}{25} = \dfrac{0,2}{275} = 0.727\ mA$

$$V_A - V_B + V_B - V_A = 0 \Rightarrow 25 I_{3A} + I_{2A}\times 50 = 0 \Rightarrow I_{2A} = -\frac{I_{3A}}{2} = -\frac{0.}{27.}$$
$$= -0.363\ mA\ A$$

$$\Rightarrow \boxed{\begin{cases} I_{1A} = \dfrac{0.3}{275} \\ I_{2A} = \dfrac{-0.1}{275} \\ I_{3A} = \dfrac{0.2}{275} \end{cases}}$$



$$I_{2B} = \frac{0,15}{\frac{25\times 75}{100}+50} = \frac{0,15\times 4}{275} \Rightarrow I_{2B} = \frac{0,6}{275}\ A = 2,18\ mA$$

$$I_{3B} = \frac{0,15-(0,6\times 50/275)}{25} = \frac{0,15-1,2/11}{25} = 1.636\ mA$$

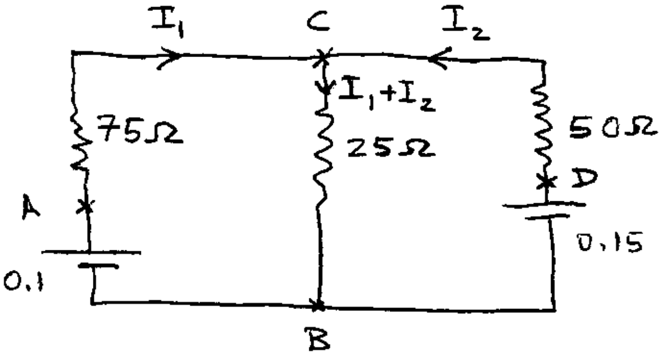
$$I_{1B} = -\cancel{25}\times\frac{(0,15-1,2/11)}{\cancel{25}\times 75} = -\frac{1,65-1,2}{11\times 75} = \frac{-0,45}{11\times 75} = -0,545\ \cancel{m}\ A$$

$$I_1 = I_{1A} + I_{1B} = \frac{0,3}{275} + \frac{-0.45}{825} = 0.545\ A\ ;$$

$$I_2 = I_{2A} + I_{2B} = -\frac{0.1}{275} + \frac{0.6}{275} = \frac{0.5}{275} = 1.81$$

$$I_3 = \qquad = 2.36\ mA$$

III - Another method:



Kirchof's Law:

$$\boxed{\begin{gathered}(V_A-V_B)+(V_B-V_C)+(V_C-V_A)=0\\ 0.1-25(I_1+I_2)-75I_1=0\end{gathered}}$$

$$\boxed{\begin{gathered}(V_D-V_B)+(V_B-V_C)+(V_C-V_D)=0\\ 0.15-25(I_1+I_2)-50I_2=0\end{gathered}}$$

$$\Rightarrow \quad 0.1-100I_1-25I_2=0 \quad (1)$$

$$0.15-25I_1-75.I_2=0 \quad (2)$$

$$\text{Eq. } (1)\times -3 \Rightarrow \quad -0.3+300I_1+75I_2=0 \quad (3)$$

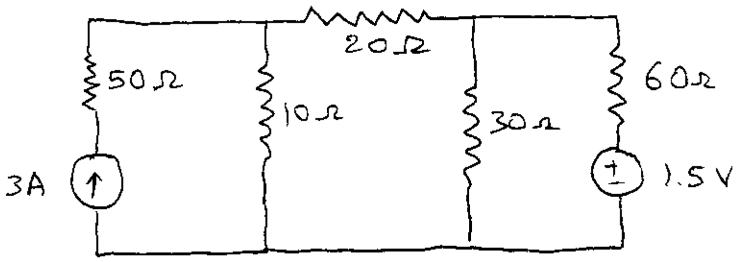
$$(3)+(2) \rightarrow \quad -0.15+275I_1=0 \Rightarrow \boxed{I_1=0.545\ \text{mA.}}$$

$$(1) \rightarrow \quad 0.1-0.0545-25I_2=0 \Rightarrow \boxed{I_2=1.81\ \text{mA.}}$$

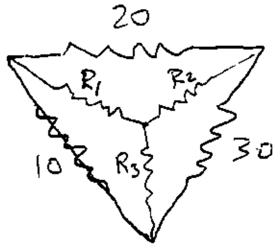
$$I_3=I_1+I_2=0.545+1.81=\boxed{2.36\ \text{mA.}=I_3}$$

Physics 228
Solution SET 1

IV - Determine the power delivered by each source.



First convert the triangle into a star "Y".

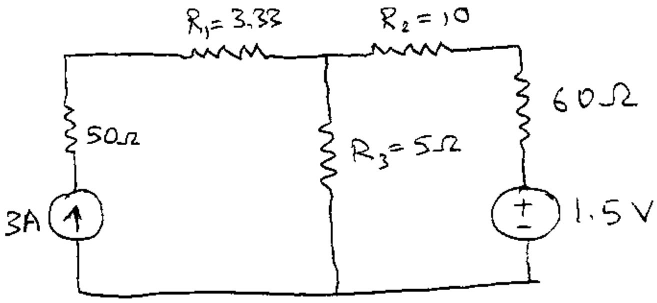


$$R_1 = \frac{2\cancel{0} \times 10}{6\cancel{0}} = \frac{10}{3} = 3.33\,\Omega$$

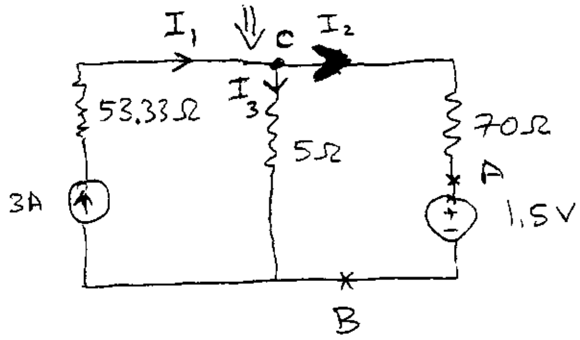
$$R_2 = \frac{20 \times \cancel{30}}{\cancel{60}} = 10\,\Omega$$

$$R_3 = \frac{10 \times 30}{60} = 5\,\Omega.$$

The Equivalent Circuit



$$I_1 = I_2 + I_3 = 3$$



take the Loop formed by (5, 70, 1.5 V.)

$$V_A - V_B + V_B - V_C + V_C - V_A = 0$$

$$\left.\begin{aligned} &1.5 - 5I_3 + 70 I_2 = 0 \\ &I_2 = 3 - I_3 \end{aligned}\right\} \Rightarrow 1.5 - 5I_3 + 70(3 - I_3) = 0$$

$$\Rightarrow 1.5 - 75 I_3 + 210 = 0 \Rightarrow$$

$$I_3 = \frac{211.5}{75} = 2.82 \text{ A}$$

$$I_2 = 3 - I_3 = 3 - 2.82 = 0.18 \text{ A}$$

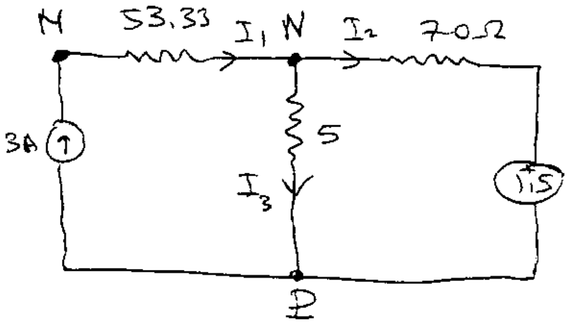
IV - Continued.

So, $I_1 = 3A$
$I_2 = 0.18\ A$
$I_3 = 2.82\ A.$

* the power of the 1.5 V source is $P = I_2 \times 1.5$

$$\boxed{P = 0.27\ W}$$ In power

* $(V_M - V_P) + (V_P - V_N) + (V_N - V_M) = 0$



$V_M - V_P - 5I_3 - 53.33\ I_1 = 0$

$\Rightarrow (V_M - V_P) = 5 \times 2.82 + 53.33 \times 3$
$= 14.1 + 159.99 = 174\ V$

$\Rightarrow P_{3A\ \text{source}} = 174 \times 3 = 522.2\ W.$

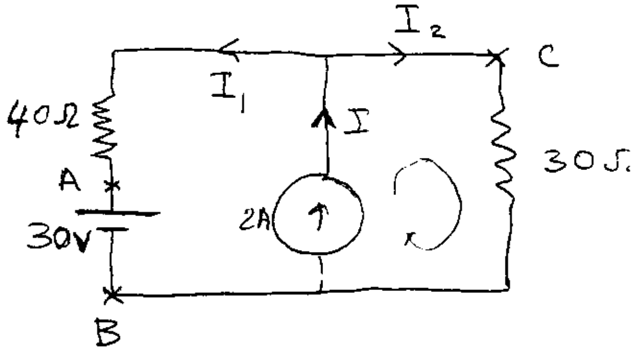
out-power.

please check the conservation of Energy.

physics 228 SI-9

Solution SET I.

V.-



$I = I_1 + I_2 = 2$ A

$(V_A - V_B) + (V_B - V_C) + (V_C - V_A) = 0$

$30 - 30 I_2 + 40 I_1 = 0$

$30 - 30(2 - I_1) + 40 I_1 = 0 \Rightarrow 30 - 60 + 30 I_1 + 40 I_1 = 0$

$\Rightarrow \quad I_1 = \frac{30}{70} = \frac{3}{7}$ A $\Rightarrow I_2 = 2 - \frac{3}{7} = \frac{11}{7}$ A

The power of the 30V source is: $30 \times \frac{3}{7} = 12.86$ W Absorbed

The power of the 2A source is: $30 \times I_2 \times I$

$= 30 \times \frac{11}{7} \times 2 = 94.285$ W delivered

Conservation of Energy:

$40 \times \frac{9}{49} + 30 \times \frac{121}{49} + 12.86 =$

$7.34\cancel{7} + 74.08 + 12.86 = 94.28$ W