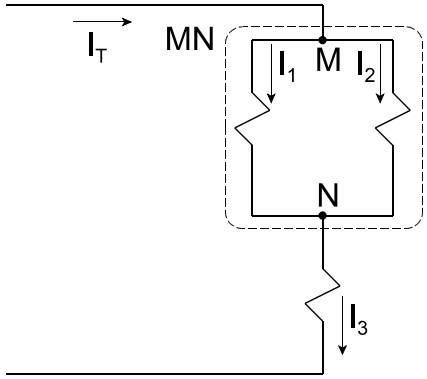
Assignment

ELECTROTECHNOLOGY
ELTK1100
ASSIGNMENT #3
SOLUTIONS
(Current Division)

1.



$$I_1 = \frac{R_{MN}}{R_1} * I_T$$

$$= \frac{1.5k\Omega}{2k\Omega} * 21.8mA = 16.3mA. \quad [3]$$

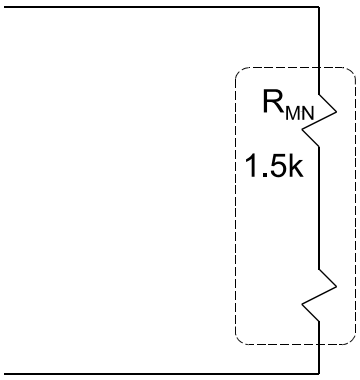
$$I_2 = \frac{R_{MN}}{R_2} * I_T$$

$$= \frac{1.5k\Omega}{6k\Omega} * 21.8mA = 5.5mA. \quad [4]$$

$$R_1 \| R_2 = 2k\Omega \| 6k\Omega = \frac{2 * 10^3 * 6 * 10^3}{(2 * 10^3 + 6 * 10^3)}$$

$$= \frac{1.2 * 10^7}{8 * 10^3} = 1.5k\Omega = R_{MN}$$

Check 16.3 + 5.5 = 21.8



	V (V)	I (mA)	R (Ω)
T	***120***	21.8 [2]	5.5k [1]
1	32.7 [5]	16.3 [3]	***2k***
2	32.7 [6]	5.5 [4]	***6k***
3	87.3 [7]	21.8 [2]	***4k***

$$R_{MN} s R_3 = 1.5k\Omega s 4k\Omega = 1.5k\Omega + 4k\Omega = 5.5k\Omega$$

$$R_T = 5.5k\Omega \quad [1]$$

$$I_T = \frac{V_T}{R_T} = \frac{120V}{5500\Omega} = 21.8mA. \quad [2]$$

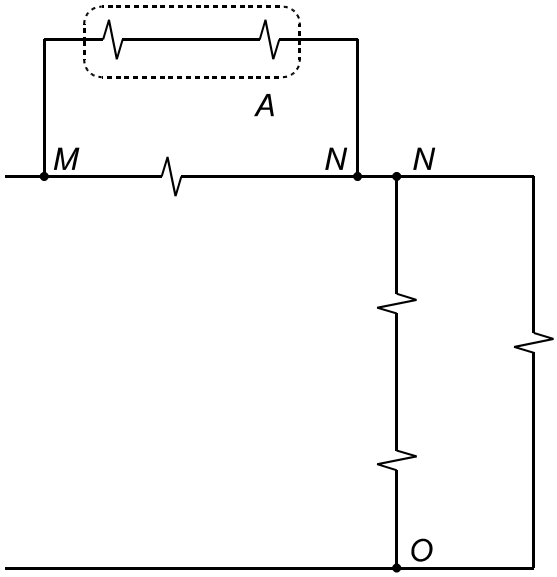
$$V_1 = I_1 R_1 = 16.3mA * 2k\Omega$$

$$= 16.3 * 10^{-3} * 2 * 10^3 = 32.7V. \quad [5]$$

$$V_2 = I_2 R_2 = 5.5mA * 6k\Omega = 32.7V. \quad [6]$$

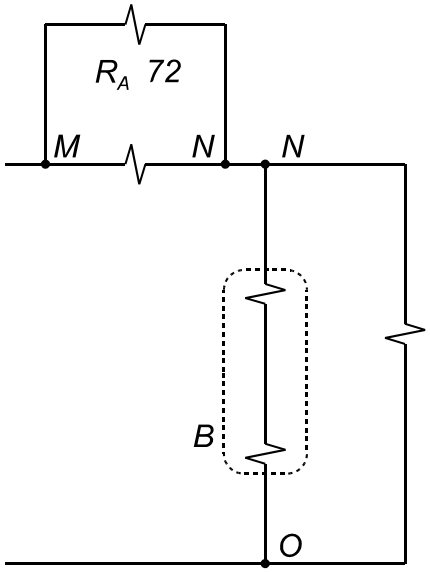
$$V_3 = I_3 R_3 = 21.8mA * 4k\Omega = 87.3V. \quad [7]$$

2. **(a)**



	V (V)	I (mA)	R (Ω)
T	***12***	75 [2]	160 [1]
1	1	62.5 [5]	***16***
2	3.5	62.5 [5]	***56***
3	4.5	12.5 [6]	***360***
4	5	33.3 [3]	***150***
5	2.5 [7]	33.3 [3]	***75***
6	7.5	41.7 [4]	***180***

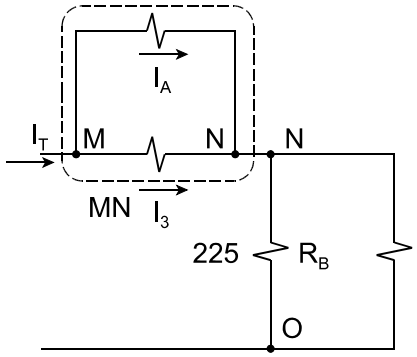
$R_1 s R_2 = 16 s 56 = 72 = R_A$



$R_4 s R_5 = 150 s 75 = 225 = R_B$

(e) $V_5 = I_5 * R_5$

$= 33.3mA * 75\Omega = 2.5V$ [7]



(c)(d)

$$I_1 = I_2 = I_A = \frac{R_{MN}}{R_A} * I_T$$

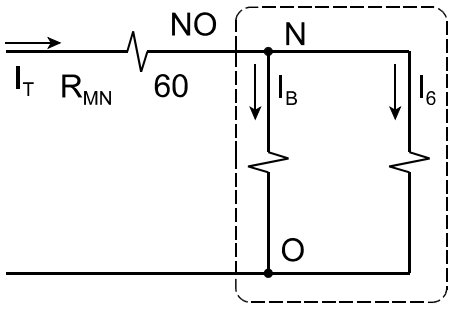
$$= \frac{60\Omega}{72\Omega} * 75mA = 62.5mA \quad 5$$

$$I_3 = \frac{R_{MN}}{R_3} * I_T$$

$$= \frac{60\Omega}{360\Omega} * 75mA = 12.5mA \quad 6$$

$$R_A \| R_3 = 72 \| 360 = \frac{72 * 360}{(72 + 360)} = 60 = R_{MN}$$

Check 62.5 + 12.5 = 75



$$I_4 = I_5 = I_B = \frac{R_{NO}}{R_B} * I_T$$

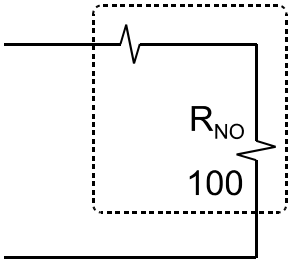
$$= \frac{100\Omega}{225\Omega} * 75mA = 33.3mA \quad 3$$

$$I_6 = \frac{R_{NO}}{R_6} * I_T$$

$$= \frac{100\Omega}{180\Omega} * 75mA = 41.7mA \quad 4$$

$$R_B \| R_6 = 225 \| 180 = \frac{225 * 180}{(225 + 180)} = 100 = R_{NO}$$

Check 33.3 + 41.7 = 75



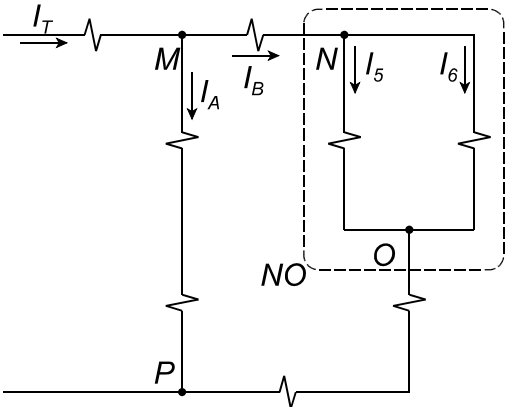
$$R_{MN} s R_{NO} = 60 s 100 = 160$$

$$R_T = 160\Omega \quad 1$$

(b)

$$I_T = \frac{V_T}{R_T} = \frac{12V}{160\Omega} = 75\ mA. \quad 2$$

3. (a)



$$I_5 = \frac{R_{NO}}{R_5} * I_B$$

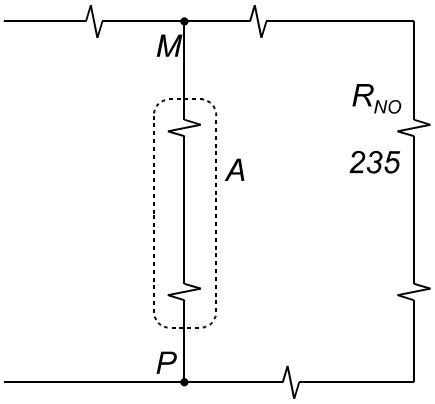
$$= \frac{235\Omega}{470\Omega} * 30.9mA = 15.5mA \quad [5]$$

$$I_6 = 15.5mA \quad [6] \quad \textit{equal resistors in parallel}$$

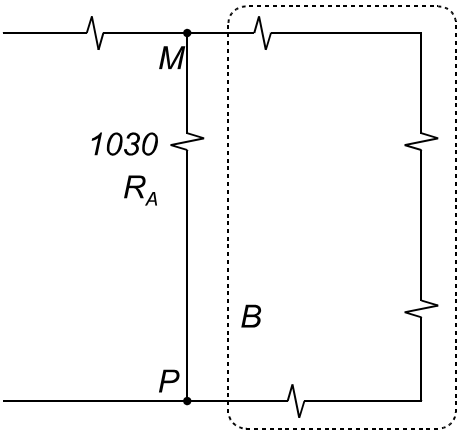
Check 15.5 + 15.5 = 31.0

Difference due to rounding

$$R_5 \| R_6 = 470 \| 470 = \frac{470}{2} = 235 = R_{NO}$$



$$R_3 s R_4 = 470 s 560 = 1030 = R_A$$



(d) $V_4 = I_4 * R_4$

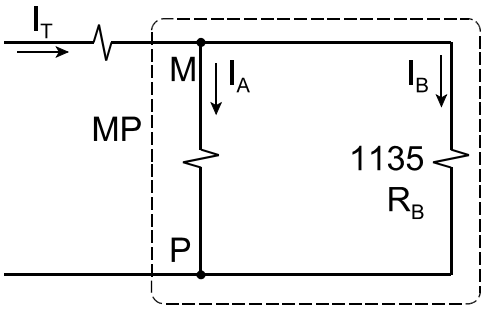
$= 34.0mA * 560\Omega = 19.0V$ [7]

(c) $V_5 = I_5 * R_5$

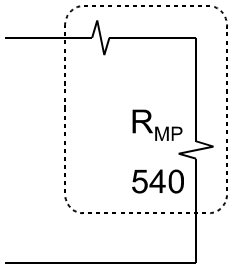
$= 15.5mA * 470\Omega = 7.29V$ [8]

	V (V)	I (mA)	R (Ω)
T	***100***	64.9 [2]	1.54k [1]
1	64.9	64.9 [2]	***1k***
3	16	34.0 [3]	***470***
4	19.0 [7]	34.0 [3]	***560***
2	10.2	30.9 [4]	***330***
7	14.5	30.9 [4]	***470***
8	3.09	30.9 [4]	***100***
5	7.29 [8]	15.5 [5]	***470***
6	7.29	15.5 [6]	***470***

$$R_2 s R_{NO} s R_7 s R_8 = 330 s 235 s 470 s 100 = 1135 = R_B$$



$$R_A \| R_B = 1030 \| 1135 = 540 = R_{MP}$$



$$R_1 s R_{MP} = 1k s 540 = 1.54k$$

$$R_T = 1.54k\Omega \quad [1]$$

(b)

$$I_T = \frac{V_T}{R_T} = \frac{100\,V}{1.54\,k\Omega} = 64.9\,mA. \quad [2]$$

(e)

$$I_3 = I_4 = I_A = \frac{R_{MP}}{R_A} * I_T$$

$$= \frac{540\,\Omega}{1030\,\Omega} * 64.9\,mA = 34.0\,mA \quad [3]$$

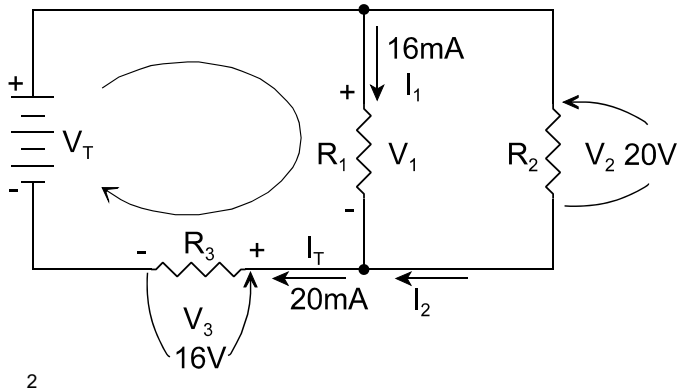
$$I_2 = I_7 = I_8 = I_B = \frac{R_{MP}}{R_B} * I_T$$

$$= \frac{540\,\Omega}{1135\,\Omega} * 64.9\,mA = 30.9\,mA \quad [4]$$

Check 34.0 + 30.9 = 64.9

4.

$I_T = 0.02A = 20mA$



From KCL

$I_T = I_1 + I_2$

$\therefore \quad I_2 = I_T - I_1 = 20mA - 16mA$

$= 4mA \quad [1]$

R_1 is parallel with R_2, $\therefore$ $V_1 = V_2 = 20V$ [2]

From KVL

$V_T = V_1 + V_3$ *or*

$V_T = V_2 + V_3$

$V_T = 20V + 16V = 36V \quad [3]$

$$R_T = \frac{V_T}{I_T} = \frac{36\,V}{20\,mA} = 1800\,\Omega \quad 4$$

$$R_1 = \frac{V_1}{I_1} = \frac{20\,V}{16\,mA} = 1250\,\Omega \quad 5$$

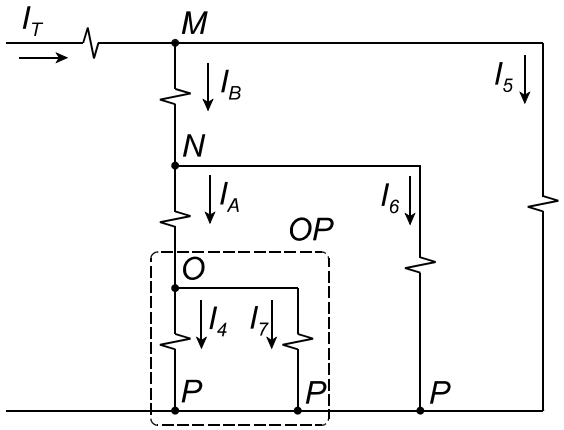
$$R_2 = \frac{V_2}{I_2} = \frac{20\,V}{4\,mA} = 5000\,\Omega \quad 6$$

$$R_3 = \frac{V_3}{I_3} = \frac{16\,V}{20\,mA} = 800\,\Omega \quad 7$$

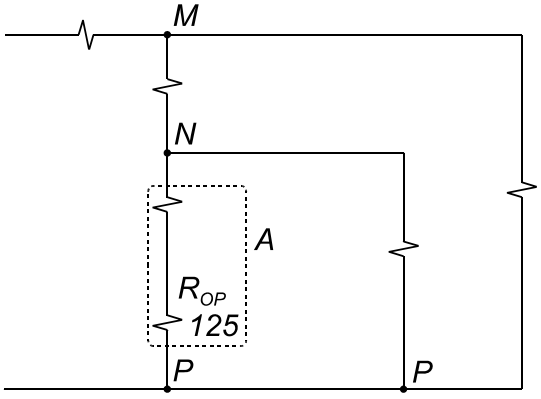
	V (V)	I (mA)	R (Ω)
T	36 [3]	***20***	1800 [4]
1	20 [2]	***16***	1250 [5]
2	***20***	4 [1]	5000 [6]
3	***16***	***20***	800 [7]

Check $1250 \| 5000 = 1000$
$1000 s 800 = 1800$

5. (a)



$$R_4 \| R_7 = 150 \| 750 = 125 = R_{OP}$$



$$R_3 s R_{OP} = 200 s 125 = 325 = R_A$$

(d)

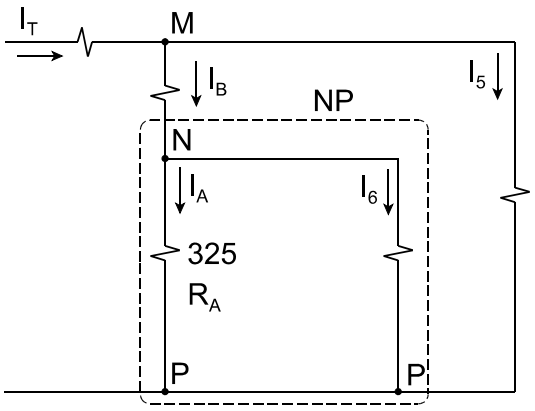
$$I_4 = \frac{R_{OP}}{R_4} * I_A$$

$$= \frac{125\,\Omega}{150\,\Omega} * 144\,mA = 120\,mA \quad 7$$

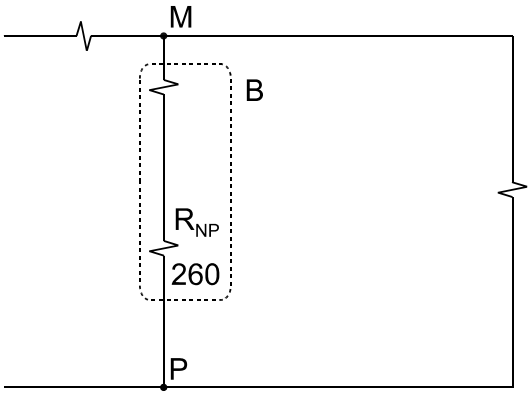
$$I_7 = \frac{R_{OP}}{R_7} * I_A$$

$$= \frac{125\,\Omega}{750\,\Omega} * 144\,mA = 24\,mA \quad 8$$

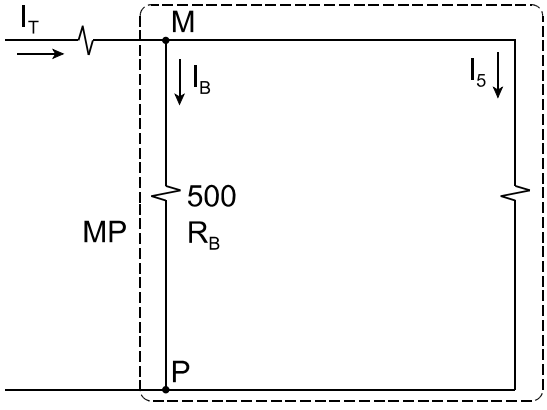
Check $120 + 24 = 144$



$R_A \| R_6 = 325 \| 1.3k = 260 = R_{NP}$



$R_2 s R_{NP} = 240 s 260 = 500 = R_B$



$R_B \| R_5 = 500 \| 750 = 300 = R_{MP}$

(d)

$$I_3 = I_A = \frac{R_{NP}}{R_A} * I_B$$

$$= \frac{260\Omega}{325\Omega} * 180mA = 144mA \quad (5)$$

$$I_6 = \frac{R_{NP}}{R_6} * I_B$$

$$= \frac{260\Omega}{1.3k\Omega} * 180mA = 36mA \quad (6)$$

Check 144 + 36 = 180

(d)

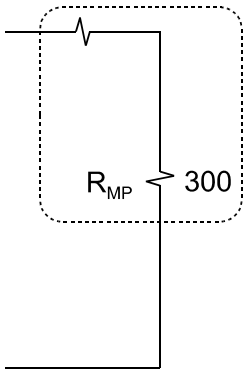
$$I_2 = I_B = \frac{R_{MP}}{R_B} * I_T$$

$$= \frac{300\Omega}{500\Omega} * 300mA = 180mA \quad (3)$$

$$I_5 = \frac{R_{MP}}{R_5} * I_T$$

$$= \frac{300\Omega}{750\Omega} * 300mA = 120mA \quad (4)$$

Check 180 + 120 = 300



$R_1 s R_{MP} = 100 s 300 = 400$

$R_T = 400\Omega$ [1]

	V (V)	I (mA)	R (Ω)
T	***120***	300 [2]	400 [1]
1	30	300 [2]	***100***
5	90 [11]	120 [4]	***750***
2	43.2	180 [3]	***240***
6	46.8 [10]	36 [6]	***1.3k***
3	28.8	144 [5]	***200***
7	18 [9]	24 [8]	***750***
4	18	120 [7]	***150***

(b)

$$I_T = \frac{V_T}{R_T} = \frac{120V}{400\Omega} = 300mA.$$ [2]

(c)

$V_7 = I_7 * R_7 = 24mA * 750\Omega = 18V$ [9]

$V_6 = I_6 * R_6 = 36mA * 1.3k\Omega = 46.8V$ [10]

$V_5 = I_5 * R_5 = 120mA * 750\Omega = 90V$ [11]

6.

This problem exercises the rules for series/parallel circuits.

The information in **Bold** and *Italics* on the VIR chart indicates what is given.

$G_5 = 0.5S$

$$R_5 = \frac{1}{G_5} = \frac{1}{0.5S} = 2\Omega$$ [1]

$I_1 = I_7 = I_T = 8A$ [2]

This is obvious since they are in series with source.

Similarily

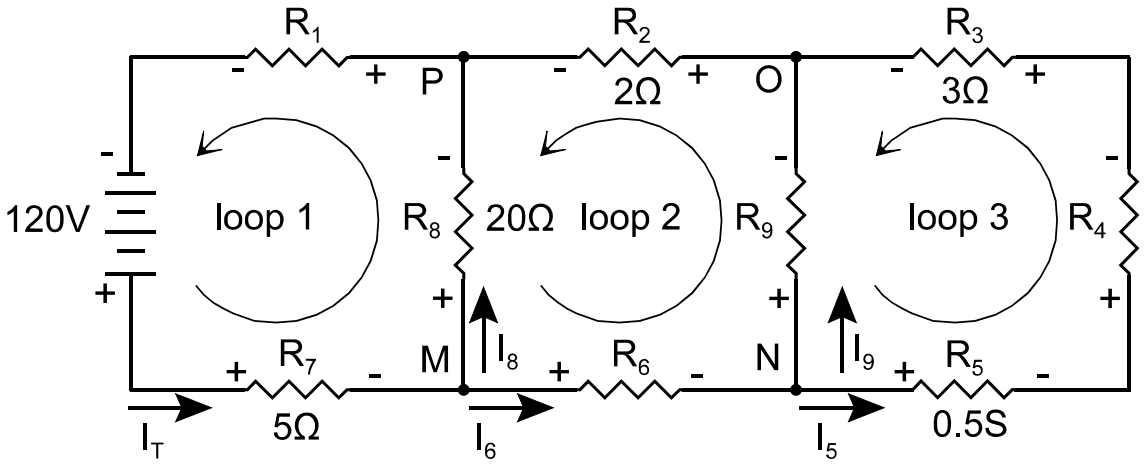
$I_2 = I_6 = 5A$ [3]

By KCL on Node M

$I_7 = I_6 + I_8$

$\therefore \quad I_8 = I_7 - I_6 = 8A - 5A = 3A$ [4]

	V (V)	I (A)	R (Ω)
T	***120***	***8***	15
1	***20***	8 [2]	2.5 [9]
7	40 [5]	8 [2]	***5***
8	60 [5]	3 [4]	***20***
2	10 [5]	5 [3]	***2***
6	20 [6]	***5***	4 [9]
9	***30***	2 [8]	15 [9]
3	***9***	3 [7]	***3***
4	***15***	3 [7]	5 [9]
5	6	3 [7]	2 [1]



You know the current and resistance for R_7, R_8 and R_2, ∴ you can work out their voltage drops.

$V_7 = I_7 * R_7 = 8A * 5\Omega = 40V$ [5]

$V_8 = I_8 * R_8 = 3A * 20\Omega = 60V$

$V_2 = I_2 * R_2 = 5A * 2\Omega = 10V$

From KVL loop 1

$+V_T - V_1 - V_8 - V_7 = 0$

$V_1 + V_8 + V_7 = V_T$

$20V + 60V + 40V = 120V$

R_1 and R_7 consume 20V + 40V of potential since they are in series with the source. The left over potential 60V is available for the rest of the circuit in parallel.

From KVL loop 2

$+V_8 - V_2 - V_9 - V_6 = 0$

$V_6 = V_8 - V_2 - V_9 = 60V - 10V - 30V = 20V$ [6]

By Ohms Law

$$I_3 = I_4 = I_5 = \frac{V_3}{R_3} = \frac{9V}{3\Omega} = 3A$$ [7]

By KCL on Node N

$I_6 = I_5 + I_9$

$\therefore \quad I_9 = I_6 - I_5 = 5A - 3A = 2A$ [8]

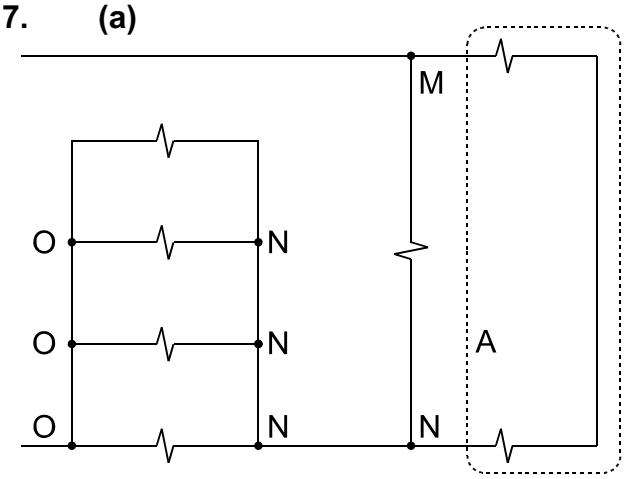
$$R_1 = \frac{V_1}{I_1} = \frac{20V}{8A} = 2.5\Omega$$ [9]

$$R_6 = \frac{V_6}{I_6} = \frac{20V}{5A} = 4\Omega$$

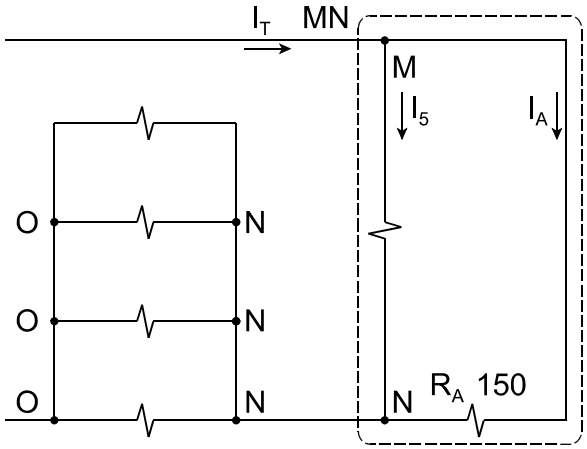
$$R_9 = \frac{V_9}{I_9} = \frac{30V}{2A} = 15\Omega$$

$$R_4 = \frac{V_4}{I_4} = \frac{15V}{3A} = 5\Omega$$

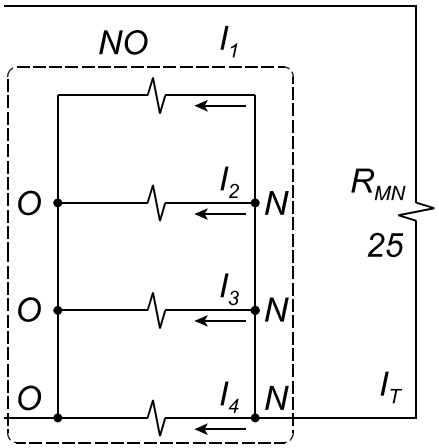
7. (a)



$R_6 s R_7 = 68 s 82 = 150 = R_A$



$R_5 \| R_A = 30 \| 150 = 25 = R_{MN}$



$R_1 \| R_2 \| R_3 \| R_4 = 180 \| 180 \| 20 \| 180 = 15 = R_{NO}$ Use reciprocal rule

or

$180 \| 180 \| 180 = 30$

$30 \| 20 = 15 = R_{NO}$

$$I_5 = \frac{R_{MN}}{R_5} * I_T$$

$$= \frac{25\Omega}{30\Omega} * 2A = 1.667A \quad 5$$

$$I_6 = I_7 = I_A = \frac{R_{MN}}{R_A} * I_T$$

$$= \frac{25\Omega}{150\Omega} * 2A = 0.333A \quad 6$$

Check $1.667 + 0.333 = 2$

(d)

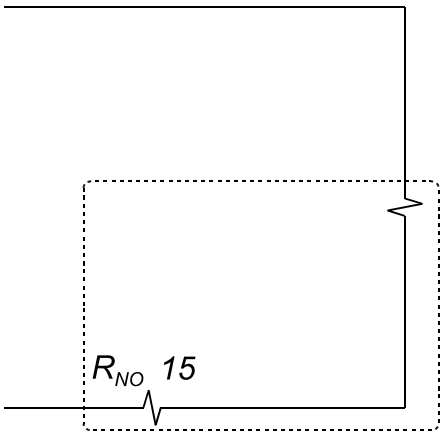
$$I_1 = I_2 = I_4 = \frac{R_{NO}}{R_1} * I_T$$

$$= \frac{15\Omega}{180\Omega} * 2A = 0.167A \quad 3$$

$$I_3 = \frac{R_{NO}}{R_3} * I_T$$

$$= \frac{15\Omega}{20\Omega} * 2A = 1.5A \quad 4$$

Check $0.167 + 0.167 + 1.5 + 0.167 = 2$



	V (V)	I (A)	R (Ω)
T	80 [2]	***2***	40 [1]
1	30	0.167 [3]	***180***
2	30	0.167 [3]	***180***
3	30	1.5 [4]	***20***
4	30	0.167 [3]	***180***
5	50	1.667 [5]	***30***
6	22.6 [6]	0.333 [6]	***68***
7	27.3	0.333 [6]	***82***

$R_{NO} s R_{MN} = 15 s 25 = 40$

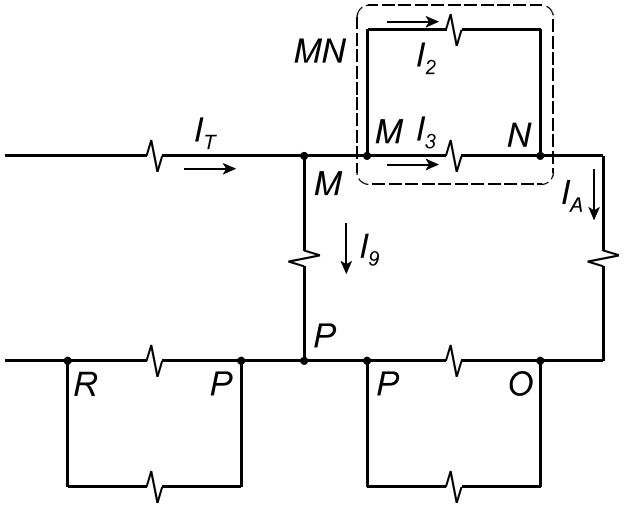
$R_T = 40\Omega$ [1]

(b)

$V_T = I_T * R_T = 2A * 40\Omega = 80V$ [2]

(c) $V_6 = I_6 * R_6 = 0.333A * 68\Omega = 22.6V$ [7]

8. (a)



$R_2 \| R_3 = 282 \| 141 = 94 = R_{MN}$

(c)

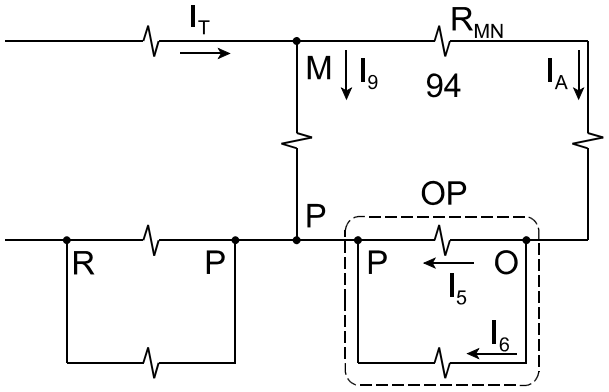
$$I_2 = \frac{R_{MN}}{R_2} * I_A$$

$$= \frac{94\Omega}{282\Omega} * 0.4A = 0.133A$$ [8]

$$I_3 = \frac{R_{MN}}{R_3} * I_A$$

$$= \frac{94\Omega}{141\Omega} * 0.4A = 0.267A$$ [9]

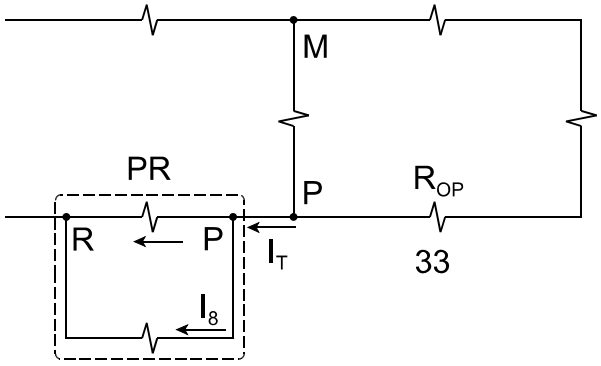
Check 0.133 + 0.267 = 0.4



$$R_5 \| R_6 = 66 \| 66 = \frac{66}{2} = 33 = R_{OP}$$

$$I_5 = I_6 = \frac{R_{OP}}{R_5} * I_A$$

$$= \frac{33\Omega}{66\Omega} * 0.4A = 0.2A \quad 7$$



$$R_7 \| R_8 = 40 \| 60 = 24 = R_{PR}$$

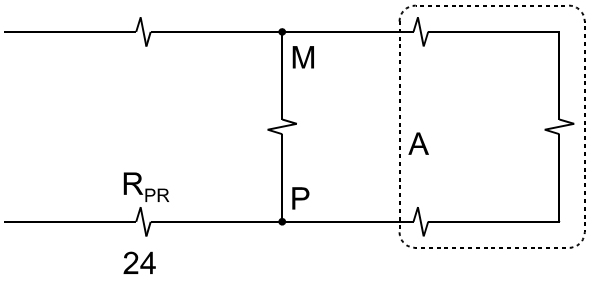
$$I_7 = \frac{R_{PR}}{R_7} * I_T$$

$$= \frac{24\Omega}{40\Omega} * 1.2A = 0.72A \quad 5$$

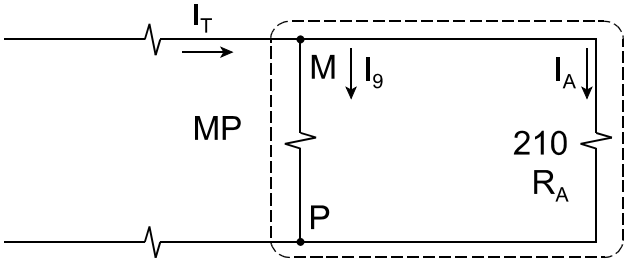
$$I_8 = \frac{R_{PR}}{R_8} * I_T$$

$$= \frac{24\Omega}{60\Omega} * 1.2A = 0.48A \quad 6$$

Check 0.72 + 0.48 = 1.2



$$R_{MN} s R_4 s R_{OP} = 94 s 83 s 33 = 210 = R_A$$



$$R_A \| R_9 = 210 \| 105 = 70 = R_{MP}$$

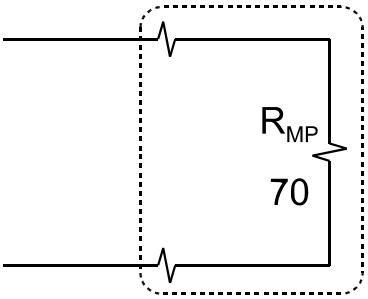
$$I_9 = \frac{R_{MP}}{R_9} * I_T$$

$$= \frac{70\Omega}{105\Omega} * 1.2A = 0.8A \quad 3$$

$$I_4 = I_A = \frac{R_{MP}}{R_A} * I_T$$

$$= \frac{70\Omega}{210\Omega} * 1.2A = 0.4A \quad 4$$

Check 0.8 + 0.4 = 1.2



$R_1 s R_{MP} s R_{PR} = 6 s 70 s 24 = 100$

$R_T = 100\Omega$ [1]

(b)

$I_T = \frac{V_T}{R_T} = \frac{120V}{100\Omega} = 1.2A.$ [2]

	V (V)	I (A)	R (Ω)
T	***120***	1.2 [2]	100 [1]
1	7.2	1.2 [2]	***6***
7	28.8	0.72 [5]	***40***
8	28.8	0.48 [6]	***60***
9	84	0.8 [3]	***105***
2	37.5	0.133 [8]	***282***
3	37.6	0.267 [9]	***141***
4	33.2	0.4 [4]	***83***
5	13.2	0.2 [7]	***66***
6	13.2 [10]	0.2 [7]	***66***

(d) $V_6 = I_6 * R_6 = 0.2A * 66\Omega = 13.2V$ [10]