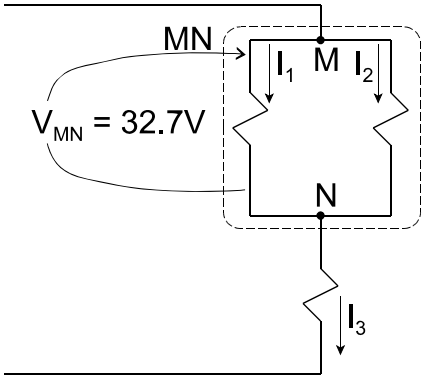
# Assignment

**ELECTROTECHNOLOGY**
**ELTK1100**
**ASSIGNMENT #3**
**SOLUTIONS**
**(Series and Parallel Rules and Ohm's Law)**

**1.**



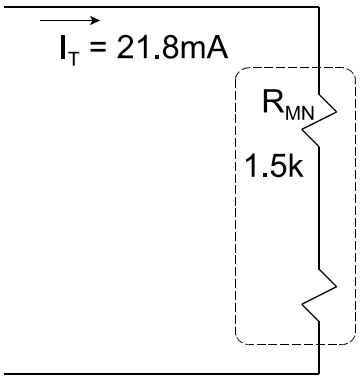

$$V_{MN} = V_1 = V_2 = 32.7V \quad {}^{5}$$

$$I_1 = \frac{V_1}{R_1} = \frac{32.7V}{2k\Omega} = 16.4mA \quad {}^{6}$$

$$I_2 = \frac{V_2}{R_2} = \frac{32.7V}{6k\Omega} = 5.5mA \quad {}^{7}$$

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

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




$$I_T = I_{MN} = I_3 = 21.8mA \quad {}^{3}$$

$$V_{MN} = I_{MN} R_{MN} = 21.8mA * 1.5k\Omega$$

$$= 21.8 * 10^{-3} * 1.5 * 10^3 = 32.7V.$$

$$V_3 = I_3 R_3 = 21.8mA * 4k\Omega = 87.2V. \quad {}^{4}$$

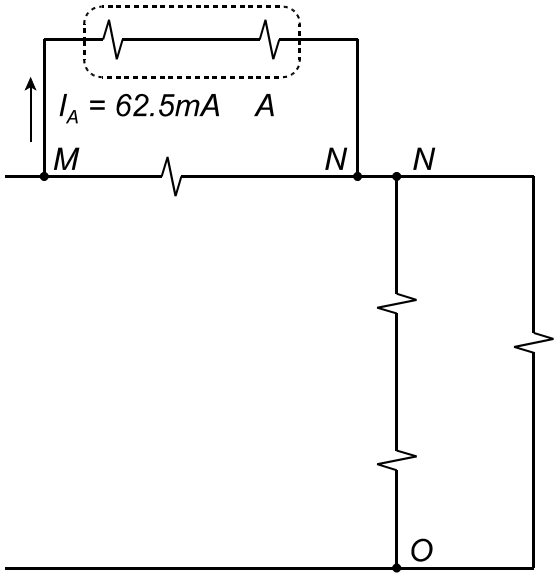
$$R_{MN} s R_3 = 1.5k\Omega s 4k\Omega = 1.5k\Omega + 4k\Omega = 5.5k\Omega$$

$$R_T = 5.5k\Omega \quad {}^{1}$$

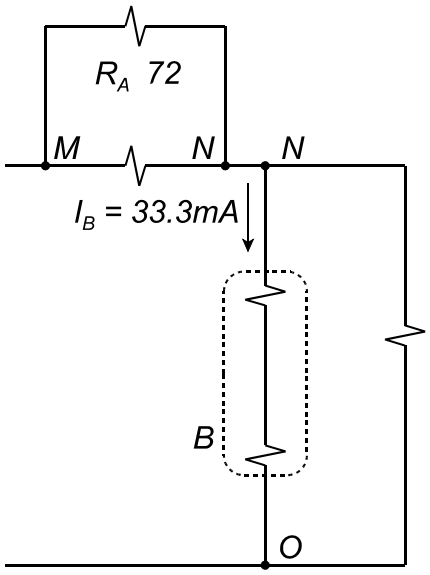
$$I_T = \frac{V_T}{R_T} = \frac{120V}{5500\Omega} = 21.8mA. \quad {}^{2}$$

| | V (V) | I (mA) | R (Ω) |
|---|---|---|---|
| T | ***120*** | 21.8 [2] | 5.5k [1] |
| 1 | 32.7 [5] | 16.4 [6] | ***2k*** |
| 2 | 32.7 [5] | 5.5 [7] | ***6k*** |
| 3 | 87.2 [4] | 21.8 [3] | ***4k*** |

**2.** **(a)**




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




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

**(c)**

$I_A = I_1 = I_2 = 62.5mA$ [10]

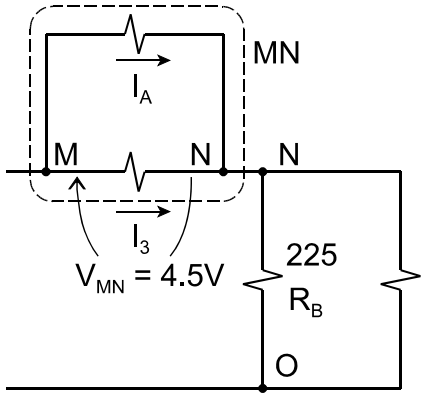
$V_1 = I_1 R_1$
$= 62.5mA * 16\Omega$
$= 1.0V.$ [11]

$V_2 = I_2 R_2$
$= 62.5mA * 56\Omega$
$= 3.5V.$ [12]

$I_B = I_4 = I_5 = 33.3mA$ [7]

$V_4 = I_4 R_4$
$= 33.3mA * 150\Omega$
$= 5.0V.$ [8]

**(e)** $V_5 = I_5 R_5$
$= 33.3mA * 75\Omega$
$= 2.5V.$ [9]



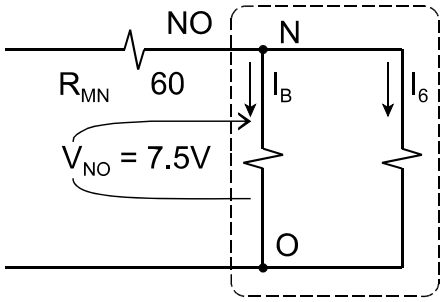

**(d)**

$$V_{MN} = V_A = V_3 = 4.5V \quad [5]$$

$$I_A = \frac{V_A}{R_A} = \frac{4.5V}{72\Omega} = 62.5mA$$

$$I_3 = \frac{V_3}{R_3} = \frac{4.5V}{360\Omega} = 12.5mA \quad [6]$$

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

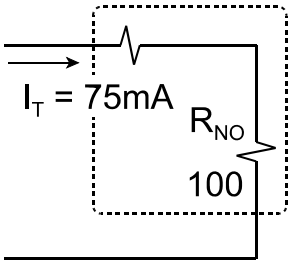



$$V_{NO} = V_B = V_6 = 7.5V \quad [3]$$

$$I_B = \frac{V_B}{R_B} = \frac{7.5V}{225\Omega} = 33.3mA$$

$$I_6 = \frac{V_6}{R_6} = \frac{7.5V}{180\Omega} = 41.7mA \quad [4]$$

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




$$I_T = I_{MN} = I_{NO} = 75mA$$

$$V_{MN} = I_{MN} R_{MN} = 75mA * 60\Omega = 4.5V.$$

$$V_{NO} = I_{NO} R_{NO} = 75mA * 100\Omega = 7.5V.$$

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

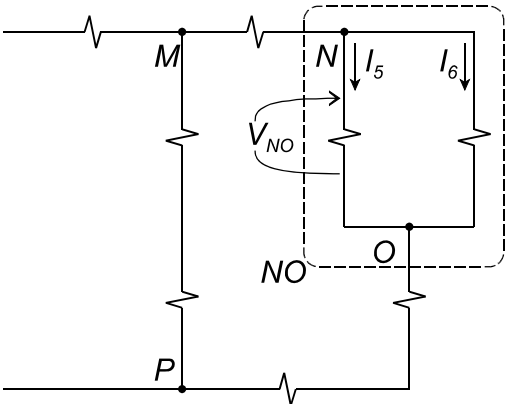
$$R_T = 160\Omega \quad [1]$$

**(b)**

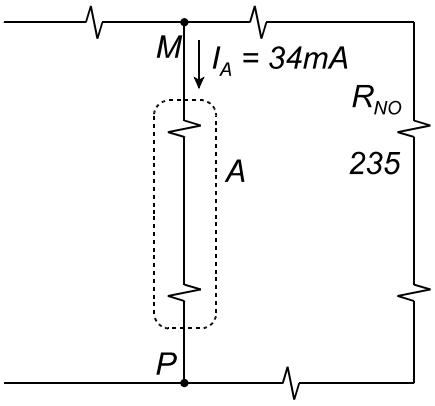
$$I_T = \frac{V_T}{R_T} = \frac{12V}{160\Omega} = 75\ mA. \quad [2]$$

| | V (V) | I (mA) | R (Ω) |
|---|---|---|---|
| **T** | ***12*** | 75 [2] | 160 [1] |
| **1** | 1 [11] | 62.5 [10] | ***16*** |
| **2** | 3.5 [12] | 62.5 [10] | ***56*** |
| **3** | 4.5 [5] | 12.5 [6] | ***360*** |
| **4** | 5 [8] | 33.3 [7] | ***150*** |
| **5** | 2.5 [9] | 33.3 [7] | ***75*** |
| **6** | 7.5 [3] | 41.7 [4] | ***180*** |

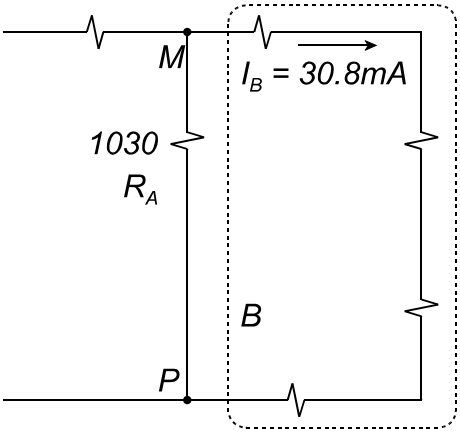
**3. (a)**




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




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




**(c)**

$$V_{NO} = V_5 = V_6 = 7.24\,V \quad [12]$$

$$I_5 = I_6 = \frac{V_5}{R_5} = \frac{7.24\,V}{470\,\Omega} = 15.4\,mA \quad [13]$$

**(d)**

$$I_A = I_3 = I_4 = 34.0\,mA. \quad [9]$$

$$V_3 = I_3\,R_3 = 34\,mA * 470\,\Omega = 16.0\,V. \quad [10]$$

$$V_4 = I_4\,R_4 = 34\,mA * 560\,\Omega = 19.0\,V. \quad [11]$$

**(e)**

$$I_B = I_2 = I_{NO} = I_7 = I_8 = 30.8\,mA \quad [5]$$

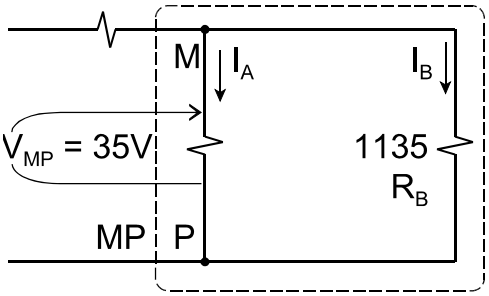
$$V_2 = I_2\,R_2 = 30.8\,mA * 330\,\Omega = 10.2\,V. \quad [6]$$

$$V_{NO} = I_{NO}\,R_{NO} = 30.8\,mA * 235\,\Omega = 7.24\,V.$$

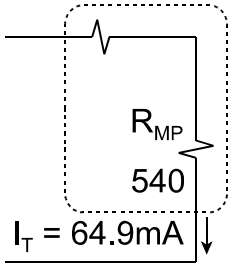
$$V_7 = I_7\,R_7 = 30.8\,mA * 470\,\Omega = 14.5\,V. \quad [7]$$

$$V_8 = I_8\,R_8 = 30.8\,mA * 100\,\Omega = 3.08\,V. \quad [8]$$

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




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




$$R_1 s R_{MP} = 1k s 540 = 1.54k$$
$$R_T = 1.54k\Omega \quad [1]$$

**(b)**

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

**4.**

$$I_T = 0.02A = 20\,mA$$

From KCL

$$I_T = I_1 + I_2$$
$$\therefore \; I_2 = I_T - I_1 = 20\,mA - 16\,mA$$
$$= 4\,mA \quad [1]$$

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

From KVL

$$V_T = V_1 + V_3 \quad or$$
$$V_T = V_2 + V_3$$
$$V_T = 20\,V + 16\,V = 36\,V \quad [3]$$

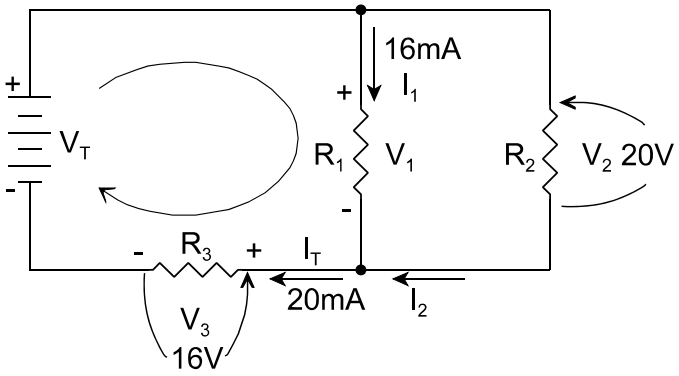
$$V_{NO} = V_A = V_B = 35\,V$$

$$I_A = \frac{V_A}{R_A} = \frac{35\,V}{1030\,\Omega} = 34\,mA$$
$$I_B = \frac{V_B}{R_B} = \frac{35\,V}{1135\,\Omega} = 30.8\,mA$$

$$I_T = I_1 = I_{MP} = 64.9\,mA \quad [3]$$

$$V_1 = I_1 R_1$$
$$= 64.9\,mA * 1\,k\Omega = 64.9\,V. \quad [4]$$
$$V_{MP} = I_{MP} R_{MP}$$
$$= 64.9\,mA * 540\,\Omega = 35\,V.$$

| | V (V) | I (mA) | R (Ω) |
|---|---|---|---|
| T | ***100*** | 64.9 [2] | 1.54k [1] |
| 1 | 64.9 [4] | 64.9 [3] | ***1k*** |
| 3 | 16.0 [10] | 34.0 [9] | ***470*** |
| 4 | 19.0 [11] | 34.0 [9] | ***560*** |
| 2 | 10.2 [6] | 30.8 [5] | ***330*** |
| 7 | 14.5 [7] | 30.8 [5] | ***470*** |
| 8 | 3.08 [8] | 30.8 [5] | ***100*** |
| 5 | 7.29 [12] | 15.5 [13] | ***470*** |
| 6 | 7.29 [12] | 15.5 [13] | ***470*** |



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

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

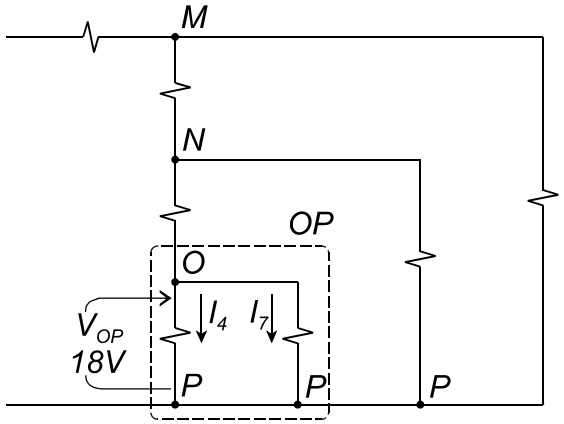
$$R_2 = \frac{V_2}{I_2} = \frac{20\,V}{4\,mA} = 5000\,\Omega \quad 6$$

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

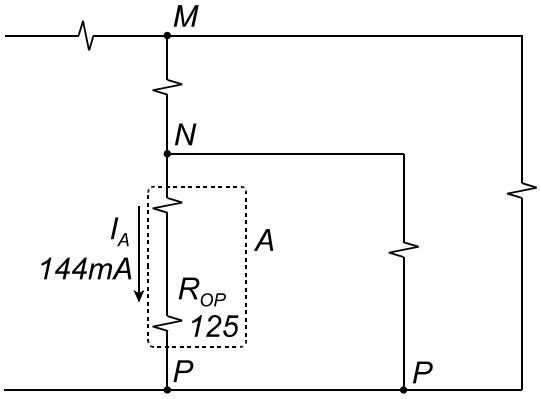
| | V (V) | I (mA) | R (Ω) |
|---|---|---|---|
| T | 36 [3] | ***20*** | 1800 [4] |
| 1 | 20 [2] | ***16*** | 1250 [5] |
| 2 | ***20*** | 4 [1] | 5000 [6] |
| 3 | ***16*** | ***20*** | 800 [7] |

*Check* $1250 \parallel 5000 = 1000$
$1000 \,s\, 800 = 1800$

**5. (a)**




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




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

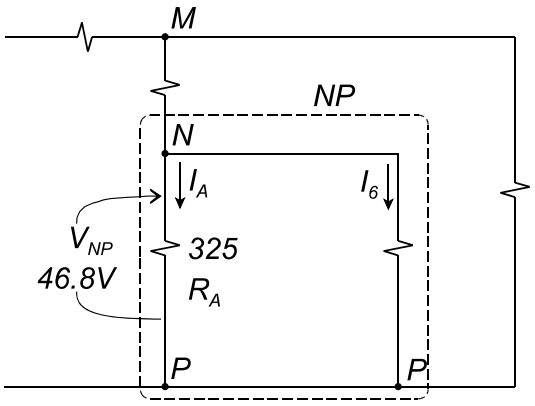
**(c)** $V_{OP} = V_4 = V_7 = 18\,V$ 13

$$I_4 = \frac{V_4}{R_4} = \frac{18\,V}{150\,\Omega} = 120\,mA \quad 14$$

**(d)** $$I_7 = \frac{V_7}{R_7} = \frac{18\,V}{750\,\Omega} = 24\,mA \quad 15$$

$$I_A = I_3 = I_{OP} = 144\,mA \quad 11$$

$$V_3 = I_3\, R_3$$
$$= 144\,mA * 200\,\Omega = 28.8\,V. \quad 12$$
$$V_{OP} = I_{OP}\, R_{OP}$$
$$= 144\,mA * 125\,\Omega = 18\,V.$$

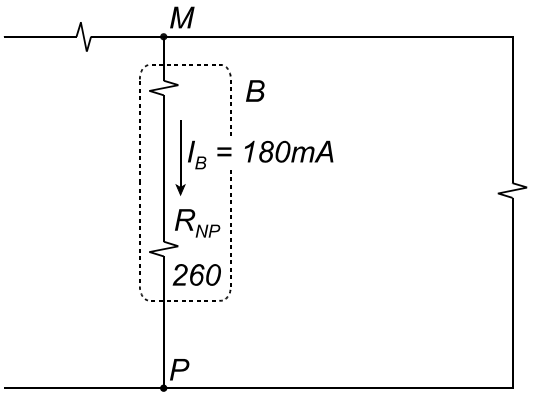



(c) $V_{NP} = V_A = V_6 = 46.8\,V$ [9]

$$I_A = \frac{V_A}{R_A} = \frac{46.8\,V}{325\,\Omega} = 144\,mA$$

(d) $$I_6 = \frac{V_6}{R_6} = \frac{46.8\,V}{1.3\,k\Omega} = 36\,mA$$ [10]

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

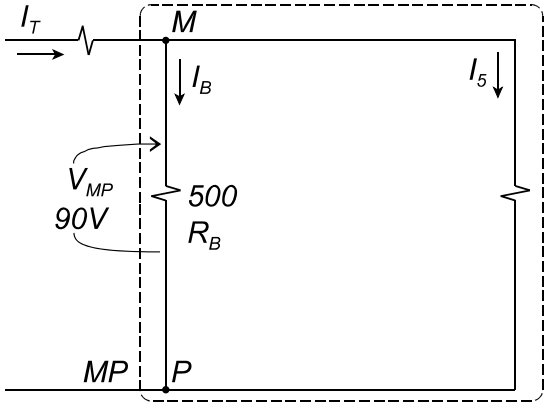



$I_B = I_2 = I_{NP} = 180\,mA$ [7]

$V_2 = I_2\, R_2$
$= 180\,mA * 240\,\Omega = 43.2\,V.$ [8]

$V_{NP} = I_{NP}\, R_{NP}$
$= 180\,mA * 260\,\Omega = 46.8\,V.$

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

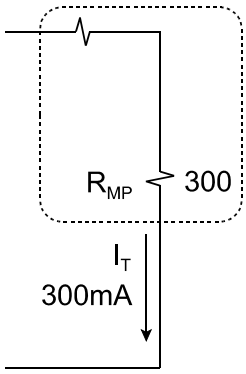



(c) $V_{MP} = V_B = V_5 = 90\,V$ [5]

$$I_B = \frac{V_B}{R_B} = \frac{90\,V}{500\,\Omega} = 180\,mA$$

(d) $$I_5 = \frac{V_5}{R_5} = \frac{90\,V}{750\,\Omega} = 120\,mA$$ [6]

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




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

$R_T = 400\Omega$ [1]

**(b)**

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

$I_T = I_1 = I_{MP} = 300mA$ [3]

$V_1 = I_1 R_1$

$= 300mA * 100\Omega = 30V.$ [4]

$V_{MP} = I_{MP} R_{MP}$

$= 300mA * 300\Omega = 90V.$

| | V (V) | I (mA) | R (Ω) |
|---|---|---|---|
| **T** | ***120*** | 300 [2] | 400 [1] |
| **1** | 30 [4] | 300 [3] | ***100*** |
| **5** | 90 [5] | 120 [6] | ***750*** |
| **2** | 43.2 [8] | 180 [7] | ***240*** |
| **6** | 46.8 [9] | 36 [10] | ***1.3k*** |
| **3** | 28.8 [12] | 144 [11] | ***200*** |
| **7** | 18 [13] | 24 [15] | ***750*** |
| **4** | 18 [13] | 120 [14] | ***150*** |

**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

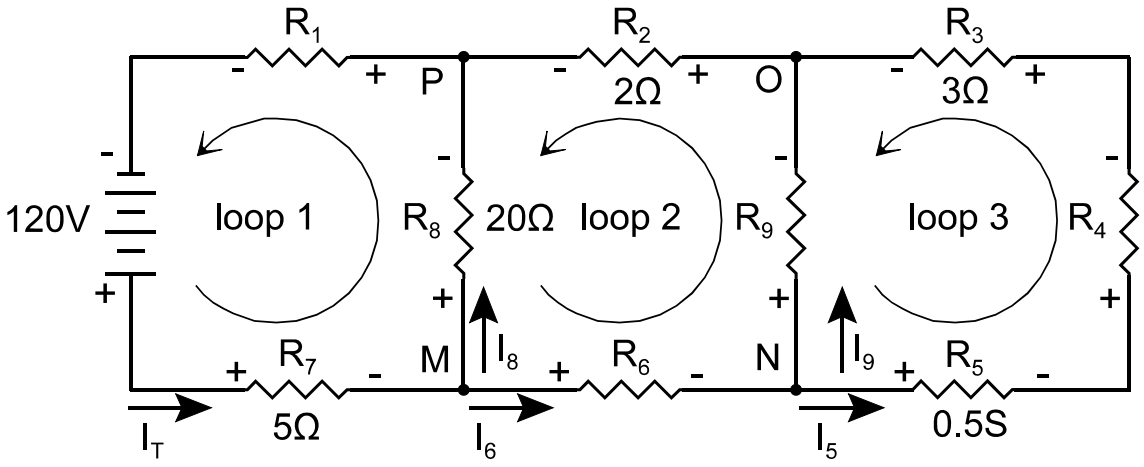
$I_2 = I_6 = 5A$ [3]

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.

$$V_7 = I_7 * R_7 = 8A * 5\Omega = 40V \quad 5$$
$$V_8 = I_8 * R_8 = 3A * 20\Omega = 60V$$
$$V_2 = I_2 * R_2 = 5A * 2\Omega = 10V$$

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

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

$$V_6 = V_8 - V_2 - V_9 = 60V - 10V - 30V = 20V \quad 6$$

By Ohms Law

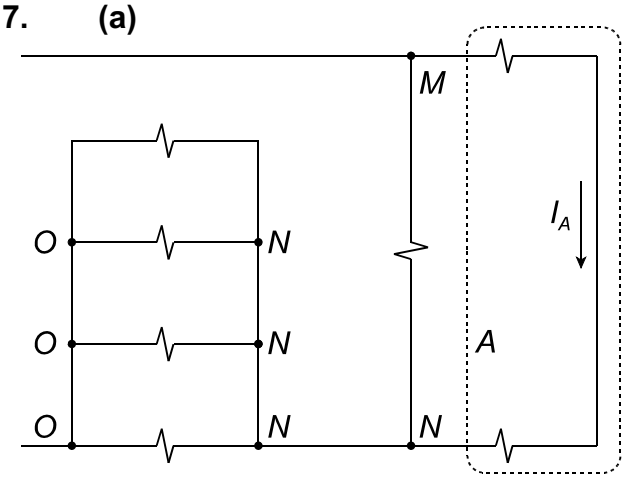
$$I_3 = I_4 = I_5 = \frac{V_3}{R_3} = \frac{9V}{3\Omega} = 3A \quad 7$$

By KCL on Node N

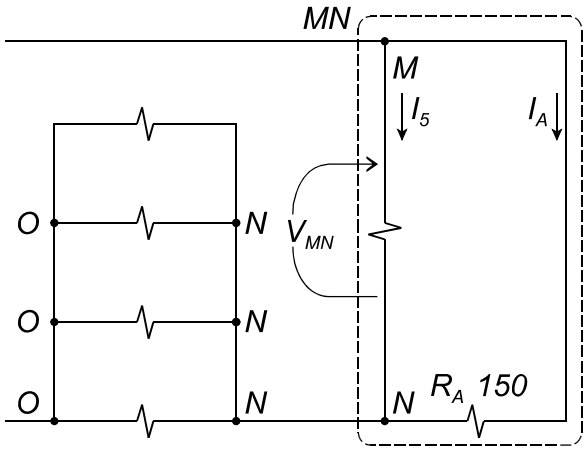
$$I_6 = I_5 + I_9$$
$$\therefore \quad I_9 = I_6 - I_5 = 5A - 3A = 2A \quad 8$$

$$R_1 = \frac{V_1}{I_1} = \frac{20V}{8A} = 2.5\Omega \quad 9$$
$$R_6 = \frac{V_6}{I_6} = \frac{20V}{5A} = 4\Omega$$
$$R_9 = \frac{V_9}{I_9} = \frac{30V}{2A} = 15\Omega$$
$$R_4 = \frac{V_4}{I_4} = \frac{15V}{3A} = 5\Omega$$

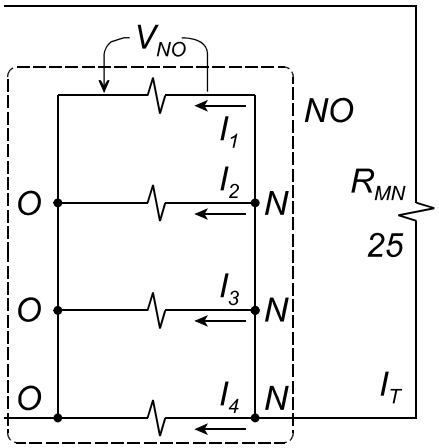
**7.** **(a)**




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




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




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

*or*

$180 \| 180 \| 180 = 30$

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

$I_A = I_6 = I_7 = 0.333A$ [8]

**(c)** $V_6 = I_6 R_6$

$= 0.333A * 68\Omega = 22.6V.$ [9]

$V_7 = I_7 R_7$

$= 0.333A * 82\Omega = 27.3V.$ [10]

$V_{MP} = V_5 = V_A = 50V$ [6]

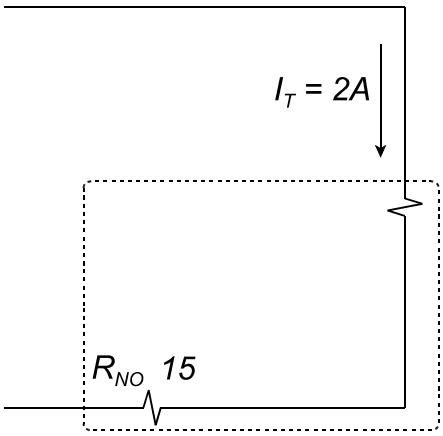
$$I_5 = \frac{V_5}{R_5} = \frac{50V}{30\Omega} = 1.67A$$ [7]

$$I_A = \frac{V_A}{R_A} = \frac{50V}{150\Omega} = 0.333A$$

$V_{NO} = V_1 = V_2 = V_3 = V_4 = 30V$ [3]

**(d)** $$I_1 = I_2 = I_4 = \frac{V_1}{R_1} = \frac{30V}{180\Omega} = 0.167A$$ [4]

$$I_3 = \frac{V_3}{R_3} = \frac{30V}{20\Omega} = 1.5A$$ [5]




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

$R_T = 40\Omega$ [1]

**(b)**

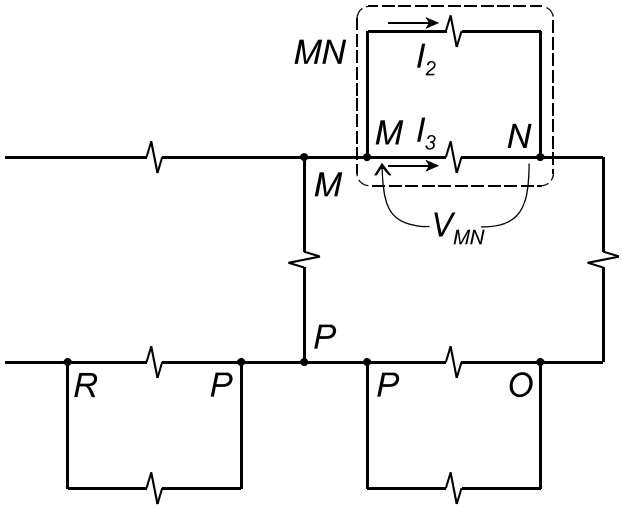
$V_T = I_T * R_T = 2A * 40\Omega = 80V$ [2]

$I_T = I_{MN} = I_{NO} = 2A$

$V_{MN} = I_{MN} R_{MN}$
$= 2A * 25\Omega = 50V.$
$V_{NO} = I_{NO} R_{NO}$
$= 2A * 15\Omega = 30V.$

| | V (V) | I (A) | R (Ω) |
|---|---|---|---|
| **T** | 80 [2] | ***2*** | 40 [1] |
| **1** | 30 [3] | 0.167 [4] | ***180*** |
| **2** | 30 [3] | 0.167 [4] | ***180*** |
| **3** | 30 [3] | 1.5 [5] | ***20*** |
| **4** | 30 [3] | 0.167 [4] | ***180*** |
| **5** | 50 [6] | 1.67 [7] | ***30*** |
| **6** | 22.6 [9] | 0.333 [8] | ***68*** |
| **7** | 27.3 [10] | 0.333 [8] | ***82*** |

**8. (a)**



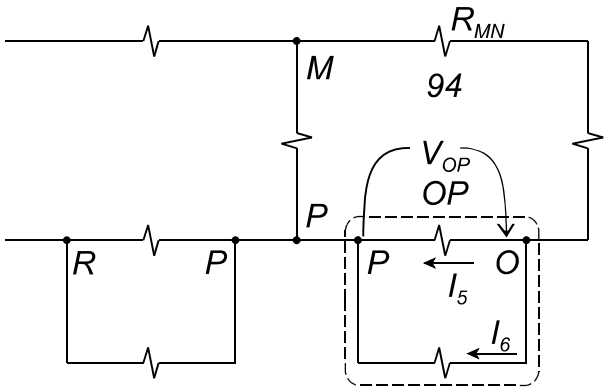

**(c)**

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

$V_{MN} = V_2 = V_3 = 37.6V$ [14]

$I_2 = \frac{V_2}{R_2} = \frac{37.6V}{282\Omega} = 0.133A$ [15]

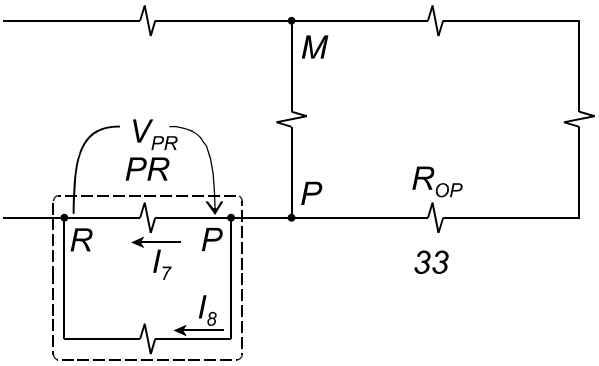
$I_3 = \frac{V_3}{R_3} = \frac{37.6V}{141\Omega} = 0.267A$ [16]




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

(d) $$V_{OP} = V_5 = V_6 = 13.2V \quad 12$$

$$I_5 = I_6 = \frac{V_5}{R_5} = \frac{13.2V}{66\Omega} = 0.2A \quad 13$$

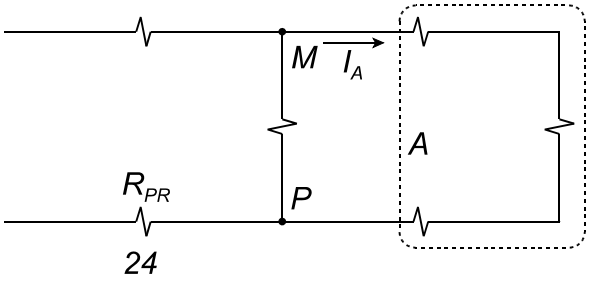



$$R_7 \| R_8 = 40 \| 60 = 24 = R_{PR}$$

$$V_{PR} = V_7 = V_8 = 28.8V \quad 9$$

$$I_7 = \frac{V_7}{R_7} = \frac{28.8V}{40\Omega} = 0.72A \quad 10$$

$$I_8 = \frac{V_8}{R_8} = \frac{28.8V}{60\Omega} = 0.48A \quad 11$$



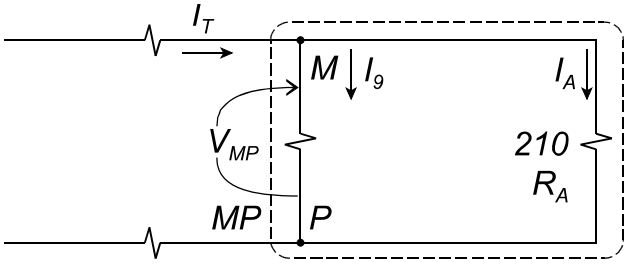

$$R_{MN} s R_4 s R_{OP} = 94 s 83 s 33 = 210 = R_A$$

$$I_A = I_{MN} = I_4 = I_{OP} = 0.4A \quad 7$$

$$V_{MN} = I_{MN} R_{MN} = 0.4A * 94\Omega = 37.6V.$$

$$V_4 = I_4 R_4 = 0.4A * 83\Omega = 33.2V. \quad 8$$

$$V_{OP} = I_{OP} R_{OP} = 0.4A * 33\Omega = 13.2V.$$

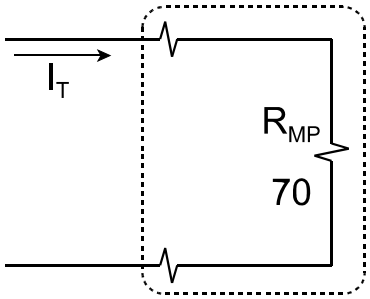



$$R_A \| R_9 = 210 \| 105 = 70 = R_{MP}$$

$$V_{MP} = V_9 = V_A = 84V \quad 5$$

$$I_9 = \frac{V_9}{R_9} = \frac{84V}{105\Omega} = 0.8A \quad 6$$

$$I_A = \frac{V_A}{R_A} = \frac{84V}{210\Omega} = 0.4A$$




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

$R_T = 100\Omega$ [1]

**(b)**

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

$I_T = I_1 = I_{MP} = I_{PR} = 1.2A$ [3]

$V_1 = I_1 R_1$
$= 1.2A * 6\Omega = 7.2V.$ [4]

$V_{MP} = I_{MP} R_{MP}$
$= 1.2A * 70\Omega = 84V.$

$V_{PR} = I_{PR} R_{PR}$
$= 1.2A * 24\Omega = 28.8V.$

| | V (V) | I (A) | R (Ω) |
|---|---|---|---|
| **T** | ***120*** | 1.2 [2] | 100 [1] |
| **1** | 7.2 [4] | 1.2 [3] | ***6*** |
| **7** | 28.8 [9] | 0.72 [10] | ***40*** |
| **8** | 28.8 [9] | 0.48 [11] | ***60*** |
| **9** | 84 [5] | 0.8 [6] | ***105*** |
| **2** | 37.5 [14] | 0.133 [15] | ***282*** |
| **3** | 37.6 [14] | 0.267 [16] | ***141*** |
| **4** | 33.2 [8] | 0.4 [7] | ***83*** |
| **5** | 13.2 [12] | 0.2 [13] | ***66*** |
| **6** | 13.2 [12] | 0.2 [13] | ***66*** |