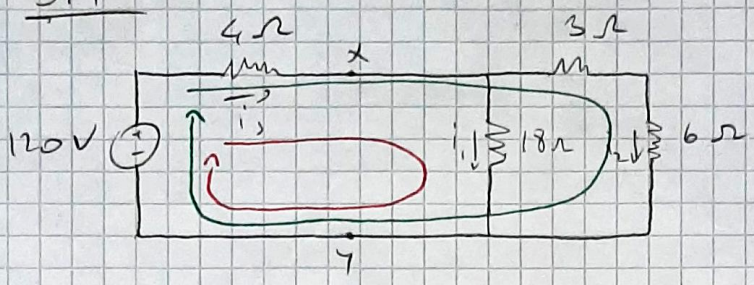
3.1



$3\Omega + 6\Omega = 9\Omega$ (serial connected)

$\frac{1}{9} + \frac{1}{18} = \frac{1}{6} \Rightarrow 6\Omega$ (parallel connected)

$R_T = 6\Omega + 4\Omega = 10\Omega$ (serial connected)

$V = I.R_T \Rightarrow 120 = I.10 \Rightarrow I = 12A$

$i_3 = 12A$

a) Current entering the junction x is same as the current leaving junction x and the current is 12A.

Current entering the junction y is same as the current leaving junction y and the current is 12A.

b) According to KVL sum of voltages in any closed loop should be equal to zero.

First loop (red one)

$4.12 + i_1.18 - 120 = 0 \Rightarrow i_1.18 = 72 \Rightarrow i_1 = 4A$

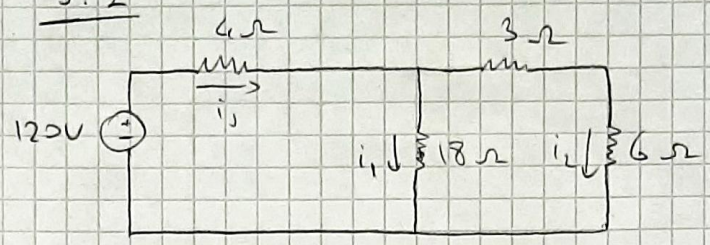
Second loop (green one)

$4.12 + i_2.9 - 120 = 0 \Rightarrow i_2.9 = 72 \Rightarrow i_2 = 8A$

According to KCL $i_3 = i_1 + i_2 \Rightarrow 12 = 8 + 4$. It checks.

So KVL is correct for any closed loop

3.2



$3\Omega + 6\Omega = 9\Omega$ (serial connected)

$\frac{1}{9} + \frac{1}{18} = \frac{1}{6} \Rightarrow 6\Omega$ (parallel connected)

$R_T = 4\Omega + 6\Omega = 10\Omega$ (serial connected)

$V = i_3 \cdot R_T \Rightarrow 120 = i_3 \cdot 10 \Rightarrow i_3 = 12A$

$4 \cdot 12 + i_1 \cdot 18 - 120 = 0 \Rightarrow i_1 \cdot 18 = 72 \Rightarrow i_1 = 4A$ (KVL)

$4 \cdot 12 + i_2 \cdot 9 - 120 = 0 \Rightarrow i_2 \cdot 9 = 72 \Rightarrow i_2 = 8A$ (KVL)

a) For 4Ω resistor

$P = i^2 R \Rightarrow P = 12^2 \cdot 4 = 576\ W$

For 3Ω resistor

$P = i^2 R \Rightarrow P = 8^2 \cdot 3 = 192\ W$

For 6Ω resistor

$P = i^2 R \Rightarrow P = 8^2 \cdot 6 = 384\ W$

For 18Ω resistor

$P = i^2 R \Rightarrow P = 4^2 \cdot 18 = 288\ W$

b) $P = V \cdot i \Rightarrow P = 120 \cdot 12 = 1440\ W$

c) The power delivered should be equal to power dissipated.

$1440 = 576 + 192 + 384 + 288$ ✓ It checks.

3.3

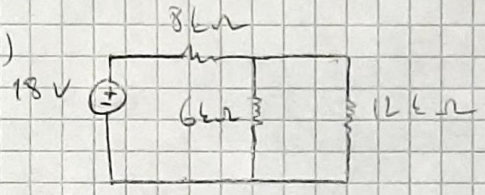
a) i) In P3.3 (a) circuit 5kΩ and 7kΩ resistors are connected in series.

ii) In P3.3 (b) circuit 800Ω - 100Ω and 300Ω - 200Ω are connected in series.

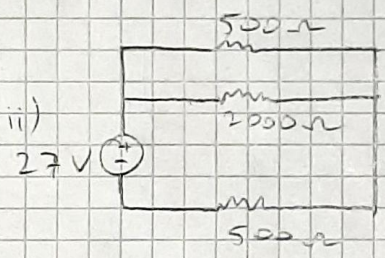
iii) In P3.3 (c) circuit 35Ω - 15Ω - 25Ω and 10Ω - 40Ω are connected in series.

iv) In P3.3 (d) circuit 50Ω - 90Ω and 80Ω - 70Ω are connected in series.

b) i)

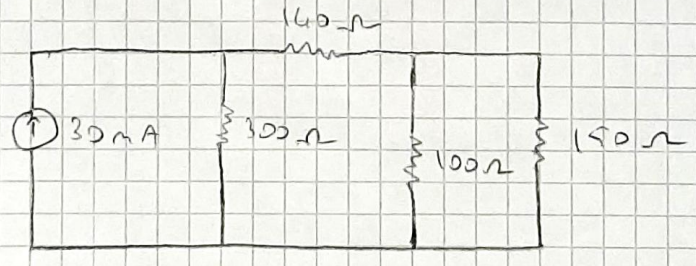


ii)



iii)

iv)



3.4

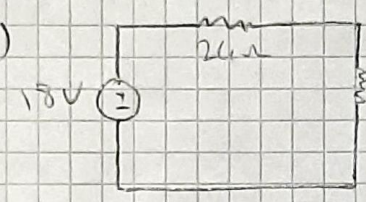
a) i) In P3.4(b) circuit 36Ω - 18Ω are connected in parallel.

ii) In P3.4(b) circuit 210Ω - 280Ω and 200Ω - 170Ω - 180Ω and 280Ω are connected in parallel

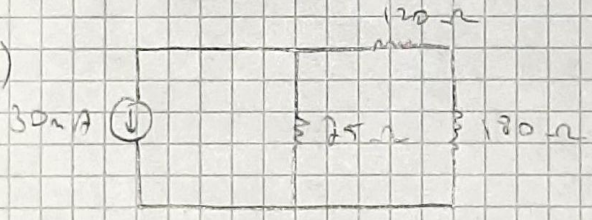
iii) In P3.4(c) circuit 50Ω - 75Ω and 100kΩ - 150kΩ - 60kΩ are connected in parallel

iv) In P3.4(d) circuit 750Ω - 500Ω - 600Ω and 900Ω, 1,5kΩ - 3kΩ are connected in parallel.

b) i)

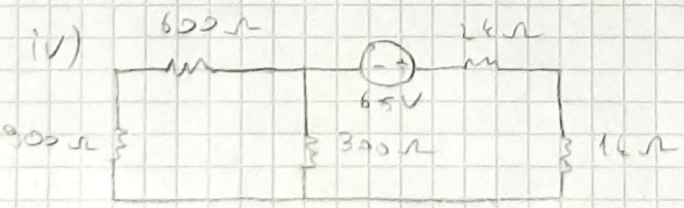


ii)



iii)

iv)



3.5

a) i) $5 + 7 = 12\ \Omega$

$\frac{1}{12} + \frac{1}{6} + \frac{1}{4} \Rightarrow 2\ \Omega$

$R_T = 8 + 2 = 12\ \Omega$

ii) $800 + 1200 = 2000\ \Omega$

$\frac{1}{500} + \frac{1}{2000} + \frac{1}{400} \Rightarrow 286\ \Omega$

$300 + 700 = 500\ \Omega$

$R_T = 500 + 286 = 786\ \Omega$

iii) $15 + 25 + 35 = 75\ \Omega$

$10 + 40 = 50\ \Omega$

$\frac{1}{R_T} = \frac{1}{75} + \frac{1}{50} = \frac{1}{30}$

$R_T = 30\ \Omega$

iv) $80 + 70 = 150\ \Omega$

$\frac{1}{150} + \frac{1}{100} = \frac{1}{60} \Rightarrow 60\ \Omega$

$50 + 90 + 60 = 200\ \Omega$

$\frac{1}{R_T} = \frac{1}{200} + \frac{1}{300} = \frac{1}{120}$

$R_T = 120\ \Omega$

3.5

b) i) $V = I \cdot R \Rightarrow 18 = I \cdot 12 \quad I = 1,5\,A$

$p = V \cdot I \Rightarrow 18 \cdot 1,5 = 27\,w$ //

ii) $V = I \cdot R \Rightarrow 27 = I \cdot 300 \quad I = 0,09\,A$

$p = V \cdot I \Rightarrow 27 \cdot 0,03 = 0,81\,w$ //

iii) $V = I \cdot R \Rightarrow 90 = I \cdot 30 \quad I = 3\,A$

$p = V \cdot I \Rightarrow 90 \cdot 3 = 270\,w$ //

iv) $V = I \cdot R \Rightarrow 0,03 = I \cdot 120 \quad I = 0,00025\,A$

$p = V \cdot I \Rightarrow 0,03 \cdot 0,00025 = 7,5 \cdot 10^{-6}\,w$ //

3.8

a) $\frac{1}{60} + \frac{1}{90} = \frac{1}{36} \Rightarrow 36\ \Omega$

$R_{ab} = 24 + 36 + 12 = 72\ \Omega$

b) $6 + 2 + 4 = 12\ \Omega$

$\frac{1}{12} + \frac{1}{8} = \frac{1}{4,8} \Rightarrow 4,8\ \Omega$

$R_{ab} = 4,8 + 5,2 = 10\ \Omega$

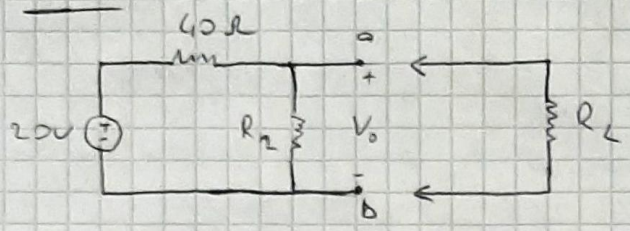
c) $\frac{1}{1200} + \frac{1}{720} = \frac{1}{450} \Rightarrow 450\ \Omega$

$320 + 480 = 800\ \Omega$

$\frac{1}{450} + \frac{1}{800} = \frac{1}{288}$

$R_{ab} = 288\ \Omega$

3.13



$$V_0 = V_s \frac{R_2}{R_2 + 40}$$

$$4 = 20 \cdot \frac{R_2}{R_2 + 40} \Rightarrow \frac{R_2}{R_2 + 40} = \frac{1}{5}$$

$$R_2 = 10\,\Omega$$

$$V = I \cdot R \Rightarrow 20 = 50 \cdot I \quad I = 0{,}4\ A$$

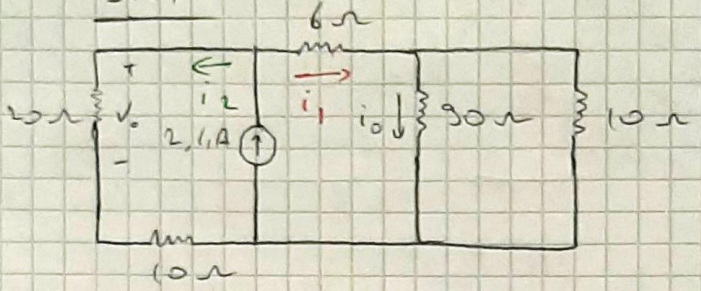
$$R_2 \cdot i_1 = 3V \Rightarrow 10 \cdot i_1 = 3V \quad i_1 = 0{,}3\ A$$

$$40 \cdot i_7 = 17V \quad i_7 = 17/40\ A$$

$$i_2 = 17/40 - 3/10 = 0{,}125\ A$$

$$R_L \cdot 0{,}125 = 3V \Rightarrow R_L = 24\,\Omega$$

3.17



a) $\frac{1}{90} + \frac{1}{10} = \frac{1}{9} \Rightarrow 9\Omega$ $\quad 9+6 = 15\Omega$

$20 + 10 = 30\Omega$

$i_1 = 1,6\,A$ $\quad i_o = 0,16\,A$ //

$i_2 = 0,3\,A$ $\quad V_o = 0,8 \cdot 20 = 16\,V$ //

b) $p = i^2 \cdot R \Rightarrow (1,6)^2 \cdot 6 = 15,36\,W$ //

c) $\frac{1}{R_T} = \frac{1}{30} + \frac{1}{15} = \frac{1}{10} \Rightarrow R_T = 10\Omega$

$V = I \cdot R \Rightarrow V = 10 \cdot 2,4 = 24\,V$ //

$p = V \cdot I \Rightarrow p = 24 \cdot 2,4 = 57,6\,W$ //

3.18

Criterias:

$i_g = 50\,mA$, $V_g = 25\,V$, $i_1 = 0{,}6\,i_2$, $i_3 = 2\,i_2$

and $i_4 = 4\,i_1$

$i_2 = 5/3\,i_1$

$i_3 = 10/3\,i_1$

$i_4 = 4\,i_1$

$10\,i_1 = 50\,mA$

$i_1 = 5\,mA$

$i_2 = 25/3\,mA$

$i_3 = 50/3\,mA$

$i_4 = 20\,mA$

$25 = 0{,}005 \cdot R_1$

$R_1 = 5k\Omega$ //

$25 = \frac{1}{60} \cdot R_2$

$R_2 = 3k\Omega$ //

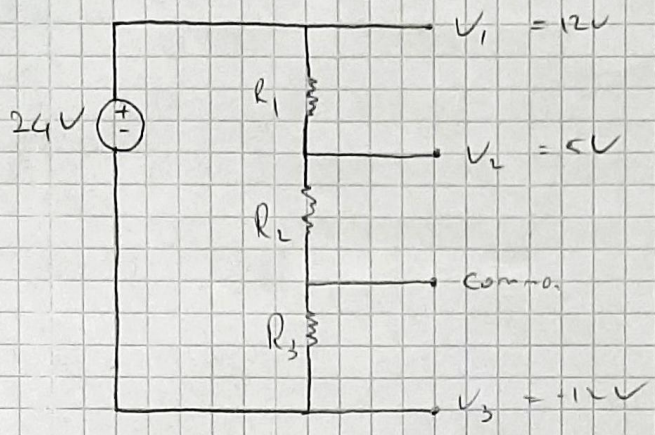
$25 = \frac{1}{60} \cdot R_3$

$R_3 = 1{,}5k\Omega$ //

$25 = 0{,}02 \cdot R_4$

$R_4 = 1{,}25k\Omega$ //

3.19



$$I = \frac{80}{24} = 10/3 \text{ A}$$

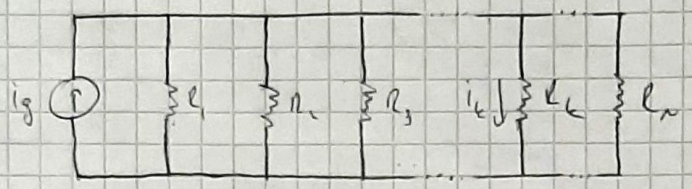
$$R_1 \cdot \frac{10}{3} = 12 - 5 \Rightarrow R_1 = 2,1\ \Omega //$$

$$R_2 \cdot \frac{10}{3} = 5 - 0 \Rightarrow R_2 = 1,5\ \Omega //$$

$$R_3 \cdot \frac{10}{3} = 0 - (-12) \Rightarrow 3,6\ \Omega //$$

3.22

a)



Show

$$i_k = \frac{i_g \cdot G_k}{G_1 + G_2 + G_3 + \dots + G_k + \dots G_N}$$

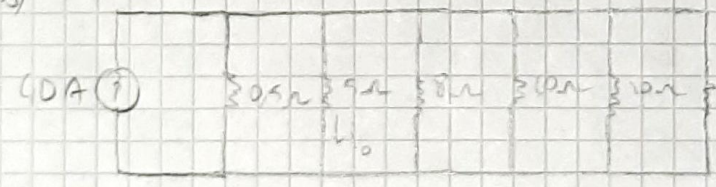
$$G = \frac{1}{R} \Rightarrow G_1 + G_2 + G_3 + \dots G_k + \dots G_N$$

$$= \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots + \frac{1}{R_k} + \dots + \frac{1}{R_N} = \frac{1}{R_T}$$

$$i_k = i_g \cdot \frac{1}{R_k} \cdot R_T \Rightarrow i_k = i_g \cdot \frac{R_T}{R_k}$$

This is valid for parallel circuits

b)

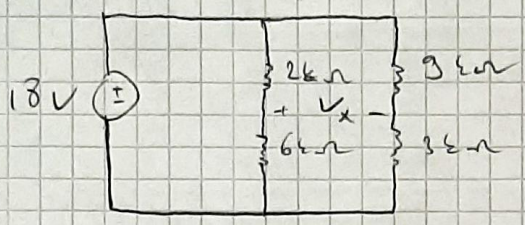


$$\frac{1}{R_T} = \frac{2}{(40)} + \frac{1}{5} + \frac{1}{8} + \frac{1}{10} + \frac{1}{10} + \frac{1}{40} = \frac{100}{40}$$

$$R_T = 2/5\ \Omega$$

$$i_0 = 40 \cdot \frac{2}{25} = 3{,}2\ A$$

3.28



a) $\frac{1}{R_t} = \frac{1}{8} + \frac{1}{12} = \frac{5}{24}$ $\quad R_t = \frac{24}{5}\ k\Omega$

$18 \cdot \frac{5}{24000} = \frac{15}{4000}\ A = I$

$\frac{15}{4000} \cdot \frac{3}{5} = \frac{3}{4000} \cdot 4000 = \frac{9}{2}\ V \qquad 18 - \frac{9}{2} = \frac{23}{2}\ V$

$\frac{15}{4000} \cdot \frac{2}{5} = \frac{3}{2000} \cdot 9000 = \frac{27}{2}\ V \qquad 18 - \frac{27}{2} = \frac{5}{2}\ V$

$V_x = \frac{23}{2} - \frac{5}{2} = \frac{18}{2} = 9V$ //

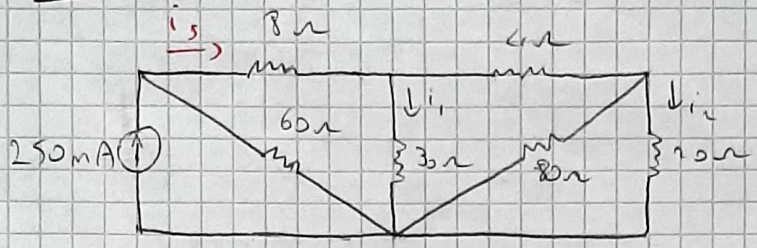
b) $R_t = \frac{24}{5}\ k\Omega \qquad I = \frac{5V_1}{24000}\ A$

$\frac{5V_1}{24000} \cdot 4000 \cdot \frac{3}{5} = \frac{V_1}{4} \qquad V_3 = \frac{V_1}{4} = \frac{3V_1}{4}$

$\frac{5V_1}{24000} \cdot 8000 \cdot \frac{2}{5} = \frac{3V_1}{4} \qquad V_3 - \frac{3V_1}{4} = \frac{V_1}{4}$

$V_x = \frac{3V_1}{4} - \frac{V_1}{4} = \frac{V_1}{2}$ //

3.32



$\frac{1}{80} + \frac{1}{20} = \frac{1}{16} \Rightarrow 16\Omega$

$16 + 4 = 20\Omega$

$\frac{1}{20} + \frac{1}{30} = \frac{1}{12} \Rightarrow 12\Omega$

$12 + 8 = 20\Omega$

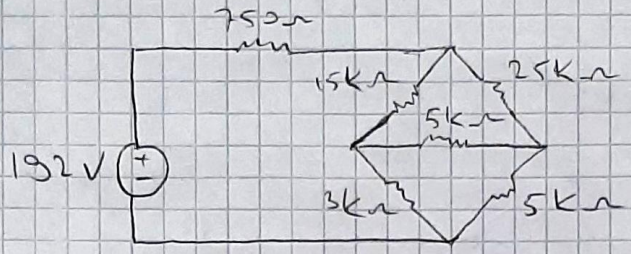
$\frac{1}{20} + \frac{1}{60} = \frac{1}{15} \Rightarrow 15\Omega = R_T$

$i_s = 250 \cdot \frac{15}{20} = 187{,}5\,mA$

$i_1 = 187{,}5 \cdot \frac{12}{30} = 75\,mA$ //

$i_2 = 112{,}5 \cdot \frac{16}{20} = 90\,mA$ //

3.52



Current doesn't pass the middle 5kΩ resistor

$15+3=18 \qquad 25+5=30$

$\frac{1}{18}+\frac{1}{30}=\frac{8}{90} \Rightarrow 11{,}25\ k\Omega$

(5) (3)

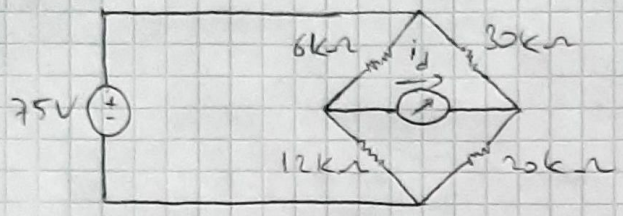
$11{,}25+0{,}75=12\ k\Omega$

$I=\frac{192}{12}=16\ mA$

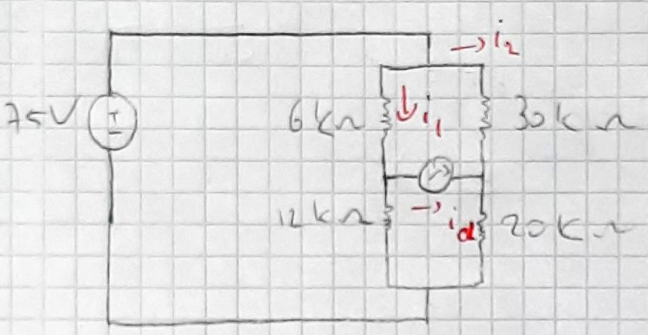
$16\cdot\frac{11{,}25}{18}=10\ mA$

$P=i^2\cdot R \Rightarrow (0{,}01)^2\cdot 3000=300\ mW$

3.53



This can be converted to



$\frac{1}{6} + \frac{1}{30} = \frac{1}{5} \Rightarrow 5k\Omega$

$\frac{1}{20} + \frac{1}{12} = \frac{1}{7,5} \Rightarrow 7,5k\Omega$

$7,5 + 5 = 12,5k\Omega \quad I = 75/12,5 = 6mA$

$i_1 = 6 \cdot \frac{5}{6} = 5mA \qquad i_d = x$

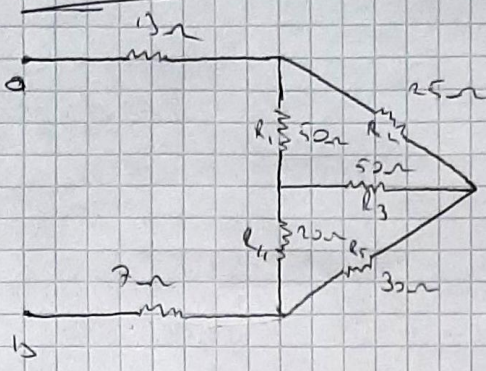
$i_2 = 6 \cdot \frac{5}{30} = 1mA$

$12 \cdot (5-x) = 20(1+x) \Rightarrow 60 - 12x = 20x + 20$

$32x = 40$

$x = 1,25mA$ //

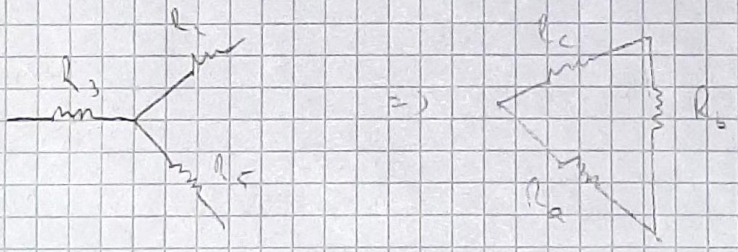
3.58



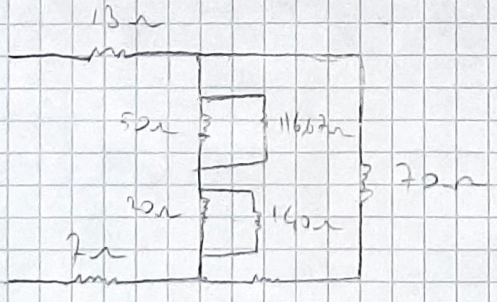
a) $R_a = \frac{25.50 + 25.30 + 50.30}{25} = 140\Omega$

$R_b = \frac{25.50 + 25.30 + 50.30}{50} = 70\Omega$

$R_c = \frac{25.50 + 25.30 + 50.30}{30} = 116,67\Omega$



=)



$50 // 116,67 = 35\Omega$

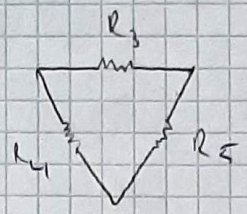
$20 // 140 = 17,5\Omega$

$70 // 52,5 = 30\Omega$

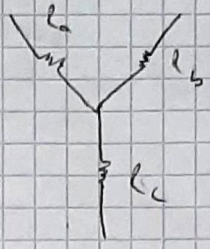
$30 + 13 + 7 = 50\Omega = R_{ab} //$

3.58

b)



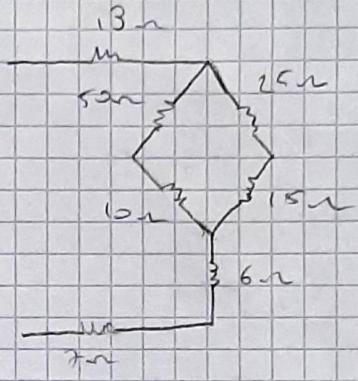
⇒



$R_a = \frac{50 \cdot 20}{100} = 10\,\Omega$

$R_b = \frac{50 \cdot 30}{100} = 15\,\Omega$

$R_c = \frac{20 \cdot 30}{100} = 6\,\Omega$



$60 \| 40 = 24\,\Omega$

$R_{ab} = 24 + 6 + 13 + 7 = 50\,\Omega$ //

c) Δ to Y (R_1, R_4, R_5)

$R_a = \frac{50 \cdot 25}{125} = 10\,\Omega$

$R_b = \frac{50 \cdot 50}{125} = 20\,\Omega$

$R_c = \frac{50 \cdot 25}{125} = 10\,\Omega$

$40 \| 40 = 20\,\Omega$

$R_{ab} = 20 + 10 + 13 + 7 = 50\,\Omega$ //

Y to Δ (R_1, R_3, R_4)

$R_a = \frac{4.500}{20} = 225\,\Omega$

$R_b = \frac{4.500}{50} = 90\,\Omega$

$R_c = \frac{4.500}{50} = 90\,\Omega$

$225 \| 225 = 22{,}5\,\Omega$

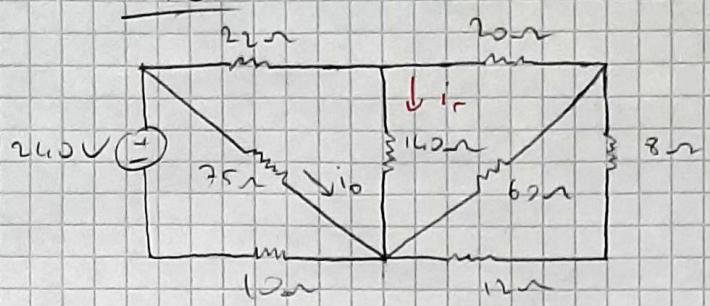
$90 \| 90 = 22{,}5\,\Omega$

} $45\,\Omega$ (in series)

$90 \| 45 = 30\,\Omega$

$R_{ab} = 30 + 13 + 7 = 50\,\Omega$ //

3.62



$8+12 = 20\,\Omega$

$20 \parallel 60 = 15\,\Omega$

$20+15 = 35\,\Omega$

$140 \parallel 35 = 28\,\Omega$

$28+22 = 50\,\Omega$

$50 \parallel 75 = 30\,\Omega$

$R_{eq} = 30+10 = 40\,\Omega$

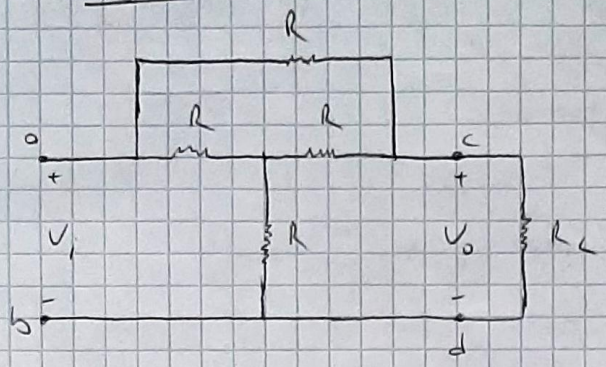
$I = 240/40 = 6\,A$

$$i_o = 6 \cdot \frac{30}{75} = 2{,}4\,A \;//$$

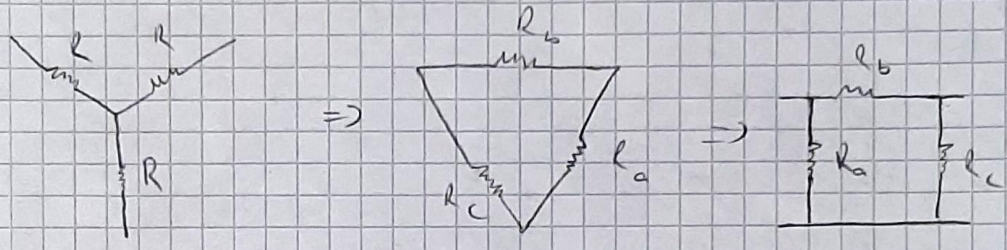
$$i_r = 3{,}6 \cdot \frac{28}{140} = 0{,}72\,A$$

$$p = i^2 \cdot R = 0{,}72^2 \cdot 140 = 72{,}58\,W \;//$$

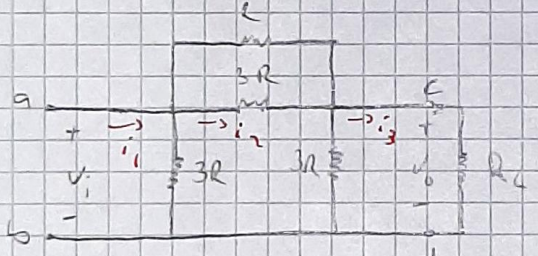
3.67



a)



$$R_a = R_b = R_c = \frac{3R \cdot R}{R} = 3R$$



$3R \parallel R = \frac{3R}{4}$

If we replace R with R_L

$R_L \parallel 3R_L = \frac{3R_L}{4}$

$\frac{3R_L}{4} + \frac{3R_L}{4} = \frac{3R_L}{2}$ $\qquad \frac{3R_L}{2} \parallel 3R_L = R_L = R_{ab}$ //

b) Let's assume that $i = i_1$

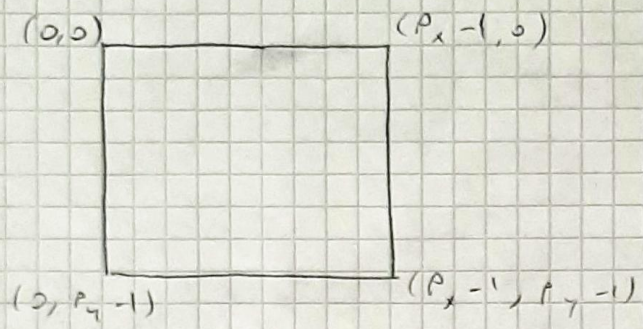
$$i_2 = i \cdot \frac{R_L}{\frac{3R_L}{2}} = \frac{2i}{3} \qquad i_3 = \frac{2i}{3} \cdot \frac{\frac{3R_L}{4}}{R_L} = \frac{1}{2}$$

$V_i = i \cdot R_{ab} = i \cdot R_L$

$V_o = \frac{i}{2} \cdot R_L$

$$V_o / V_i = \frac{\frac{i R_L}{2}}{i R_L} = 0.5 \text{ //}$$

3.73



a) $\alpha = \frac{V_x}{V_s}$ $\beta = \frac{V_y}{V_s}$

$V_s = 5V$ $\alpha = \frac{1}{5} = 0,2$

$V_x = 1V$ $\beta = \frac{3,75}{5} = 0,75$

$V_y = 3,75V$

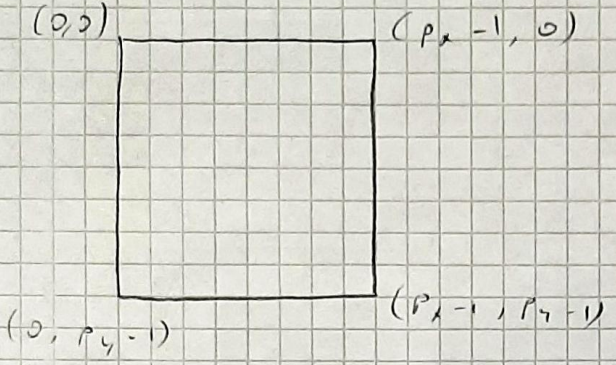
b) $x = (1-\alpha) \cdot P_x$

$y = (1-\beta) \cdot P_y$

$x = (1-0,2) \cdot 480 = 0,8 \cdot 480 = 384$

$y = (1-0,25) \cdot 800 = 0,25 \cdot 800 = 200$

3.74



$$\frac{3}{4}\cancel{80} = (1-\alpha)\cdot\cancel{64}\,^{4}0 \Rightarrow \alpha = 1/4$$

$$\frac{\cancel{19}\,^{1}2}{3} = (1-\beta)\cdot\frac{\cancel{10}\,^{5}4}{16} \Rightarrow \beta = 13/16$$

$$\frac{1}{4} = \frac{V_x}{8} \Rightarrow V_x = 2\ V$$

$$\frac{13}{16} = \frac{V_y}{8} \Rightarrow V_y = 6{,}5\ V$$