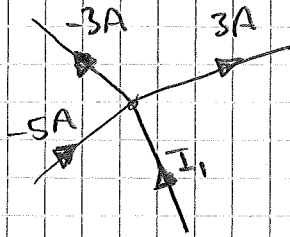
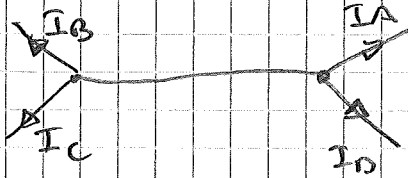


1.1 a)

KI

$$-3 + 3 - I_1 - (-5) = 0 \Rightarrow \underline{\underline{I_1 = 5A}}$$

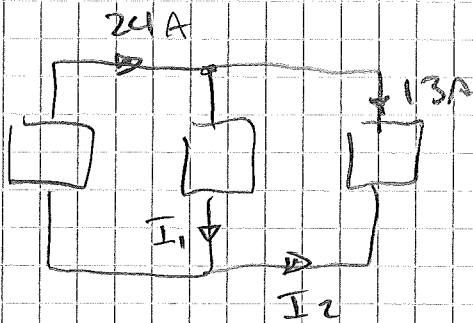
b)



$$I_A + I_B + I_C + I_D = 0$$

$$\underline{\underline{I_A}} = -(I_B + I_C + I_D) = -(3,5 + 7,2 + 5,3) = \underline{\underline{-16A}}$$

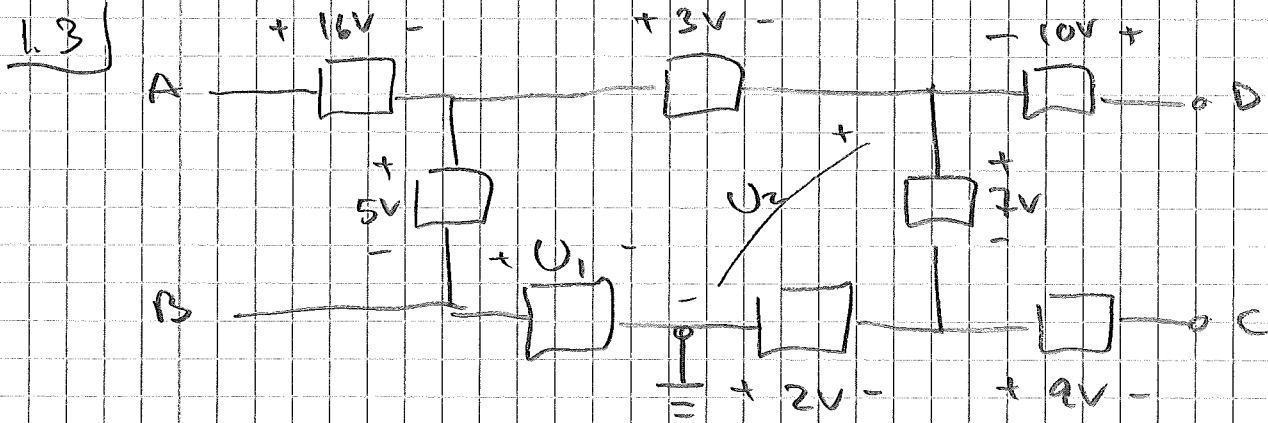
1.2



$$24 - 13 - I_1 = 0 \Rightarrow \underline{\underline{I_1 = 11A}}$$

$$13 + I_2 = 0 \Rightarrow \underline{\underline{I_2 = -13A}}$$

(2)



a) KVL $\Rightarrow U_2 - 7 + 2 = 0 \Rightarrow \underline{U_2 = 5V}$

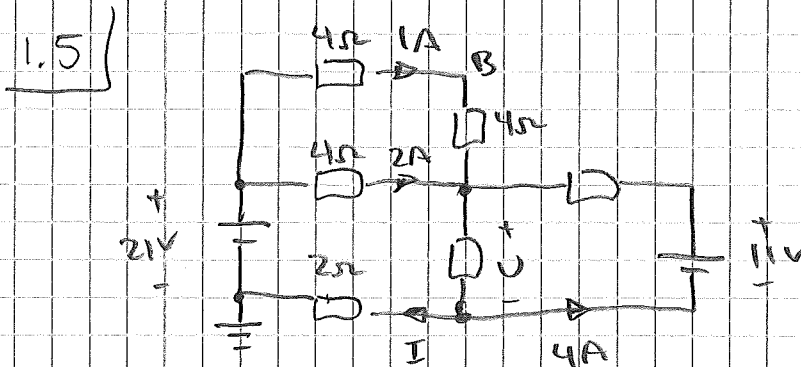
KVL $\Rightarrow U_1 + 5 - 3 - U_2 = 0 \Rightarrow \underline{U_1 = +3V}$

b) $V_A = U_1 + 5 + 16 = 3 + 5 + 16 = 24V$

$V_B = U_1 = 3V$

$V_C = -2 - 9 = -11V$

$V_D = U_2 + 10 = 15V$



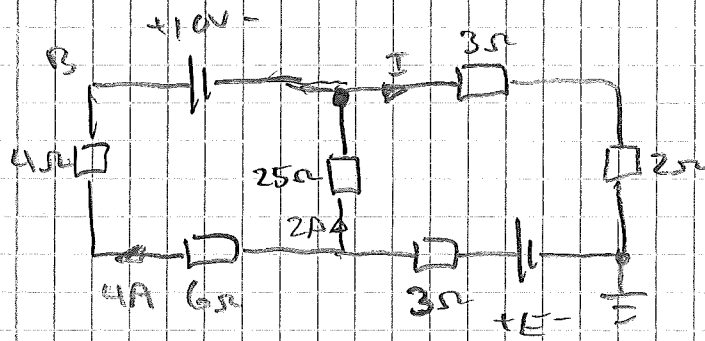
a) KI $I - 1 - 2 = 0 \Rightarrow \underline{I = 3A}$

b) $\underline{V_B = 21 - 4 \cdot 1 = 17V}$

c) KVL $U + 2 \cdot 4 - 21 + 2 \cdot 3 = 0 \Rightarrow \underline{U = 7V}$

(3)

1.7



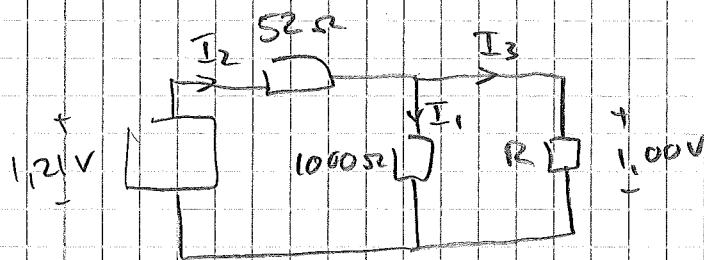
a) KI $4 + 2 - I = 0 \Rightarrow \underline{I = 6A}$

b) $\underline{V_B = 5 \cdot I + 10 = 5 \cdot 6 + 10 = 40V}$

c) KV η $5I + 25 \cdot 2 + 3I - E = 0$
 $\underline{E = 8I + 50 = 8 \cdot 6 + 50 = 98V}$

d) $\underline{P = -10 \cdot 4 = -40W}$

1.8



$$I_1 = \frac{1,00}{1000} = 1 \mu A$$

KV η $1,00 + 52I_2 - 1,21 = 0$

$$I_2 = \frac{1,21 - 1,00}{52} = 4,038 \mu A$$

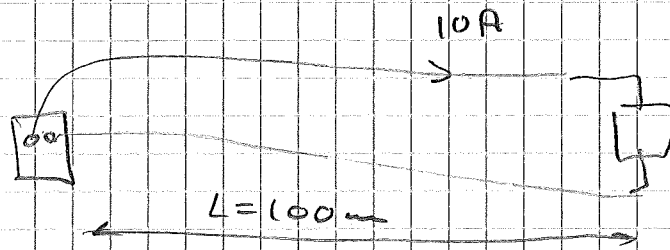
KI $I_2 - I_1 - I_3 = 0$

$$I_3 = I_2 - I_1 = 3,038 \mu A$$

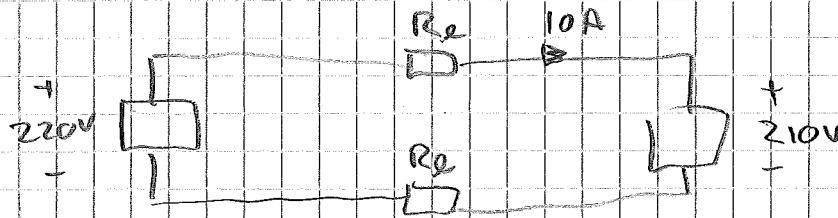
$$R = \frac{1,00}{I_3} = \frac{1,00}{3,038 \cdot 10^{-3}} = 329 \Omega$$

1.10

Kopplungs-Schema



Berührungsschema

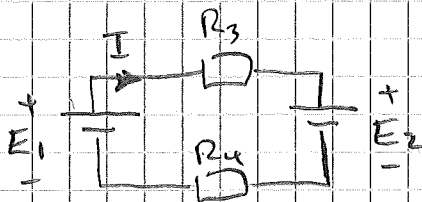


KV $\rightarrow 220 - 2R_L \cdot 10 - 210 = 0$

$$R_L = \frac{10}{20} = 0,5 \Omega$$

$$R_L = \rho \frac{L}{A} \Rightarrow \underline{\underline{A = \frac{\rho L}{R_L} = \frac{1,72 \cdot 10^{-2} \cdot 100}{0,5} = 3,44 \text{ mm}^2}}$$

1.12



$$E_1 = 12V$$

$$E_2 = 8V$$

$$R_3 = 3\Omega$$

$$R_4 = 5\Omega$$

KV $\rightarrow E_1 - R_3 I - E_2 - R_4 I = 0$

$$I = \frac{E_1 - E_2}{R_3 + R_4} = \frac{12 - 8}{8} = 0,5A$$

a) E_1 abgibt $P_1 = E_1 \cdot I = 6W$

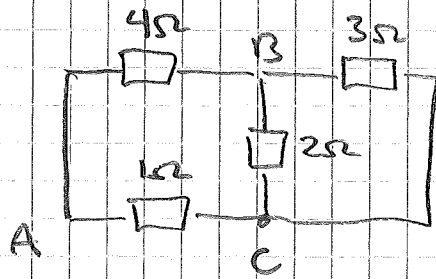
b) E_2 nimmt $P_2 = E_2 \cdot I = 4W$

R_3 " $P_3 = R_3 I^2 = 3 \cdot 0,5^2 = 0,75W$

R_4 " $P_4 = R_4 I^2 = 5 \cdot 0,5^2 = 1,25W$

5

1.13



$$a) R_{AB} = (2//3 + 1) // 4 =$$

$$= \left(\frac{2 \cdot 3}{2 + 3} + 1 \right) // 4 = 2,2 // 4 = \frac{2,2 \cdot 4}{2,2 + 4} = 1,42 \Omega$$

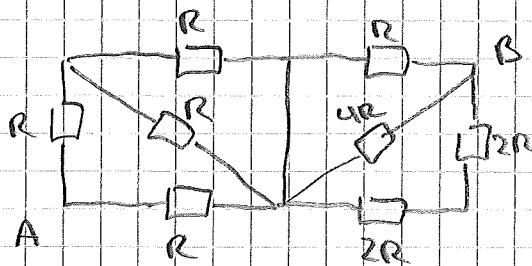
$$b) R_{AC} = (2//3 + 4) // 1 = 5,2 // 1 = \frac{5,2 \cdot 1}{5,2 + 1} = 0,839 \Omega$$

$$c) R_{BC} = (2//3) // (4 + 1) = 1,2 // 5 = \frac{1,2 \cdot 5}{1,2 + 5} = 0,968 \Omega$$

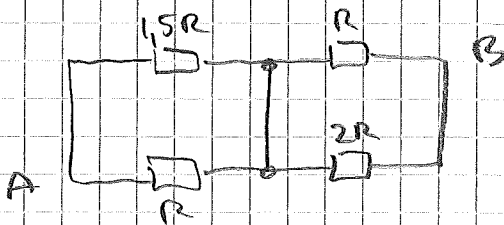
1.14

$$\frac{1}{R} = \frac{1}{5} + \frac{1}{4} + \frac{1}{10} + \frac{1}{20} \Rightarrow R = 1,667 \Omega$$

1.16



$$R = 60 \Omega$$



$$R_{AB} = 1,5R // R + R // 2R = \frac{1,5 \cdot 1}{1,5 + 1} R + \frac{1 \cdot 2}{1 + 2} R = 1,267 R = 76 \Omega$$

1.18

$$R_1 = 53 \Omega$$

$$R_2 = 106 \Omega$$

$$R_3 = 53 + 106 = 159 \Omega$$

$$R_4 = 53 // 106 = 35,33 \Omega$$

$$U = 230 \text{ V}$$

$$P_1 = \frac{U^2}{R_1} = 998 \text{ W}$$

$$P_2 = \frac{U^2}{R_2} = 499 \text{ W}$$

$$P_3 = \frac{U^2}{R_3} = 333 \text{ W}$$

$$P_4 = \frac{U^2}{R_4} = 1497 \text{ W}$$

1.19

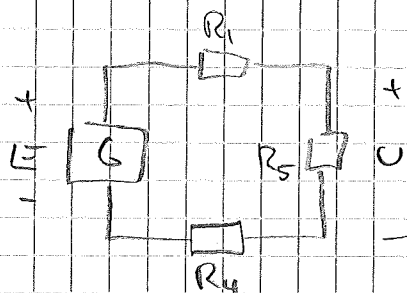
Sp. delning

$$U = \frac{10}{5+10+25} \cdot 9 \text{ V} = 2,25 \text{ V}$$

1.20

Strom delning

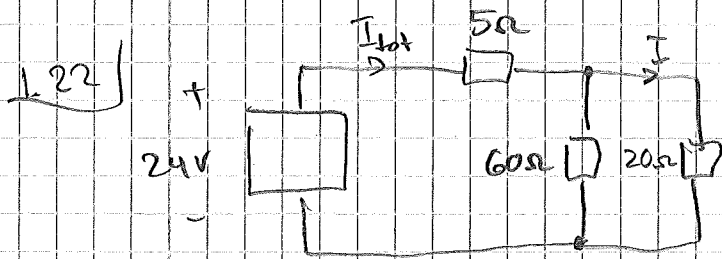
$$I = \frac{3}{2+3+4} \cdot 3 \text{ A} = 1,0 \text{ A}$$

1.21

$$R_5 = R_2 // R_3 = \frac{40 \cdot 60}{40 + 60} = 24 \Omega$$

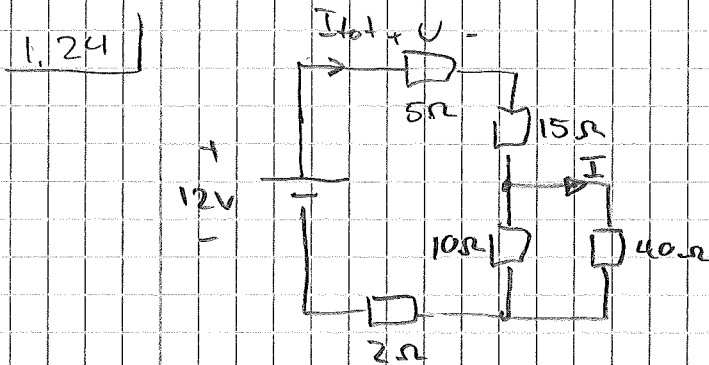
$$U = \frac{R_5}{R_1 + R_4 + R_5} \cdot E = \frac{24}{10 + 16 + 24} \cdot 100 \text{ V} = 48 \text{ V}$$

7



$$I_{tot} = \frac{24V}{5\Omega + 60\parallel 20} = \frac{24}{5 + 15} = 1,2 A$$

Stromteilung $I = \frac{60}{60+20} \cdot I_{tot} = \frac{60}{80} \cdot 1,2 = 0,9 A$

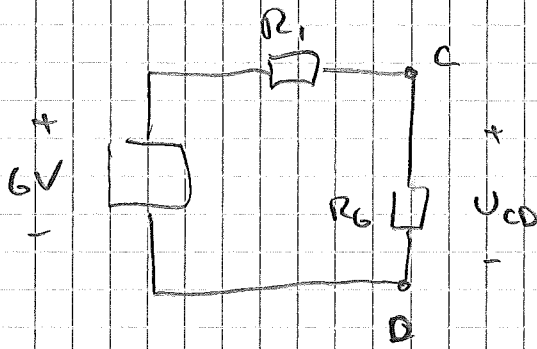


$$I_{tot} = \frac{12V}{(5 + 15 + 10\parallel 40 + 2)\Omega} = \frac{12V}{30\Omega} = 0,4 A$$

$$U = 5\Omega \cdot I_{tot} = 5 \cdot 0,4 = \underline{\underline{2,0 V}}$$

Stromteilung. $I = \frac{10}{10+40} \cdot I_{tot} = \frac{10}{50} \cdot 0,4 = \underline{\underline{80 \mu A}}$

1.25



$$R_c = (R_2 + R_4) \parallel (R_3 + R_5) = 500 \parallel 900 = 321,4 \Omega$$

$$U_{CD} = \frac{R_6}{R_1 + R_6} \cdot 6V = \frac{321,4}{100 + 321,4} \cdot 6V = 4,577 V$$

$$U_{AD} = \frac{R_4}{R_2 + R_4} \cdot U_{CD} = \frac{300}{200 + 300} \cdot 4,577 = 2,746 V$$

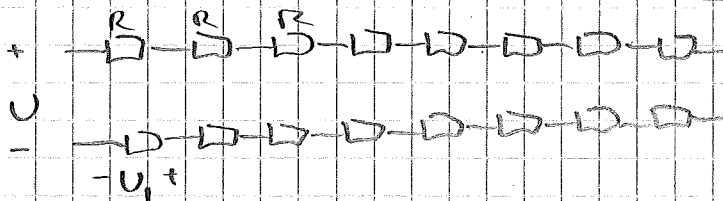
$$U_{BD} = \frac{R_5}{R_3 + R_5} \cdot U_{CD} = \frac{400}{500 + 400} \cdot 4,577 = 2,034 V$$

KU

$$U_{AD} - U_{AB} - U_{BD} = 0$$

$$U_{AB} = U_{AD} - U_{BD} = 2,746 - 2,034 = 0,712 V$$

1.27 a)



$$U = 230 V$$

$$P = 3 W / lamp$$

Sp deln

$$U_1 = \frac{R}{16 \cdot R} \cdot U = \frac{230}{16} = \underline{\underline{14,375 V}}$$

$$R = \frac{U_1^2}{P} = \frac{14,375^2}{3} = 68,9 \Omega$$

$$b) \underline{\underline{U_1}} = \frac{R}{7R} \cdot U = \frac{230}{7} = \underline{\underline{32,9 V}}$$

$$R = \frac{U_1^2}{P} = \frac{32,9^2}{3} = 361 \Omega$$

c) Effekten i 33 V lampor blir mycket större än i övriga lampor eftersom den har högre resistans än övriga de sitter seriekopplade $\Rightarrow$ samma ström ($P = R \cdot I^2$)

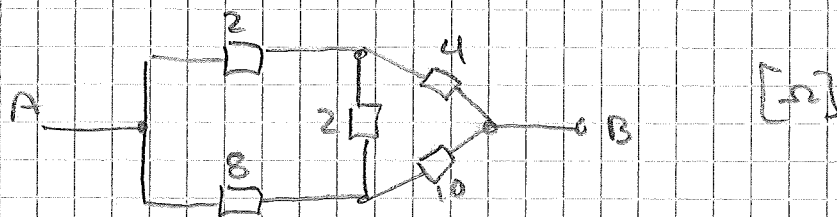
1.28

$$R_A = \frac{R_1 \cdot R_2}{R_1 + R_2 + R_3} = 600 \Omega$$

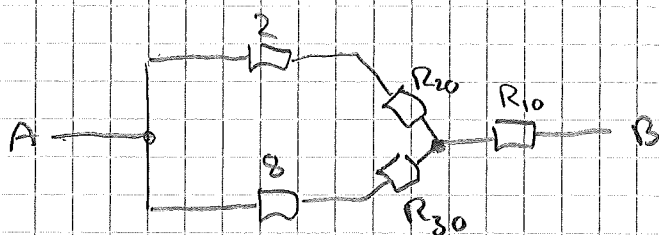
$$R_B = \frac{R_2 \cdot R_3}{R_1 + R_2 + R_3} = 720 \Omega$$

$$R_C = \frac{R_1 \cdot R_3}{R_1 + R_2 + R_3} = 480 \Omega$$

⑨ A

1.29

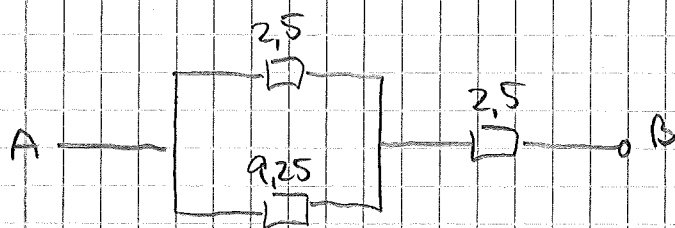
Dreieck-Strich transformation



$$R_{10} = \frac{4 \cdot 10}{2 + 4 + 10} = 2,5 \Omega$$

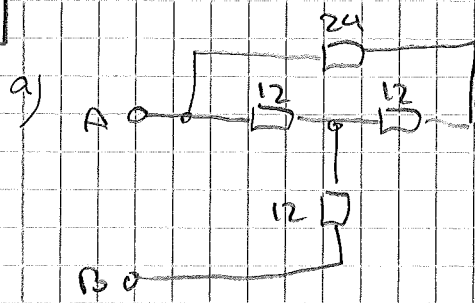
$$R_{20} = \frac{2 \cdot 4}{2 + 4 + 10} = 0,5 \Omega$$

$$R_{30} = \frac{2 \cdot 10}{2 + 4 + 10} = 1,25 \Omega$$

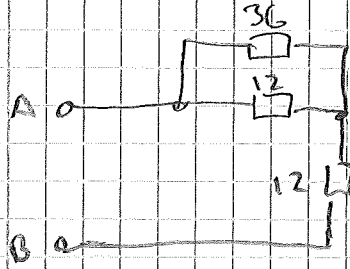


$$R_{AB} = 2,5 \parallel 8 + 2,5 = \frac{2,5 \cdot 8}{2,5 + 8} + 2,5 = \underline{\underline{4,47 \Omega}}$$

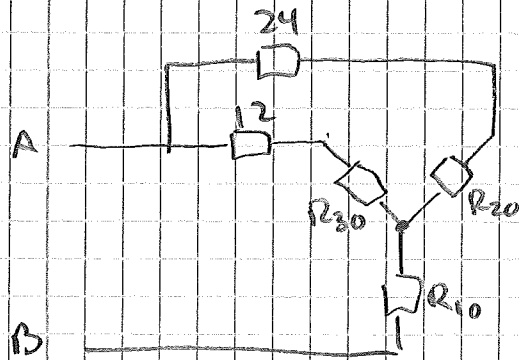
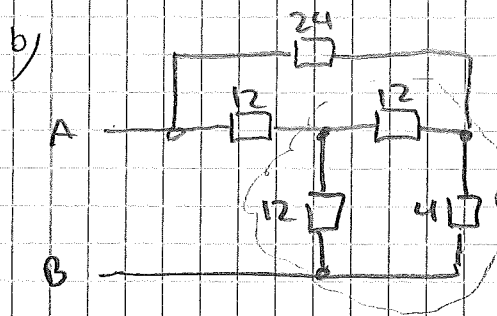
1.30



[Ω]



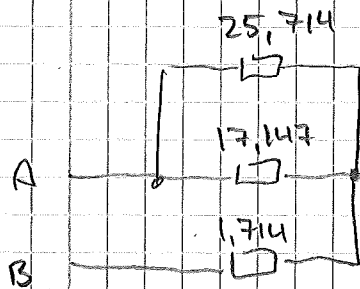
$$R_{AB} = 12 + 12 // 36 = 12 + \frac{12 \cdot 36}{12 + 36} = 21 \Omega$$



$$R_{10} = \frac{4 \cdot 12}{4 + 12 + 12} = 1,714 \Omega$$

$$R_{20} = \frac{4 \cdot 12}{4 + 12 + 12} = 1,714 \Omega$$

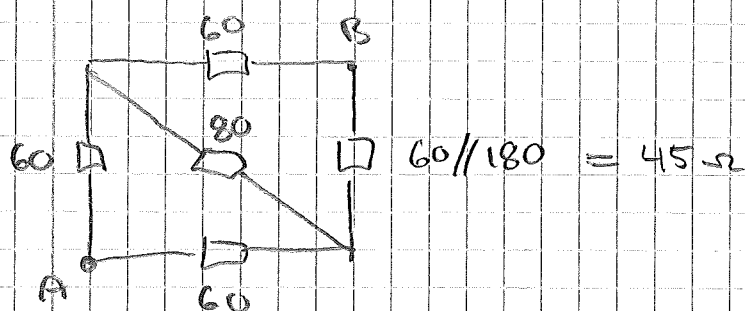
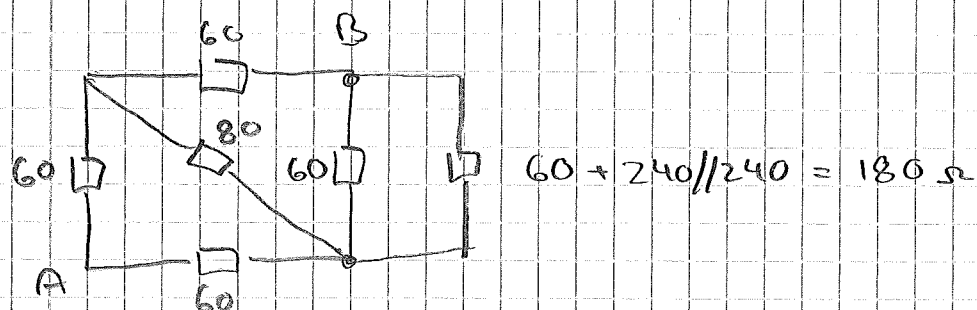
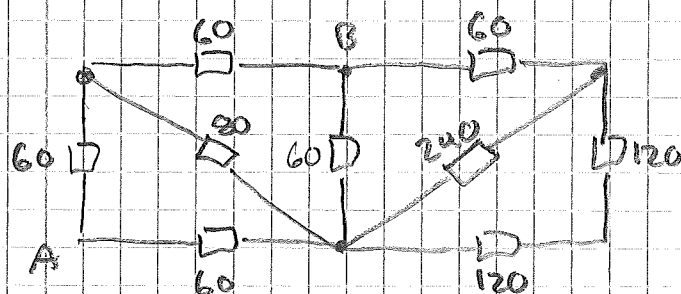
$$R_{30} = \frac{12 \cdot 12}{4 + 12 + 12} = 5,143 \Omega$$



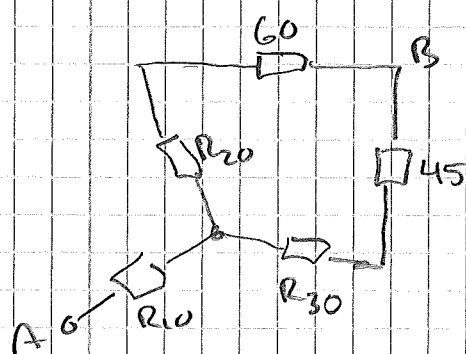
$$R_{AB} = 1,714 + 25,714 // 17,147 = 12,00 \Omega$$

1.31

(10)



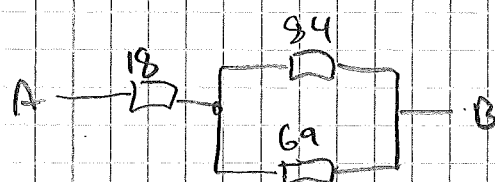
Triangle - Stern transformation



$$R_{10} = \frac{60 \cdot 60}{60 + 60 + 80} = 18 \Omega$$

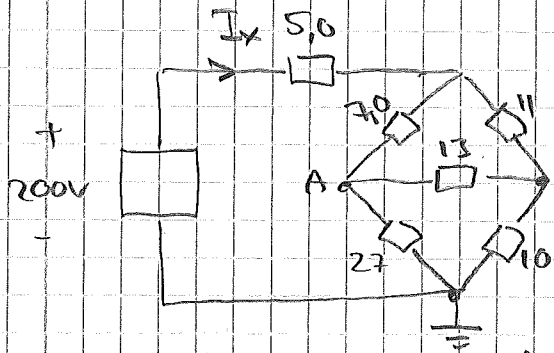
$$R_{20} = \frac{60 \cdot 80}{60 + 60 + 80} = 24 \Omega$$

$$R_{30} = \frac{60 \cdot 80}{60 + 60 + 80} = 24 \Omega$$

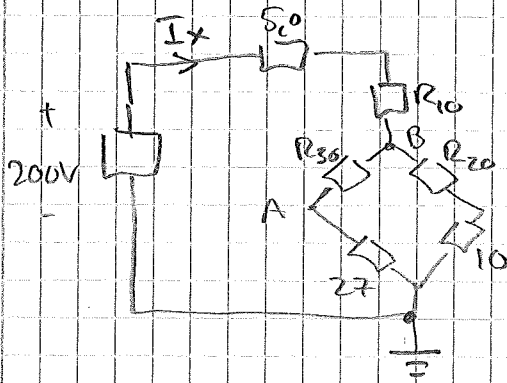


$$R_{AB} = 18 + 84 // 69 = 55.9 \Omega$$

(11)

1,32[k Ω]

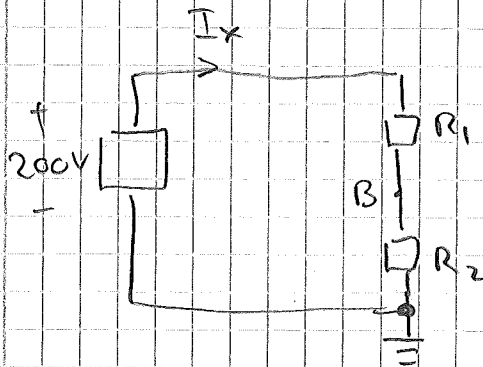
Dreieck-Sterntransformation



$$R_{10} = \frac{7 \cdot 11}{7 + 11 + 13} = 2,484 \text{ k}\Omega$$

$$R_{20} = \frac{11 \cdot 13}{7 + 11 + 13} = 4,613 \text{ k}\Omega$$

$$R_{30} = \frac{7 \cdot 13}{7 + 11 + 13} = 2,935 \text{ k}\Omega$$



$$R_1 = 5 + R_{10} = 7,484 \text{ k}\Omega$$

$$R_2 = (27 + R_{30}) \parallel (10 + R_{20}) = 29,935 \parallel 14,613 = 9,820 \text{ k}\Omega$$

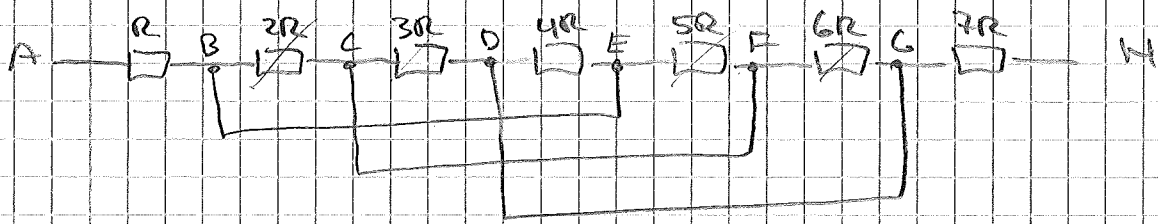
$$V_B = \frac{R_2}{R_1 + R_2} \cdot 200 \text{ V} = \frac{9,820}{7,484 + 9,820} \cdot 200 \text{ V} = 113,5 \text{ V}$$

$$\underline{V_A} = \frac{27}{27 + R_{30}} \cdot V_B = \frac{27}{27 + 2,935} \cdot 113,5 = \underline{102,4 \text{ V}}$$

$$\underline{I_x} = \frac{200}{R_1 + R_2} = \frac{200}{(7,484 + 9,820) \cdot 10^3} = \underline{11,6 \text{ mA}}$$

1.35

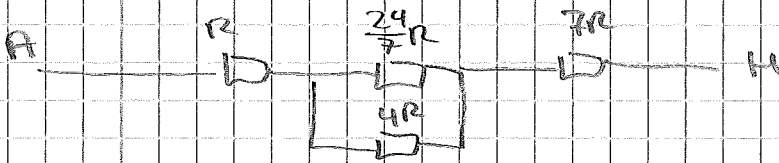
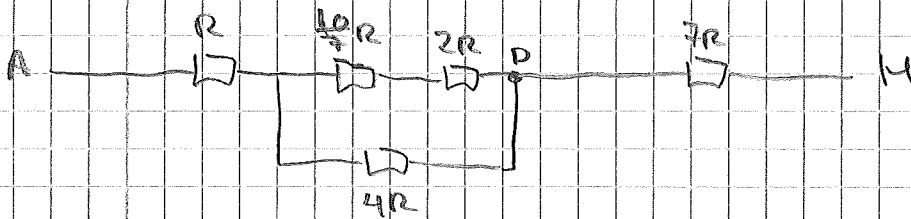
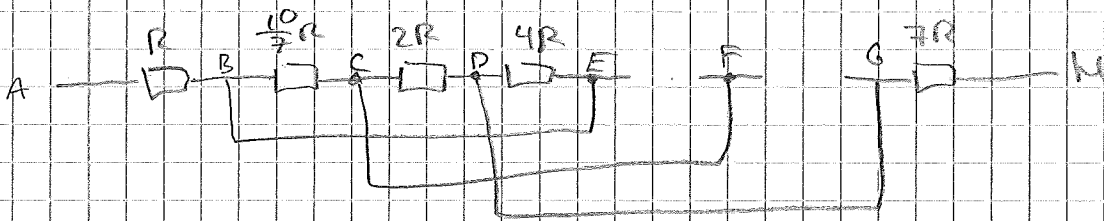
12



$R = 100\Omega$

$$2R // 5R = \frac{2 \cdot 5}{2 + 5} \cdot R = \frac{10}{7} R$$

$$3R // 6R = \frac{3 \cdot 6}{3 + 6} \cdot R = 2R$$

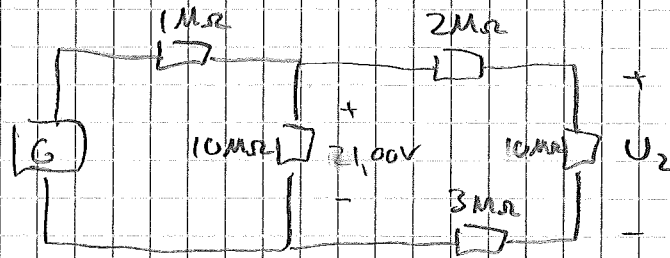


$$\frac{24}{7} R // 4R = \frac{\frac{24}{7} \cdot 4}{\frac{24}{7} + 4} R = 1.846 R$$



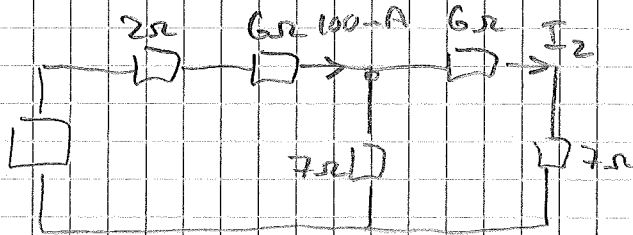
$$R_{AM} = 9.846 R = 984.6 \Omega$$

2.1



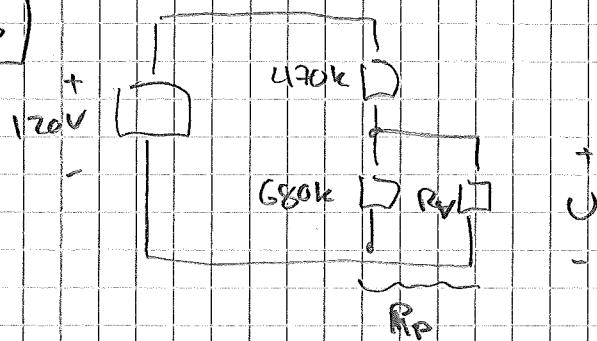
Sp. deln
$$\underline{U_2 = \frac{10M}{(2+3+10)M} \cdot 21,00V = 14,00V}$$

2.2



Strömdeln
$$\underline{I_2 = \frac{7}{7+13} \cdot 100mA = 35mA}$$

2.3



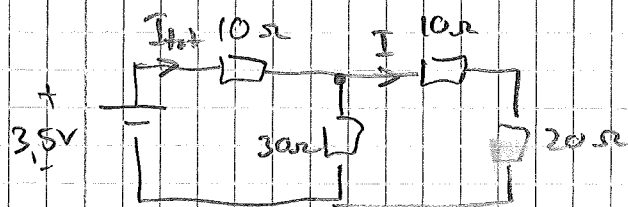
a) $R_p = 680k // 100k = 87,18k\Omega$

$$\underline{U = \frac{R_p}{R_p + 470k} \cdot 120V = \frac{87,18}{87,18 + 470} \cdot 120V = 18,8V}$$

b) $R_p = 680k // 10M = 636,7k\Omega$

$$\underline{U = \frac{R_p}{R_p + 470k} \cdot 120V = \frac{636,7}{636,7 + 470} \cdot 120V = 69,0V}$$

2,4

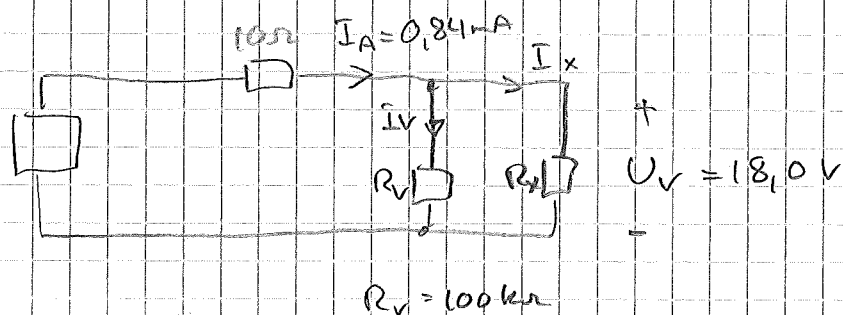


$$R_{tot} = 10 + 30 \parallel 30 = 25 \Omega$$

$$I_{tot} = \frac{3,5V}{25\Omega} = 0,14A$$

Strom durch $I = \frac{30}{30+30} \cdot I_{tot} = \frac{0,14}{2} = \underline{\underline{70\mu A}}$

2,5



$$I_x = I_A - I_V = I_A - \frac{U_V}{R_V} = 0,84 \cdot 10^{-3} - \frac{18,0}{100 \cdot 10^3} = 0,66 \mu A$$

$$\underline{\underline{R_x = \frac{U_V}{I_x} = \frac{18,0}{0,66 \cdot 10^{-3}} = \underline{\underline{27,3 k\Omega}}}}$$

2.9

$$R = 330 \Omega \pm 10\% \Rightarrow \begin{cases} R_{\max} = 363 \Omega \\ R_{\min} = 297 \Omega \end{cases}$$

$$I = 680 \text{ mA} \pm 15 \text{ mA} \Rightarrow \begin{cases} I_{\max} = 695 \text{ mA} \\ I_{\min} = 665 \text{ mA} \end{cases}$$

$$P_{\max} = R_{\max} \cdot I_{\max}^2 = 363 \cdot 0,695^2 = 175 \text{ W}$$

$$P_{\min} = R_{\min} \cdot I_{\min}^2 = 297 \cdot 0,665^2 = 131 \text{ W}$$

2.10

$$U = 18,0 \text{ V} \pm 0,3 \text{ V} \Rightarrow \frac{\Delta U}{U} = \frac{0,3}{18,0} = 1,7\%$$

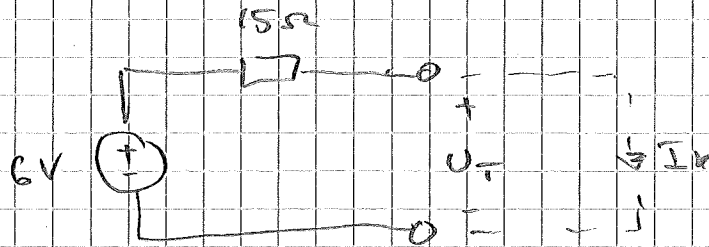
$$I = 2,25 \text{ mA} \pm 0,07 \text{ mA} \Rightarrow \frac{\Delta I}{I} = \frac{0,07}{2,25} = 3,1\%$$

$$R_x = \frac{U}{I} \pm \left(\frac{\Delta U}{U} + \frac{\Delta I}{I} \right) =$$

$$= \frac{18,0}{2,25 \cdot 10^{-3}} \left(1,7\% + 3,1\% \right) = 8000 \Omega \pm 4,8\% =$$

$$= 8000 \Omega \pm 400 \Omega$$

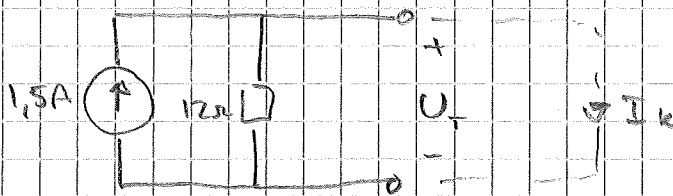
3.2 a)



$$U_T = 6,0 \text{ V}$$

$$I_k = \frac{6,0}{15} = 0,4 \text{ A}$$

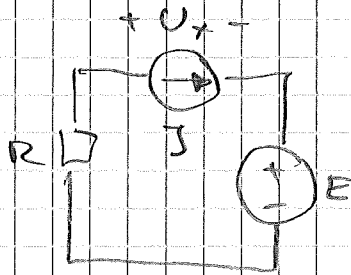
3.2 b)



$$U_T = 1,5 \cdot 12 = 18 \text{ V}$$

$$I_k = 1,5 \text{ A}$$

3.3



$$E = 10 \text{ V}$$

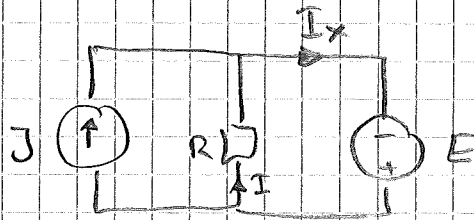
$$J = 1 \text{ A}$$

$$R = 4 \Omega$$

$$\text{KVL} \rightarrow E + U_x + RJ = 0$$

$$\underline{U_x} = -E - RJ = -10 - 4 \cdot 1 = \underline{\underline{-14 \text{ V}}}$$

3.4



$$E = 2V$$

$$J = 350 \mu A$$

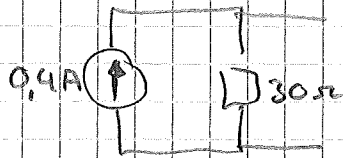
$$R = 10 \Omega$$

$$I = \frac{E}{R} = \frac{2}{10} = 0,2 A$$

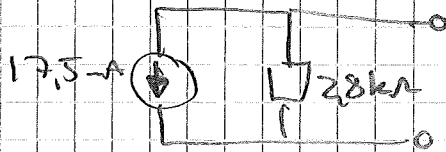
KI
$$\underline{I_x = J + I = 0,35 + 0,2 = 0,55 A}$$

17

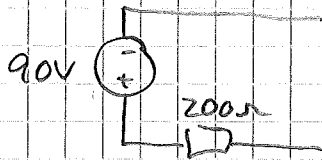
3.5 a) $J = I_k = \frac{12}{30} = 0,4 A$



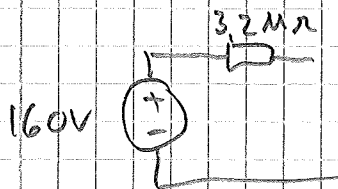
b) $J = I_k = \frac{49}{2800} = 17,5 \mu A$



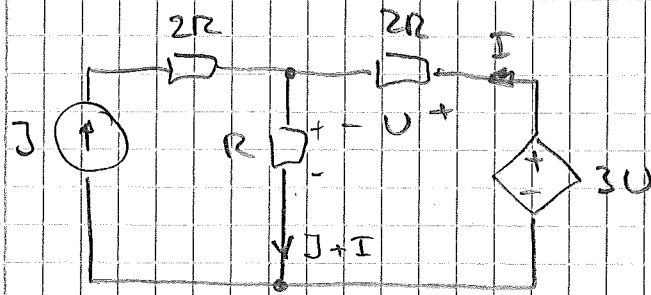
3.6 a) $E = U_T = 0,45 \cdot 200 = 90 V$



b) $E = U_T = 50 \cdot 10^{-6} \cdot 3,2 \cdot 10^6 = 160 V$



3.11



$$R = 2 \text{ k}\Omega$$

$$J = 10 \text{ mA}$$

$$U = 2RI$$

KV

$$3U - U - R(I + I) = 0$$

 $\Rightarrow$

$$U = 2RI$$

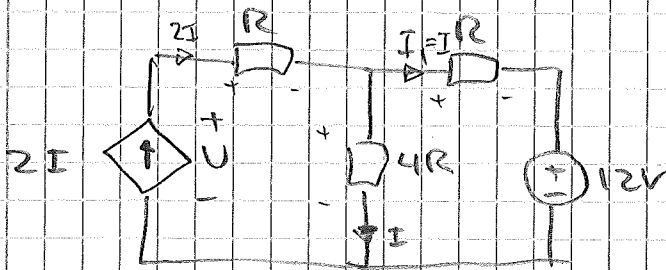
$$2U - RJ - RI = 0$$

 $\Rightarrow$

$$4RI - RJ - RI = 0$$

$$\underline{\underline{I = \frac{J}{3} = \frac{10 \text{ mA}}{3} = 3,33 \text{ A}}}$$

3.12



$$R = 1 \text{ k}\Omega$$

KI

$$2I = I_1 + I \Rightarrow I_1 = I$$

KV

$$12 + RI - 4RI = 0$$

KV

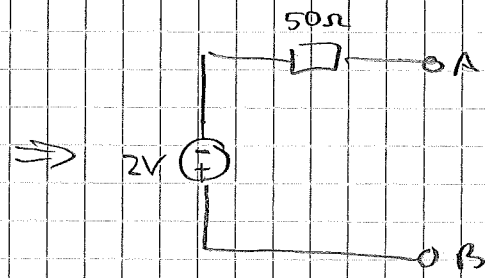
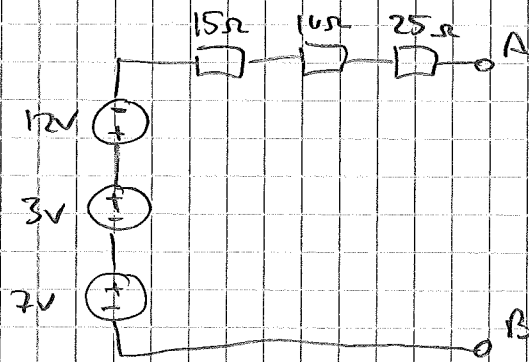
$$U - R \cdot 2I - 4RI = 0$$

 $\Rightarrow$

$$I = \frac{12}{3R} = \frac{12}{3000} = 4 \text{ mA}$$

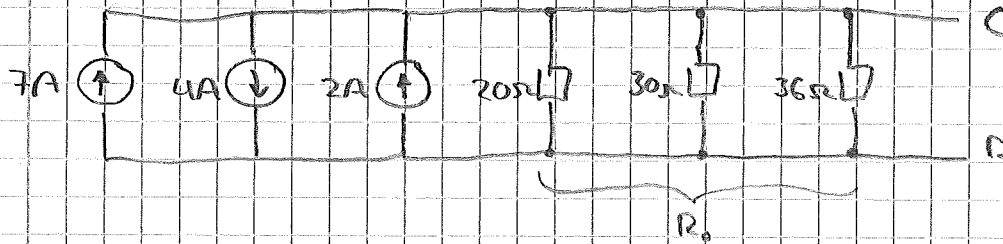
$$\underline{\underline{U = 6RI = 6 \cdot 1000 \cdot 4 \cdot 10^{-3} = 24 \text{ V}}}$$

4.1

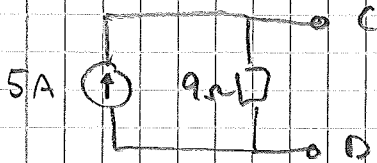


19

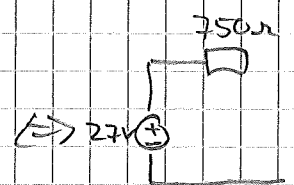
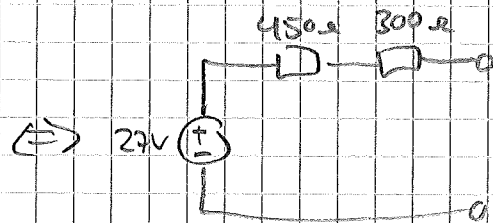
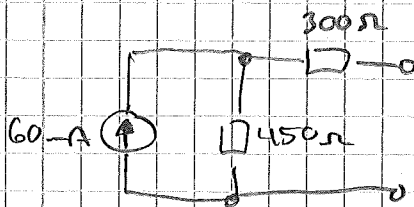
4.2



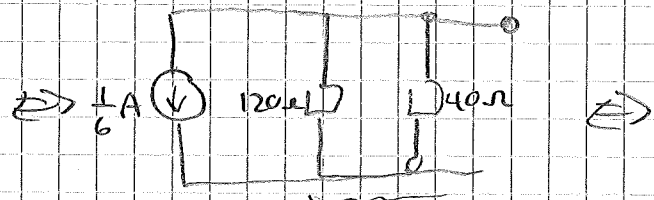
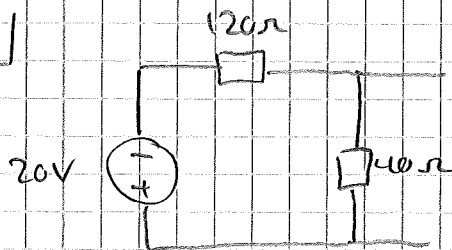
$$\frac{1}{R_0} = \frac{1}{20} + \frac{1}{30} + \frac{1}{36} \Rightarrow R_0 = 9\Omega$$



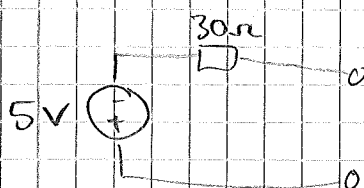
4.3



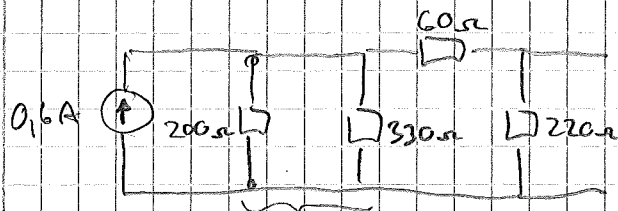
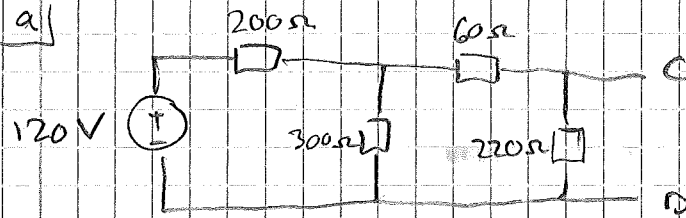
4.4



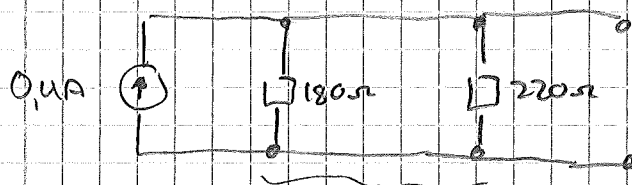
$$120 \parallel 40 = 30\Omega$$



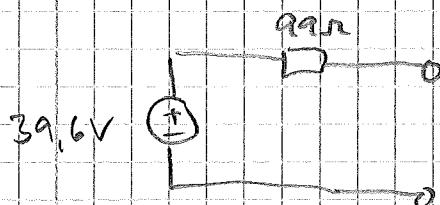
4,5 a)



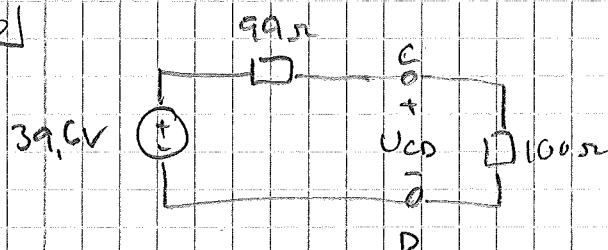
$$200 // 300 = 120\Omega$$



$$180 // 220 = 99\Omega$$



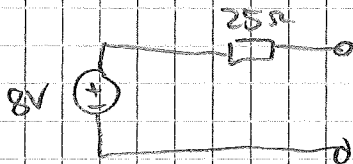
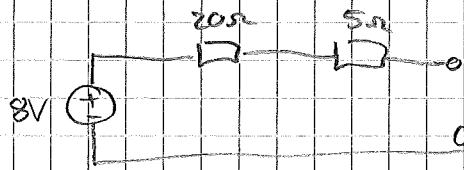
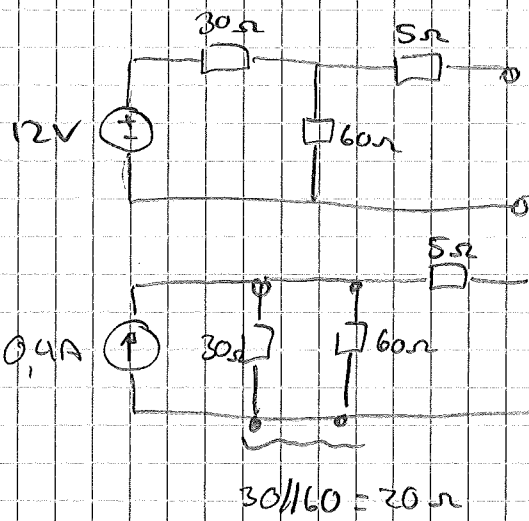
b)

S_P delm

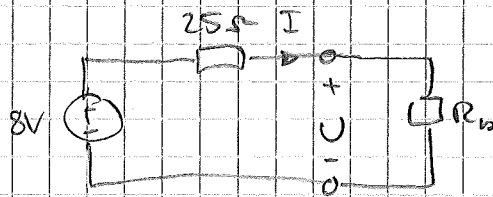
$$\underline{\underline{U_{CD} = \frac{100}{100 + 99} \cdot 39,6V = 19,9V}}$$

4.6 a)

(21)



b/



$$I = 80 \text{ mA}$$

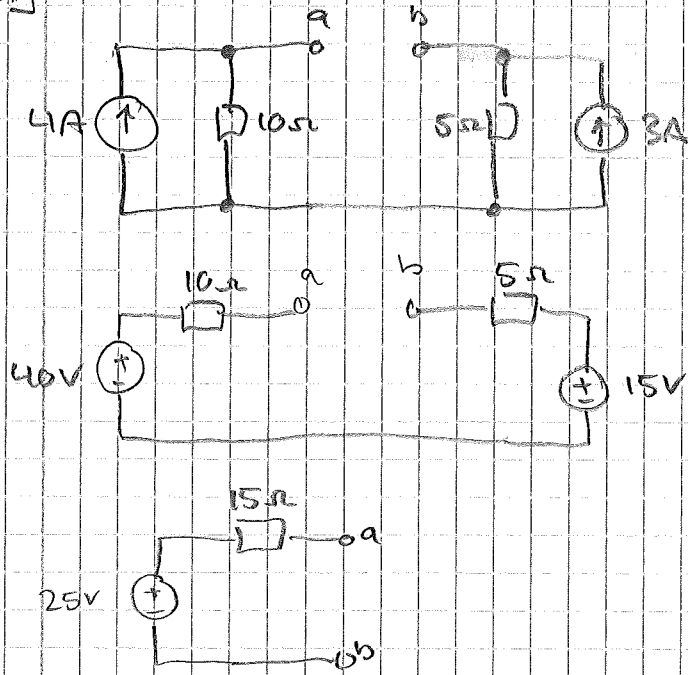
$$U = 8 - 25 \cdot 0,08 = 6 \text{ V}$$

Effekt R_b : $P = U \cdot I = 0,080 \cdot 6 = 0,48 \text{ W}$

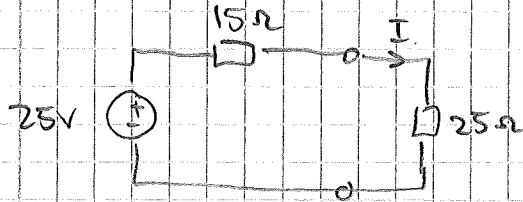
$$R_b = \frac{U}{I} = \frac{6}{0,08} = 75 \Omega$$

4.7 a)

22

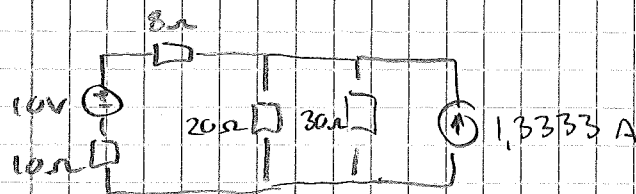
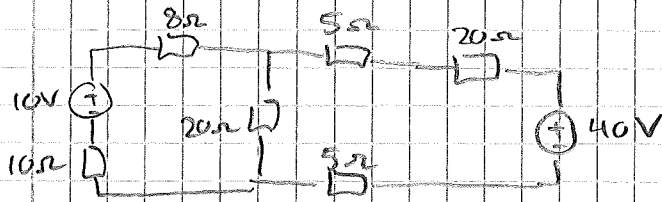
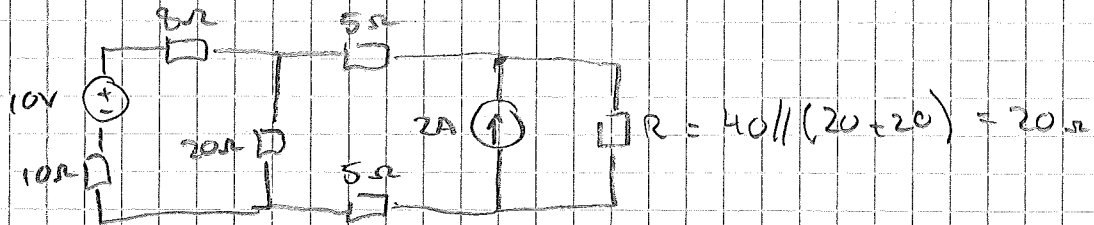


b)

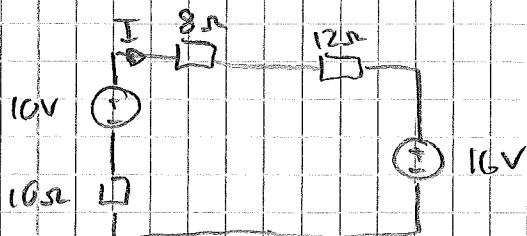


$$I = \frac{25}{15+25} = 0,625 \text{ A}$$

4.11



$$20 || 30 = 12\Omega$$

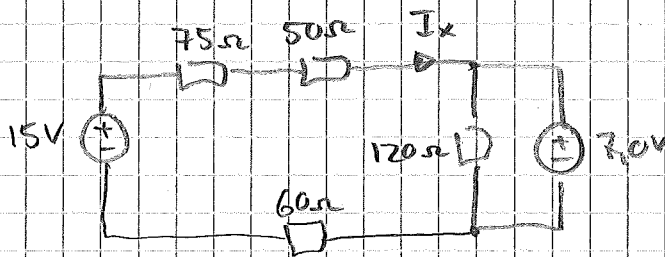
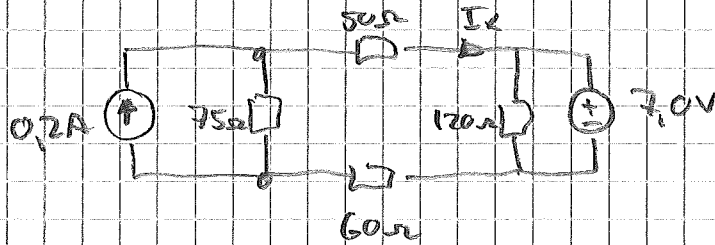
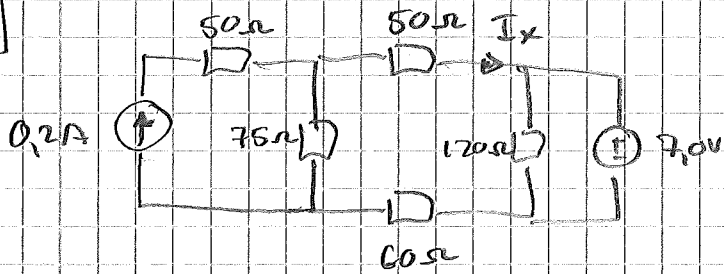


$$\text{KVL } 16 + 20I - 10 + 10I = 0$$

$$I = \frac{-6}{30} = -0,2 \text{ A}$$

$$P_{\text{avg}} = 10V \cdot I = \underline{\underline{-2 \text{ W}}}$$

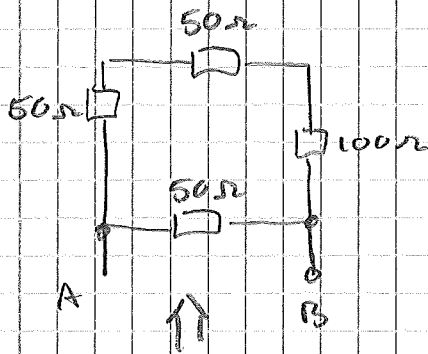
4.12



$$KVL \quad 70 + 50I_x + 75I_x - 15 + 60I_x = 0$$

$$I_x = \frac{8}{185} = 43.2 \text{ mA}$$

4.14



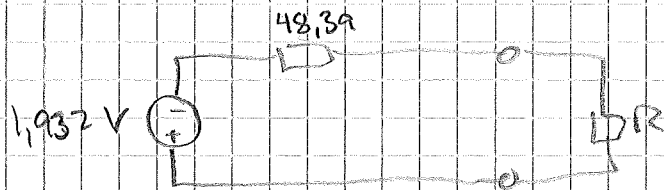
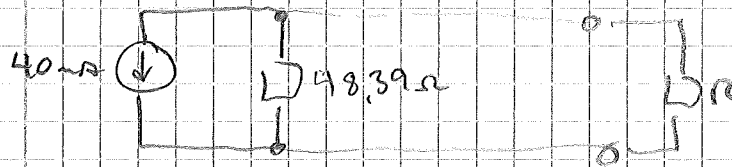
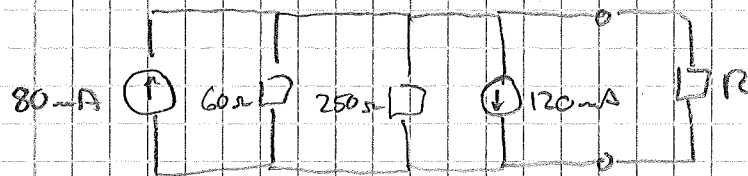
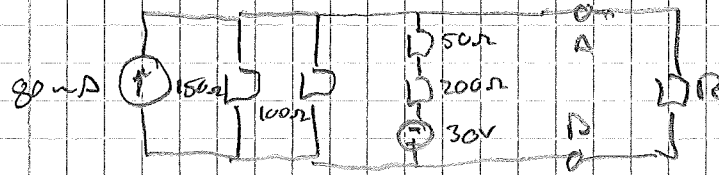
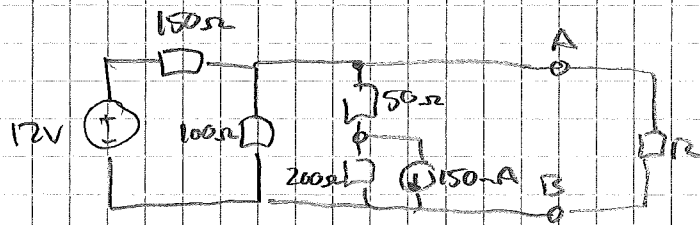
Nollstell oberende Kähler

$$R_0 = 50 \parallel 200 = 40 \Omega$$

Effektanpassung V_{eff} $\underline{R_L} = R_0 = \underline{40 \Omega}$

4.15

24

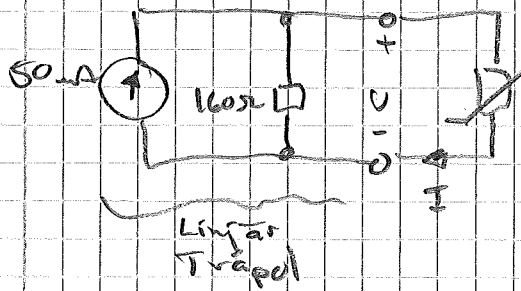


Effektanpassung V_{eff} , $\underline{R = R_o = 48,39\Omega}$

Effekt in R

$$P = \frac{\left(\frac{1,932}{2}\right)^2}{R} = \frac{\left(\frac{1,932}{2}\right)^2}{48,39} = 19,3 \text{ mW}$$

4,21



Linjär
Träpol : $U_+ = 50 \text{ mA} \cdot 160 \Omega = 8 \text{ V}$
 $I_k = 50 \text{ mA}$

Rita linjär träpols karakteristika i diagrammet.

a) Skärningsplot mellan kurvor ger $I \approx 33 \text{ mA}$

b)

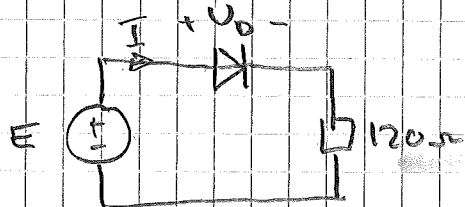
$$U \approx 2,7 \text{ V}$$

Av skärningen, angeffekt

$$\underline{P_{avg}} = U \cdot 50 \text{ mA} =$$

$$= 2,7 \cdot 0,05 = \underline{\underline{0,135 \text{ W}}}$$

K1

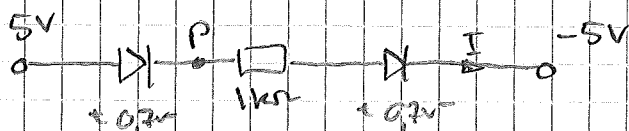


a) $E = 5V \Rightarrow$ Diode leitet $U_D = 0,7V$

$$\underline{I} = \frac{E - U_D}{120\Omega} = \frac{5 - 0,7}{120} = \underline{35,8\text{ mA}}$$

b) $E = -5V \Rightarrow$ Diode sperrt $\Rightarrow \underline{I = 0}$

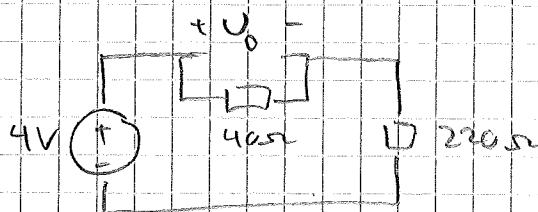
K2



Diode leitet: $-5 + 0,7 + I \cdot 1000 < 0,7 = 5 \Rightarrow$

$$\underline{I} = \frac{10 - 2 \cdot 0,7}{1000} = \underline{8,6\text{ mA}}$$

K3 a)

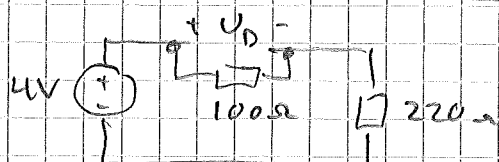


$$U_D = \frac{40}{40 + 220} \cdot 4V = 0,615V$$

$U_D < 0,7V \Rightarrow$ Diode sperrt $\Rightarrow$

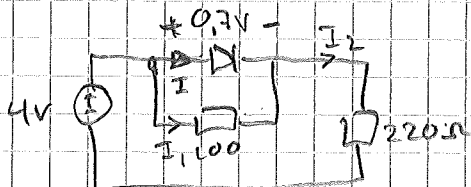
$$\underline{I = 0}$$

b)



$$U_D = \frac{100}{100 + 220} \cdot 4V = 1,25V$$

$U_D > 0,7V \Rightarrow$ Diode leitet.



$$I_1 = \frac{0,7}{100} = 7\text{ mA}$$

$$I_2 = \frac{3,3}{220} = 15\text{ mA}$$

$$\underline{I} = I_2 - I_1 = \underline{8\text{ mA}}$$