

2.13 SUURIMMAN OSAN TEHOSÄ TUOTTA
HEIKKULAN KA. MUISTETAAN KAAVAT

$$P = UI \quad \text{JA} \quad U = RI$$

ILMAISTAAN P SUUREIDEN R JA I
AVULLA, KYSKÄ I ON SAMA.

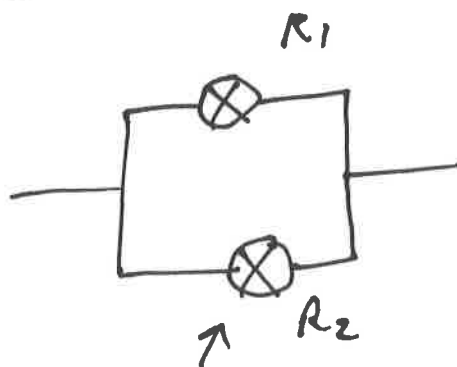
$$P = UI = RI^2$$

$$\left[R = \frac{U}{I} \Rightarrow I = \frac{U}{R} \Rightarrow P = \frac{U^2}{R} \right]$$

SIIS P ON SITA² SUUREMPI
MITÄ SUUREMPI R ON

V! PÖYTÄLAMPU HEIKKULAN
RESISTANSSI ON SUUREMPI
WIN VIRTALAMPU HEIKKULAN
RESISTANSSI

VERTA:



$$R_1 > R_2$$

$$P_1 = \frac{U^2}{R_1} < \frac{U^2}{R_2} = P_2$$

↑
PÄÄ
TUOTTA

ISOMMAN TEHDN



$$R_1 > R_2$$

$$P_1 = R_1 I^2 \geq R_2 I^2 = P_2$$

$$2.17 \quad R = \rho \frac{L}{A} = \rho \frac{L}{\pi r^2}$$

$$\rho_A > \rho_B \Rightarrow R_A < R_B$$

$$P = UI \quad U = RI \Rightarrow I = \frac{U}{R}$$

$$= RI^2$$

$$= \frac{U^2}{R}$$

$$a) \quad P_A = \frac{U^2}{R_A} > \frac{U^2}{R_B} = P_B \Rightarrow \underline{\underline{A}}$$

$$b) \quad P_A = R_A I^2 < R_B I^2 = P_B \Rightarrow \underline{\underline{B}}$$

$$2.18 \quad U = 11,5 \text{ V}$$

$$R_S = 0,040 \Omega$$

$$Q = It = 20 \text{ Ah} = 72000 \text{ Ad} = (20 \cdot 3600)$$

$$\text{YRITYS: } I = 150 \text{ A} \quad t = 700$$

$$Q_Y = 150 \cdot 7 = 1050 \text{ C}$$

$$= 1050 \text{ Ad}$$

$$N = \frac{Q}{Q_Y} = \frac{72000}{1050} = \underline{\underline{68,5}}$$

$$b) \quad P = UI$$

$$W = UI t = UC = 11,5 \text{ V} \cdot 72000 \text{ C}$$
$$= 828000 \text{ J}$$
$$= \underline{\underline{828 \text{ kJ}}}$$

2.19

$$U = 1,0 \text{ kV}$$

$$P = 100 \text{ kW}$$

$$P = UI \Rightarrow I = \frac{P}{U} = \frac{100 \text{ kW}}{1 \text{ kV}} = 100 \text{ A}$$

$$P = UI$$

$$U = RI$$

$$= RI^2$$

$$\Rightarrow R = \frac{P}{I^2} = \frac{5 \text{ kW}}{100^2 \text{ A}^2} = \frac{5000}{10000} = 0,5 \Omega$$

$$L = \frac{0,5 \Omega}{0,85 \Omega/\text{km}} = 0,588 \text{ km} = \underline{\underline{590 \text{ m}}}$$

2.20

$$P = \frac{W}{t} = \frac{340 \text{ kg} \cdot 9,81 \text{ m/s}^2 \cdot 25 \text{ m}}{55 \text{ s}}$$

$$= \frac{83385 \text{ J}}{55 \text{ s}} = 1516,09 \text{ W}$$
$$= 1516 \text{ W}$$

ТОИСААЦА $P = \eta UI$

$$\Rightarrow I = \frac{P}{\eta U} = \frac{1516}{0,89 \cdot 230} = \underline{\underline{7,4 \text{ A}}}$$

$$2.21 \quad I = 250 \text{ kA}$$

$$t = 1 \text{ ms}$$

$$P = UI = RI^2$$

$$U = RI$$

$$R = \rho_E \frac{L}{\pi r^2} = \rho \frac{L}{\pi d^2} = \rho \frac{L}{A}$$

$$Q = mc \Delta T$$

$$m = \rho_m V = \rho_m AL$$

$$\text{LÄMPÖÄI} \quad E = Pt = RI^2 t = mc \Delta T$$

$$\rightarrow R = \frac{mc \Delta T}{t I^2} \quad m = \rho_m AL$$
$$R = \rho \frac{L}{A}$$

$$\rho_E \frac{L}{A} = \rho_m \frac{AL c \Delta T}{t I^2}$$

$$A = \sqrt{\frac{\rho_E t I^2}{c \Delta T \rho_m}}$$

$$A^2 = \frac{17,2 \cdot 10^{-9} \Omega \text{ m} \cdot 1 \cdot 10^{-3} \text{ s} \cdot 250^2 \cdot 10^6 \text{ A}^2}{389 \frac{\text{kg}}{\text{m}^3} \cdot 480^\circ \cdot 8930}$$
$$= \frac{17,2 \cdot 250 \cdot 10^{-6}}{389 \cdot 480 \cdot 8930} = \frac{4300 \cdot 10^{-6}}{1,667 \cdot 10^9}$$

$$= 2,579 \cdot 10^{-12}$$

$$A = 1,60 \cdot 10^{-6} \text{ m}^2$$

$$= 1,60 \text{ mm}^2 = \pi r^2$$

$$r = \sqrt{\frac{A}{\pi}} = 0,713 \text{ mm}$$

KUPARI $\rho_R = 17,2 \cdot 10^{-9} \underline{\Omega m}$ $20^\circ C$

$$\rho_{R1} = \rho_R (1 + \alpha_R T)$$

$$\alpha_R = 10^{-3} \cdot 3,9 \frac{1}{^\circ C}$$

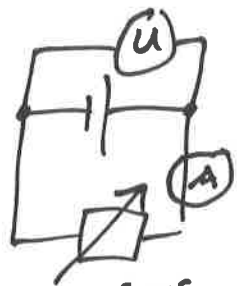
$$\rho(500^\circ C) = \rho_R \left(1 + 3,9 \cdot \frac{480}{1000} \right) = \rho_R \cdot 2,872$$

$$\rho_{AVERAGE} = \frac{2,872}{2} \cdot 17,2$$

$$= \underline{\underline{1,436}} \cdot 17,2 = 25 \cdot 10^{-9} \Omega m$$

$$A' = \sqrt{1,436} A$$

2.22

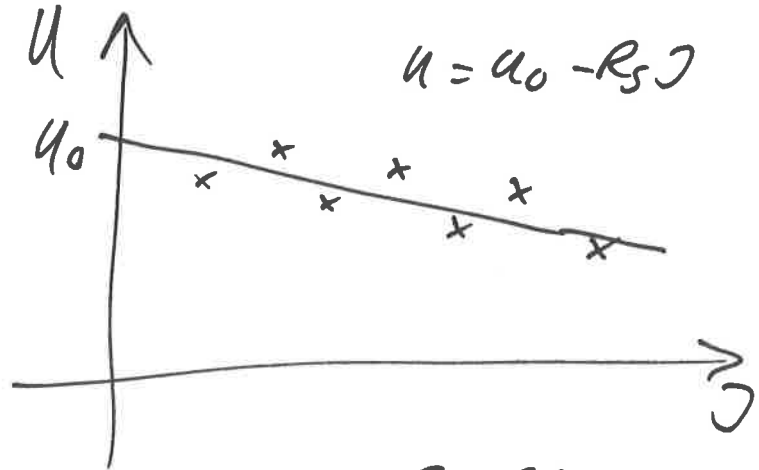


SÄÄTÄMÄSSÄ

$$U = U_0 - R_S I$$

$$R_S I = U_0 - U$$

$$R_S = \frac{U_0 - U}{I}$$



SOVI TE TÄN SUORA

→ KILMAKERROIN = R_S

$$-R_S = \frac{U_2 - U_1}{I_2 - I_1} = \frac{1,133 - 1,222 \text{ V}}{460 - 100 \text{ mA}}$$

$$I_0 = 0$$

$$R_S = \frac{0,089 \text{ V}}{0,36 \text{ A}} = 0,247 \Omega$$

$$-R_S = \frac{U - U_0}{I - I_0} = \frac{U - U_0}{I}$$

$$U = R_S I$$

$$-R_S I = U - U_0$$

$$U_0 = U + R_S I$$

$$0,1 \text{ A}$$

$$= 1,222 + 0,247 \Omega \cdot 100 \text{ mA}$$

$$= 1,222 + 0,02 \text{ V}$$

$$= 1,24 \text{ V}$$

2,23 U kasvaa \Rightarrow J kasvaa \Rightarrow

$R(w)$ kasvaa & $R(c)$ pienenee

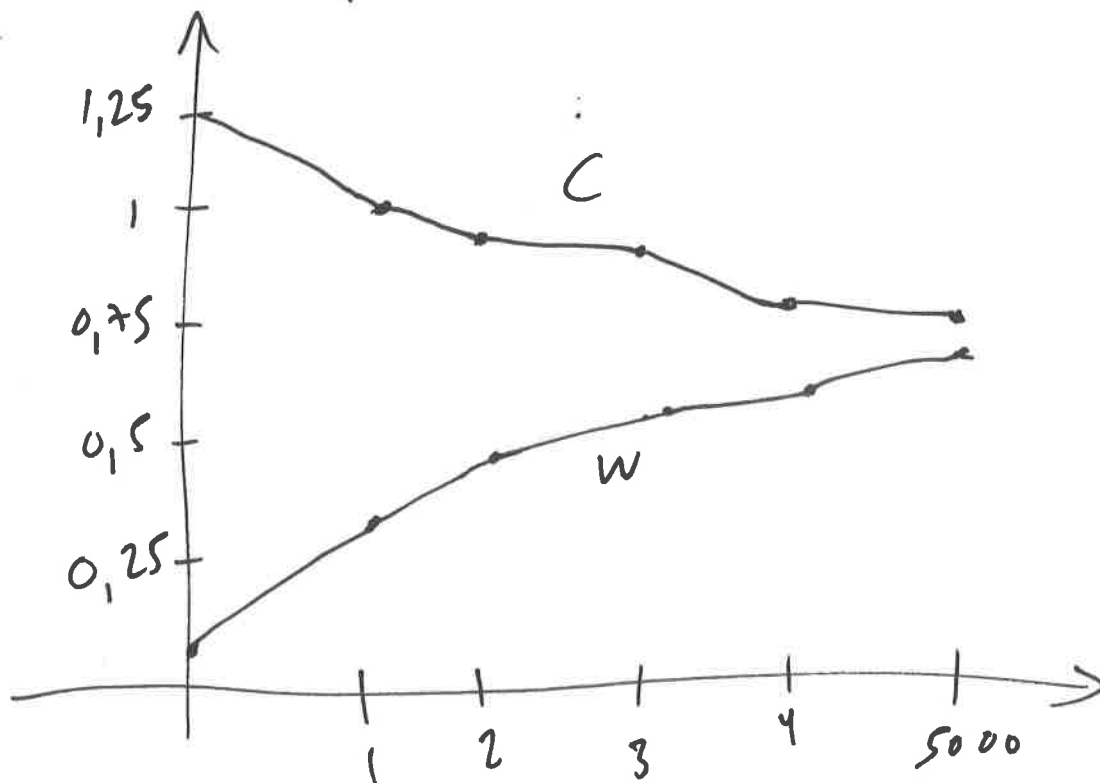
$$\frac{J(w)}{U(w)} \downarrow \quad \frac{J(c)}{U(c)} \uparrow$$

ylempi käyrä on wolfnamin käyrä.

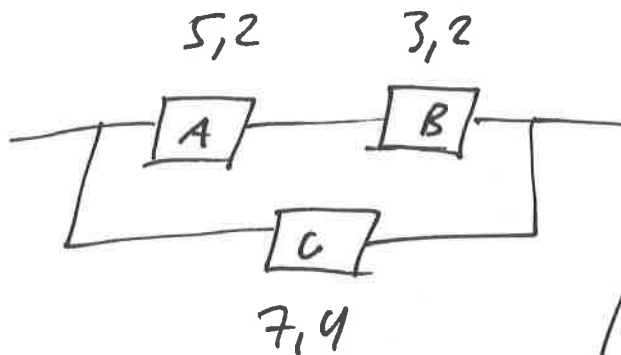
$P = U \cdot J$ $R = \frac{U}{J}$ $U = R \cdot J$

w	U	J	P	R
10	8	80	80	1,25
20	18	360	360	1,111
30	30	900	900	1
40	45	1800	1800	0,888
50	60	3000	3000	0,833
60	78	4680	4680	0,75

w	U	J	P	R
5	33	165	165	0,15
10	45	450	450	0,22
20	58	1160	1160	0,344
30	66	1980	1980	0,45
40	73	2900	2900	0,542
50	80	4000	4000	0,625
60	85	5100	5100	0,706



2.24



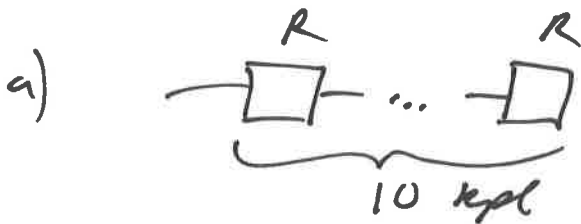
$$R_{AB} = 5,2 + 3,2 = 8,4$$

$$\frac{1}{R_{ABC}} = \frac{1}{R_{AB}} + \frac{1}{R_C} = \frac{1}{8,4} + \frac{1}{7,4}$$

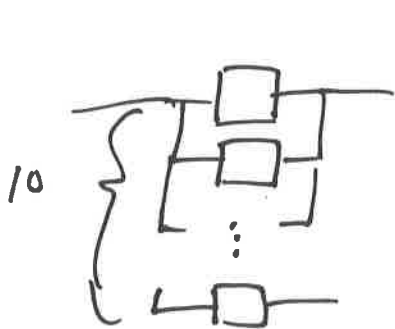
$$R_{ABC} = \frac{8,4 \cdot 7,4}{8,4 + 7,4} = \frac{62,16}{15,8} = \underline{\underline{3,93 \text{ k}\Omega}}$$

$$\begin{aligned} \frac{1}{R} &= \frac{1}{R_1} + \frac{1}{R_2} \\ &= \frac{R_1 + R_2}{R_1 R_2} \\ R &= \frac{R_1 R_2}{R_1 + R_2} \end{aligned}$$

2.25



$$R_{KOK} = 10R$$



$$R_{KOK} = \frac{R}{10}$$

2.26

$$R = 10 \Omega$$

$$R_1 = 10,14 \Omega$$

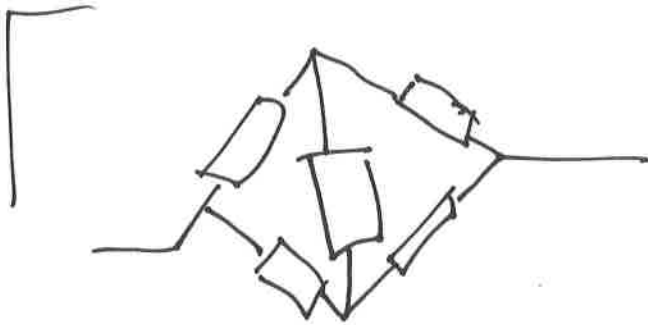
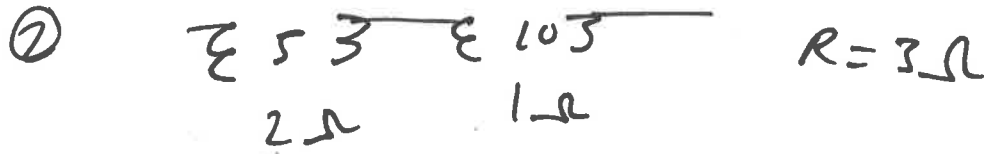
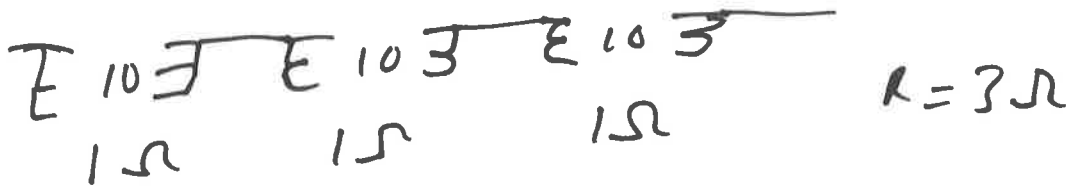
$$R_2 = 8L$$

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} \rightarrow \frac{1}{R_2} = \frac{1}{R} - \frac{1}{R_1} = \frac{0,14 \Omega}{10^2 \Omega^2}$$

$$R_2 = \frac{10^2}{0,14} \Omega$$

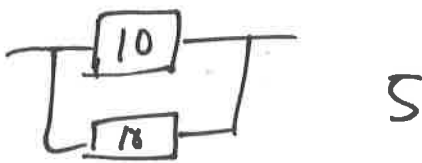
$$L = \frac{R_2}{8} = \frac{10^2}{0,14 \cdot 35} = \frac{10^2}{4,9} = \underline{\underline{20,41 \text{ m}}}$$

2,27 ①



$$3 = \cancel{40} \cdot 3 \cdot 10 \cdot \frac{1}{10}$$

$$= 2 \cdot 5 \cdot \frac{1}{10} + \cancel{10} \cdot \frac{1}{10}$$



$$R = \frac{10^2}{10+10} = \frac{100}{20} = 5$$

$$\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

3 $\rightarrow R = 3,33 = \frac{10}{3}$

4 $\rightarrow R = 2,5$

5 $\rightarrow R = 2$

6 $\rightarrow R =$

7 $\rightarrow R = 1,4,28$

8 $\rightarrow R = 1,25$

2.28



$$\begin{aligned}
 R_{\text{Koch}} &= R_1 + R_2 \\
 &= R_{01} (1 + \alpha_1 (t - t_0)) + R_{02} (1 + \alpha_2 (t - t_0)) \\
 &= R_{01} + R_{02} \\
 &\quad + (R_{01} \alpha_1 + R_{02} \alpha_2) (t - t_0) = VAK10
 \end{aligned}$$

$$\begin{aligned}
 \Rightarrow R_{01} \alpha_1 + R_{02} \alpha_2 &= 0 & \frac{10000}{40} &= 250 \\
 R_{01} \alpha_1 &= -R_{02} \alpha_2
 \end{aligned}$$

$$\frac{R_{01}}{R_{02}} = \frac{-\alpha_2}{\alpha_1} = \frac{0,040}{0,001} = 40$$

$$\begin{aligned}
 \text{S.115 } R_{01} &= 40 R_{02} \Rightarrow R_{\text{Koch}} = VAK10 \\
 &= R_{01} + R_{02} \\
 &= 41 R_{02}
 \end{aligned}$$

$$41 R_{02} = 10 \text{ k}\Omega$$

$$R_{02} = 250 \Omega$$

$$R_{01} = 40 R_{02} = 10 \text{ k}\Omega$$

$$\underline{V: R_{02} = \frac{10000 \Omega}{41} \quad \& \quad R_{01} = \frac{40}{41} \cdot 10000 \Omega}$$

$$2.29 \quad \rho_R(\text{Cu}) = 17,2 \cdot 10^{-9} \Omega \cdot \text{m}$$

$$\rho_R(\text{Fe}) = 18,4 \cdot 10^{-8} \Omega \cdot \text{m}$$

$$R = \rho_R \frac{L}{A} = \text{RESISTIIVISYYS}$$

$$S = \frac{1}{R} = \frac{A}{\rho_R L} = \text{JOHTAVUUS}$$

$$150 \mu\text{m} = 0,15 \text{mm}$$

$$\frac{S}{L} = \frac{A}{\rho_R L}$$

HALKASIJAN
 10^{-6}m^2

$$\frac{S}{L}(\text{Fe}) = \frac{\pi \cdot 3^2 \text{mm}^2}{4 \cdot 18,4 \cdot 10^{-8}} = \frac{9\pi}{18,4} \cdot \frac{100}{4} \frac{\text{m}}{\Omega}$$

$$\frac{S}{L}(\text{Cu}) = \frac{\pi \cdot 3 \cdot 0,15 \cdot 10^{-6} \text{m}^2}{17,2 \cdot 10^{-9} \Omega \cdot \text{m}}$$

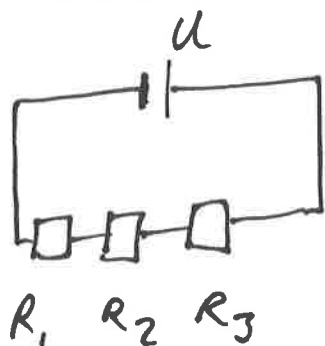
$$= \frac{0,45\pi}{17,2} \cdot 1000 \frac{\text{m}}{\Omega}$$

$$\frac{S}{L} \text{kok} = \frac{S}{L}(\text{Fe}) + \frac{S}{L}(\text{Cu})$$

$$S =$$

$$U = R I = \frac{U}{S} = \frac{3,5 \text{A}}{S}$$

2.30



$$U = 2,5 \text{ V}$$

~~27~~ 27

±

$$R_1 = 17,8 \text{ k}\Omega$$

6

$$R_2 = 29,7 \text{ k}\Omega$$

10

$$+ R_3 = 33,2 \text{ k}\Omega$$

11

$$R_{\text{KWK}} = 80,7 \text{ k}\Omega$$

~~$$R_{\text{KWK}} = 17,8$$~~

$$U = R I \rightarrow I = \frac{U}{R} = \frac{2,5 \text{ V}}{80,7 \text{ k}\Omega} = 31,25 \text{ mA}$$

$$\left[\begin{array}{l} \frac{24}{8} = 3 \quad \frac{1}{8} = 1,25 \\ \quad \quad \quad = 0,125 \\ \frac{2,5}{80} = \\ \frac{2500}{80} = 31,25 \end{array} \right]$$

$$\frac{2,5 \text{ V}}{27} = 0,09$$

$$U_1 = 0,09 \cdot 6 = 0,54 \text{ V}$$

$$U_2 = 0,09 \cdot 10 = 0,9 \text{ V}$$

$$U_3 = 0,09 \cdot 11 = 0,99 \text{ V}$$

$$P_1 = U_1 I = 16,2 \text{ W}$$

$$P_2 = U_2 I = 27 \text{ W}$$

$$P_3 = U_3 I = 31 \text{ W}$$

$$P_{\text{KWK}} = 80 \text{ mW}$$

$$P_{\text{KWK}} = 2,5 \text{ V} \cdot 31,25 \text{ mA}$$

$$= 62,5 \text{ mW} + 15,25 \text{ mW}$$

$$= 80 \text{ mW} \quad \text{ok}$$

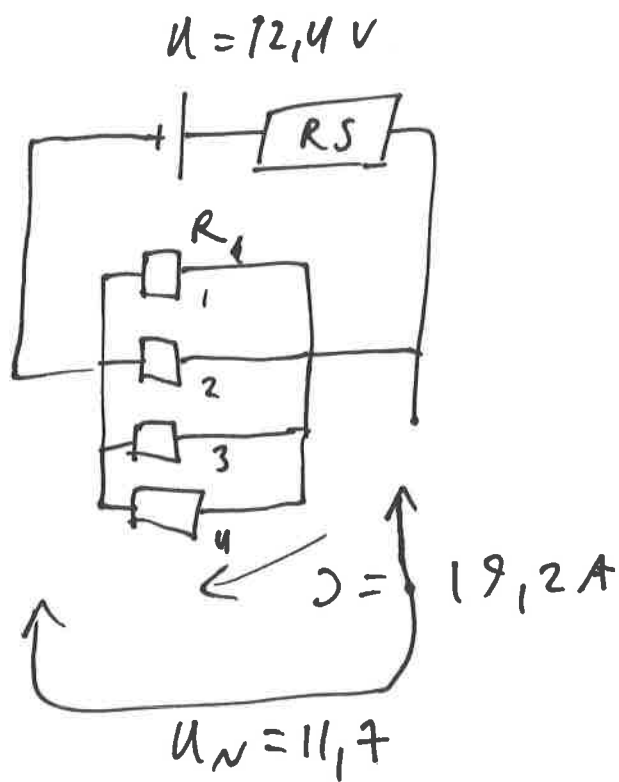
$$I = \frac{U}{R}$$

$$U = R I$$

$$P = U I = R I^2 = \frac{U^2}{R}$$

2.32

a)



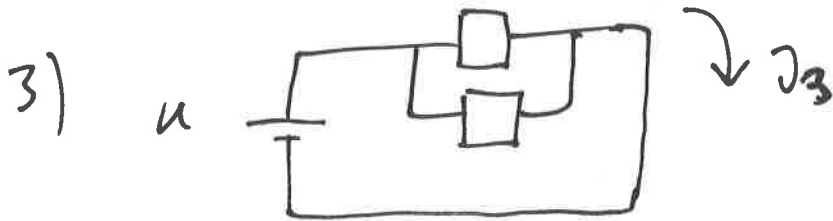
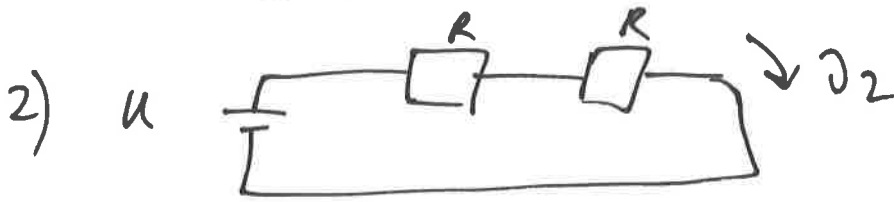
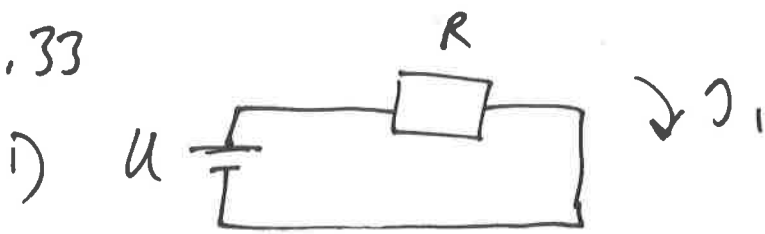
$$U = R_{\text{KlK}} \cdot I \rightarrow R_{\text{KlK}} = \frac{U}{I} = \frac{11,7 \text{ V}}{19,2 \text{ A}}$$

$$U - U_N = 12,4 - 11,7 = 0,7 \text{ V} = R_S \cdot I$$

$$b) \rightarrow R_S = \frac{U - U_N}{I} = \frac{0,7 \text{ V}}{19,2 \text{ A}}$$

$$c) P_1 = U \cdot I = 11,7 \text{ V} \cdot \frac{19,2 \text{ A}}{4} =$$

2.33



a) TOSI, $J_1 > J_2$ siluä: $J_1 = \frac{U}{R} > \frac{U}{2R} = J_2$

b) EPA TOSI, oclwon $S = \frac{1}{R}$.

$J_1 = US < U \cdot 2S = J_3 \Rightarrow J_1 < J_3$

c) ~~MAW~~ EPA TOSI, $P = RJ^2$
 ~~$P = UJ$~~ $\Rightarrow P_1 = RJ_1^2 > RJ_2^2 = P_2$
 $\Rightarrow P_1 > P_2$

d) TOSI, $P = UJ \rightarrow P_1 = UJ_1 < UJ_3 = P_3$

2.34

a) ~~$R_a =$~~

$$P = UI = RI^2 = \frac{U^2}{R} \quad \left[I = \frac{U}{R} \right]$$

OLKON JÄNNITELÄHTEIDEN JÄNNITTEETU,
VASTUKSET R JA $S = \frac{1}{R}$.

$$P = \frac{I^2}{S} = U^2 S$$

$$a) R_a = 2R$$

$$\frac{P_B}{P_A} = \frac{U^2}{R_a} \cdot \frac{R}{U^2} = \frac{R}{2R} = \underline{\underline{\frac{1}{2}}}$$

$$b) S_a = 2S$$

$$\frac{P_{B\text{kok}}}{P_A} = \frac{U^2 S_a}{U^2 S} = \frac{2S}{S} = 2$$

$$P_B = \frac{P_{B\text{kok}}}{2}$$

$$\frac{P_B}{P_A} = \frac{2}{2} = \underline{\underline{1}}$$

$$c) U_c = 2U$$

$$\frac{P_B}{P_A} = \frac{U_c^2}{R} \cdot \frac{R}{U^2} = \frac{2^2 U^2}{U^2} = \underline{\underline{4}}$$

$$d) R_{\text{kok}} = R + \frac{1}{2}R = \frac{3}{2}R$$

$$U = RI$$

$$\rightarrow I = \frac{U}{R}$$

$$I_{\text{kok}} = \frac{U}{R_{\text{kok}}} = \frac{U}{\frac{3}{2}R} = \frac{2}{3} \frac{U}{R} = \frac{2}{3} I$$

$$I_B = \frac{I_{\text{kok}}}{2} = \frac{1}{3} I$$

$$\frac{P_B}{P_A} = \frac{R I_B^2}{R I^2} = \underline{\underline{\frac{1}{9}}}$$

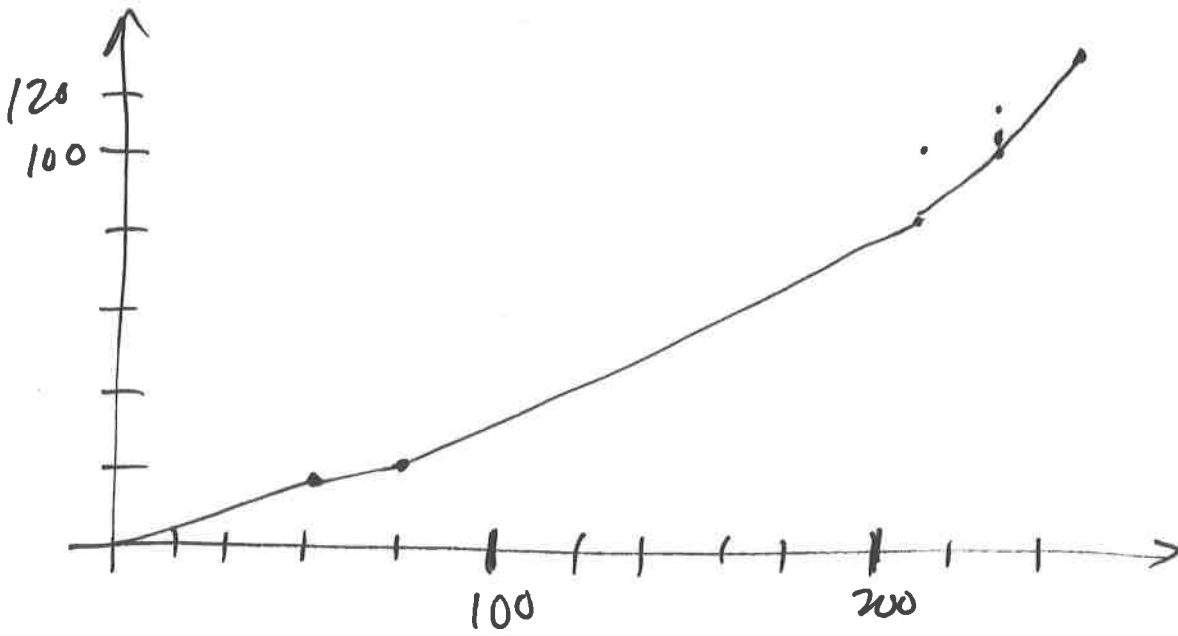
2.35 a) ~~LAMP~~ JÄNNITTEEN NOUSTESSA
 TEHO KASVAA LÄMMITTÄEN
 LAMPPIA, JOLLEIN LAMPUN
 RESISTANSSI KASVAA JA SUHDE
 ~~$P = UI$~~ $\frac{1}{R} = \frac{I}{U}$ PIENENEVÄ.

b)

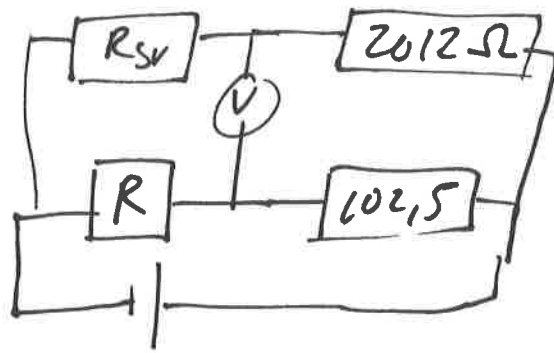
$$P = UI$$

U [V]	I [A]	P [W]
20	0,125	2,5 2,5
40	0,17	6,8 6,8
60	0,22	13,2
80	0,25	20
100	0,275	27,5
120	0,30	36
140	0,32	42 + 3 = 42 45
160	0,35	48 + 4 = 48 52
180		60
200		77,5
220		95
240	0,5	120

$$70 \frac{70}{4} = 20 - 2,5 = 17,5$$



2.36



TASAPAINO TILASSA

$$\frac{R}{R_{sv}} = \frac{102,5}{2012} \Rightarrow R = \frac{102,5}{2012} \cdot 1274$$

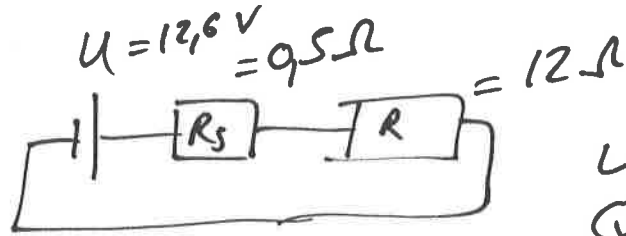
$$= \frac{1}{20} \cdot 1274 = 63,7 \Omega$$

$$= \underline{\underline{63 \Omega}}$$

$$\Rightarrow R = \frac{102,5}{2012} \cdot 1274$$

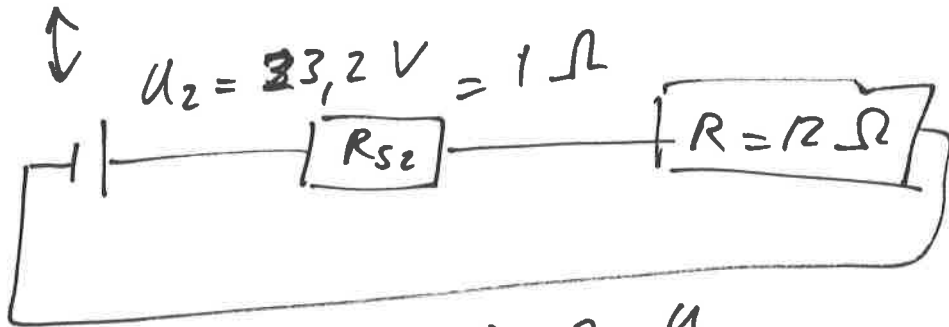
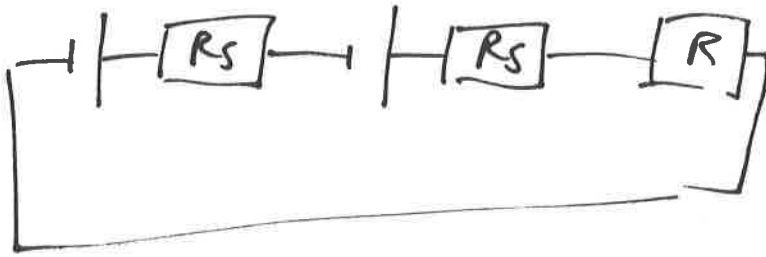
$$\approx \frac{100}{2000} \cdot 1260 = \frac{1}{20} \cdot 1260 = \frac{1260}{10} = \underline{\underline{63 \Omega}}$$

2.37 a)



U_{aus}
 $Q = 80 \text{ Ah}$

b)



$P = U \cdot I$

$\leadsto P = \frac{U^2}{R}$

$U = R \cdot I \Rightarrow I = \frac{U}{R}$

a) $I = \frac{U}{R} = \frac{12,6 \text{ V}}{12,5 \Omega} = 1 \text{ A}$

$P_{\text{aus}} = U \cdot I = 12 \Omega \cdot 1 \text{ A} = \underline{\underline{12 \text{ W}}}$

$I = \frac{Q}{t} \rightarrow t = \frac{Q}{I} = \frac{40 \text{ Ah}}{1 \text{ A}} = 40 \text{ h}$
 $2 \text{ A} \cdot 40 \text{ h} \rightarrow \underline{\underline{80 \text{ h}}}$

b) $I = \frac{U}{R} = \frac{23,2 \text{ V}}{13 \Omega} = 1,78 \text{ A}$

$P = U \cdot I = \cancel{12 \Omega} \cdot 23,2 \text{ V} \cdot 1,78 \text{ A} = \underline{\underline{41,4 \text{ W}}}$

$t = \frac{Q}{I} = \frac{40 \text{ Ah}}{1,78 \text{ A}} = \underline{\underline{22,5 \text{ h}}}$

$$2.38 \text{ a) } U = RI \rightarrow I = \frac{U}{R}$$

$$I_{\text{VASEN}} = \frac{18 \text{ V}}{4,5 \Omega} = 4 \text{ A}$$

$$I_{\text{OIKKA}} = \frac{18 \text{ V}}{4,5 \Omega} = 4 \text{ A}$$

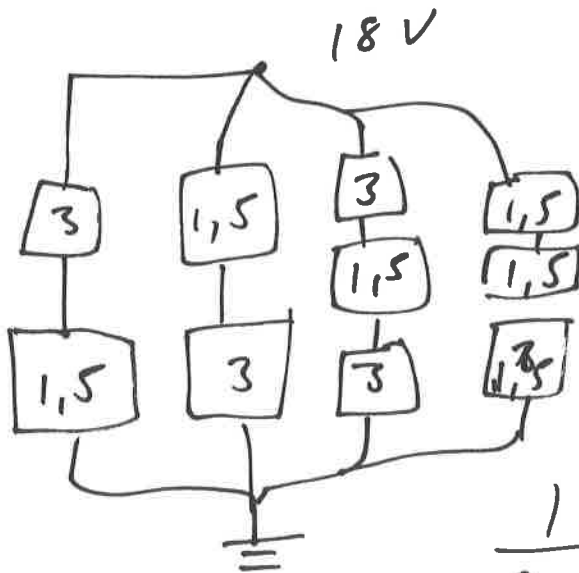
$$V_P = 18 - 3 \Omega \cdot 4 \text{ A} = 6 \text{ V}$$

$$V_Q = 18 - 1,5 \cdot 4 \text{ A} = 12 \text{ V}$$

$$U_{PQ} = 6 \text{ V}$$

~~$$b) \quad I = \frac{U}{R} = \frac{U_{PQ}}{1,5 \Omega} = \frac{6 \text{ V}}{1,5 \Omega} = 4 \text{ A}$$~~

TUUEF TILANNE



$$I_{\text{KOK}} = \frac{18}{1,25} = \underline{\underline{14,4 \text{ A}}}$$

$$\frac{1}{R_{\text{KOK}}} = \frac{3}{4,5} + \frac{1}{7,5} =$$

$$= \frac{1}{1,5} + \frac{1}{7,5} =$$

$$R_{\text{KOK}} = \frac{1,5 \cdot 7,5}{1,5 + 7,5} =$$

$$= \frac{11,25}{9} = 1,25$$

