

1. MASS iz Osnova elektrotehnike

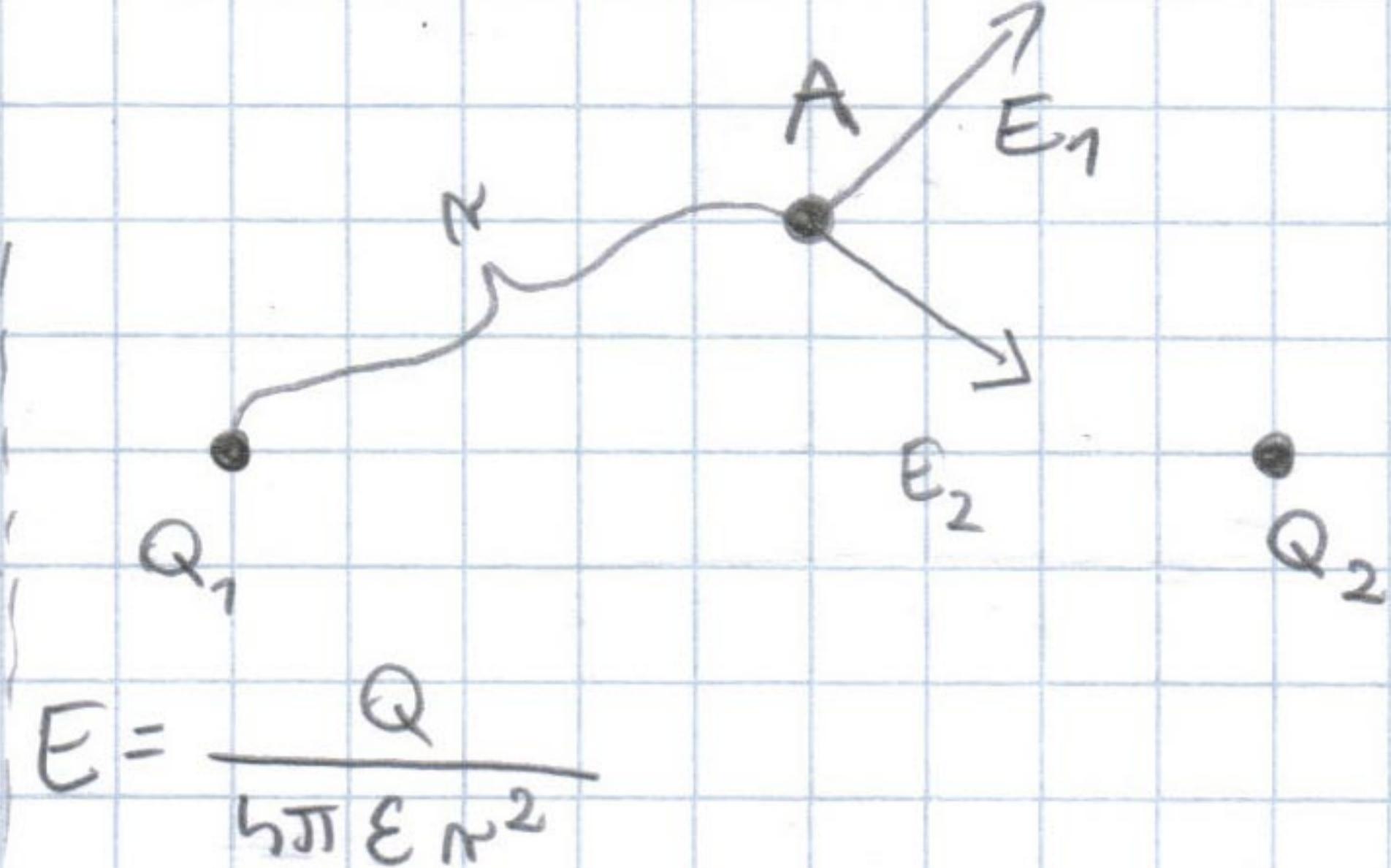
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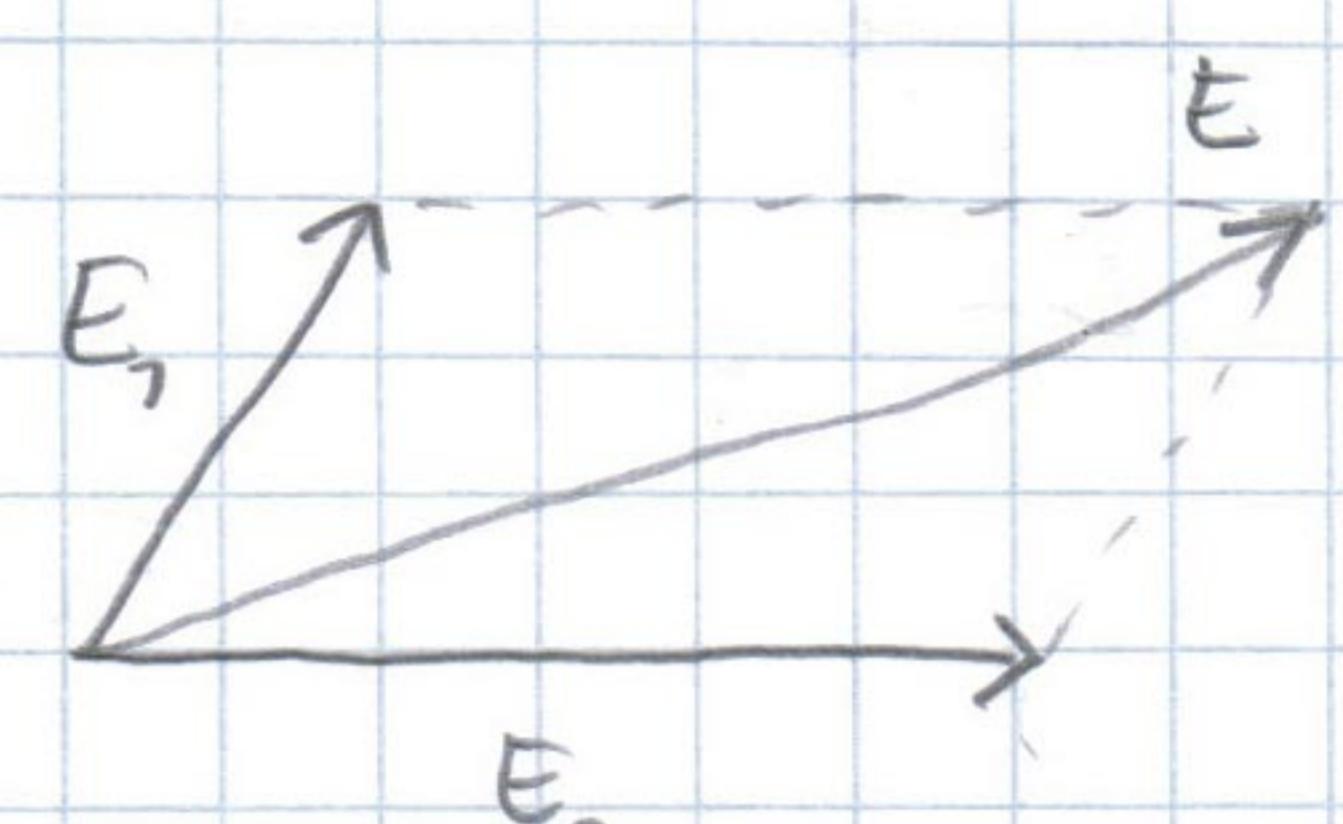
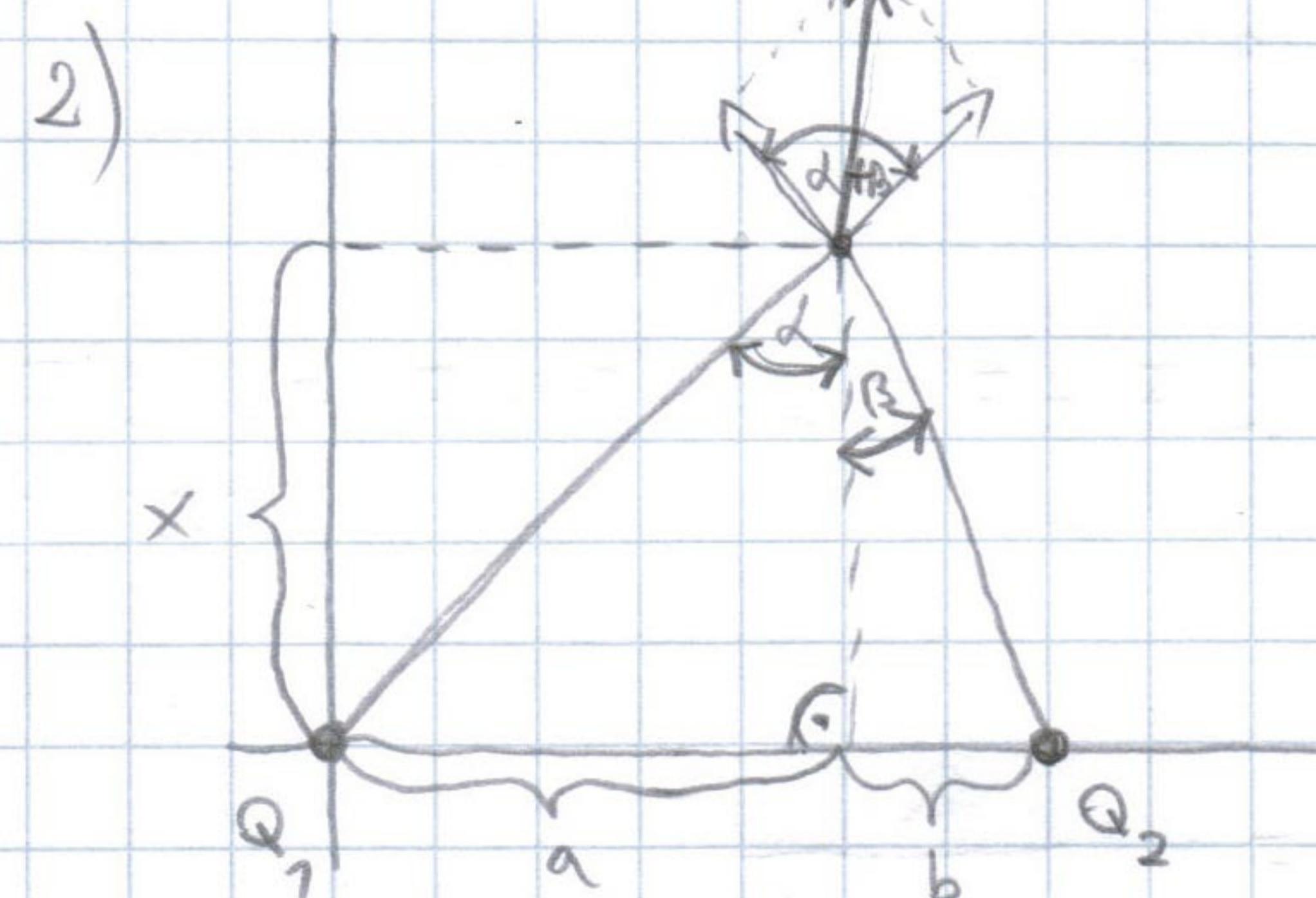
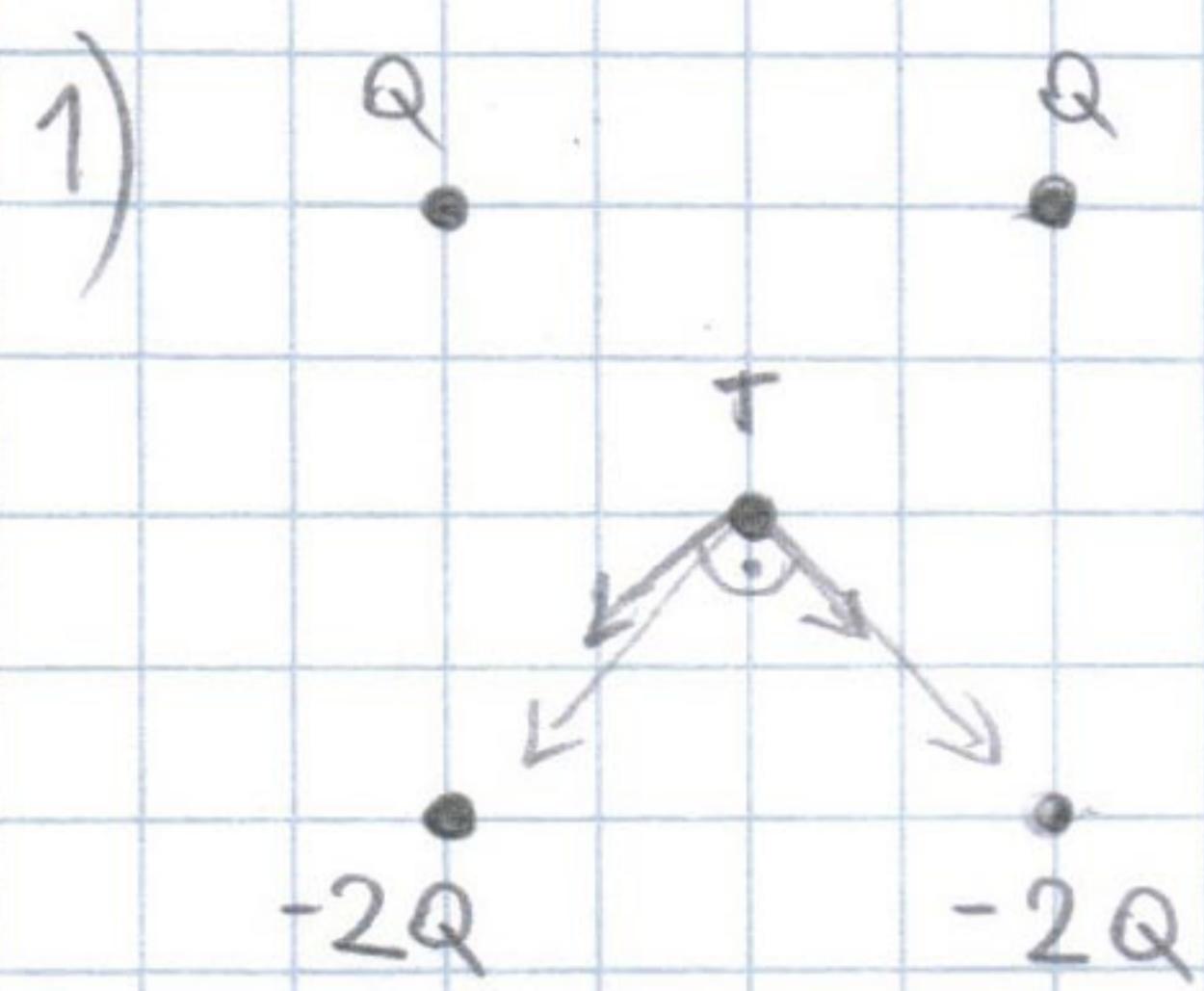
NABOJI \Rightarrow

\rightarrow ako je naboje $+$, polje ide od njega



\rightarrow naboje $-$, polje ide u mreza

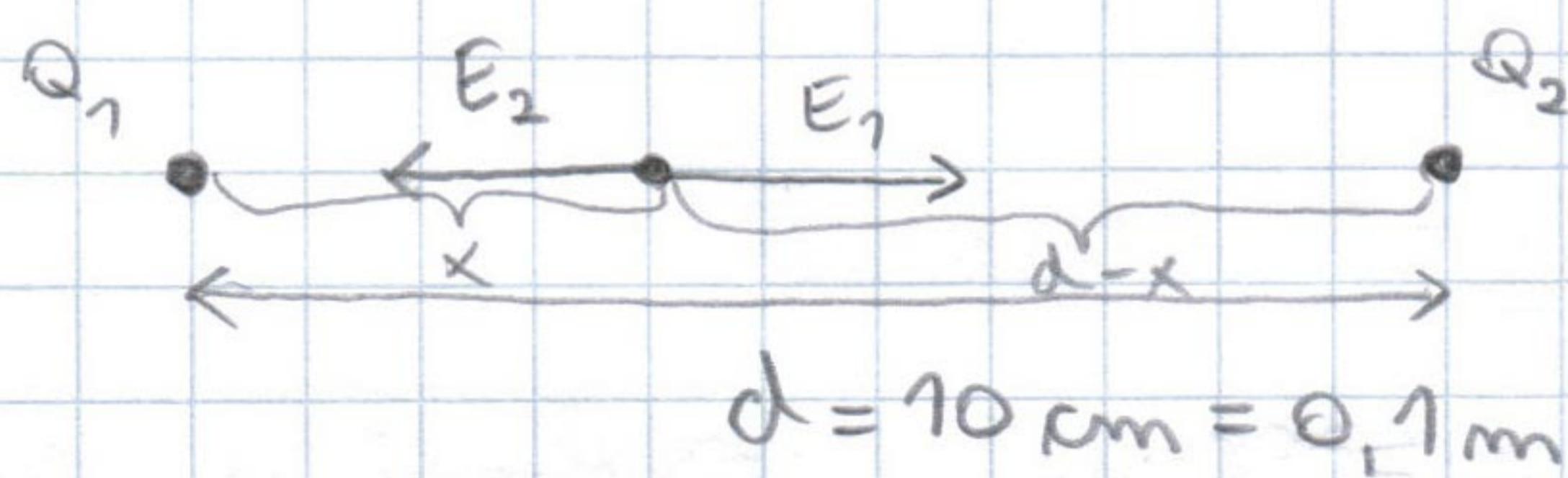
$$E = \frac{Q}{4\pi\epsilon_0 r^2}$$



$$E^2 = E_1^2 + E_2^2 - 2E_1 E_2 \cdot \cos\theta$$

1.) $Q_1 = 2 \text{ mC}$

$Q_2 = 1 \text{ mC}$



$E_1 = E_2 \Rightarrow$ polje je 0

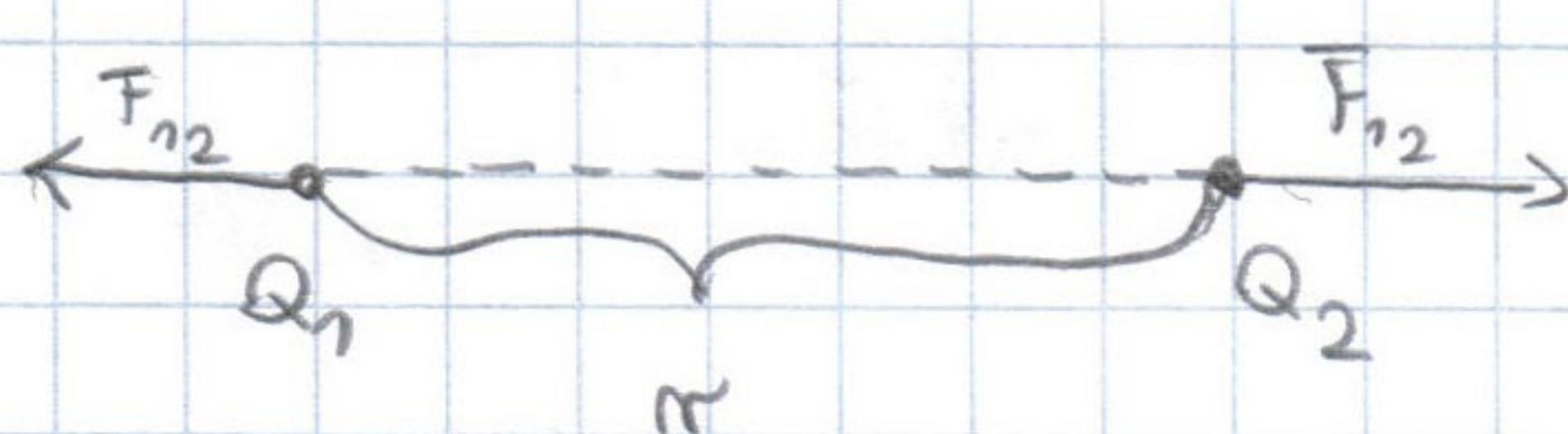
$$\frac{Q_1}{4\pi\epsilon_0 x^2} = \frac{Q_2}{4\pi\epsilon_0 (d-x)^2}$$

$$2(d-x)^2 = x^2$$

$$\sqrt{2}d - \sqrt{2}x = x$$

$$x(1+\sqrt{2}) = \sqrt{2} \cdot 0.1$$

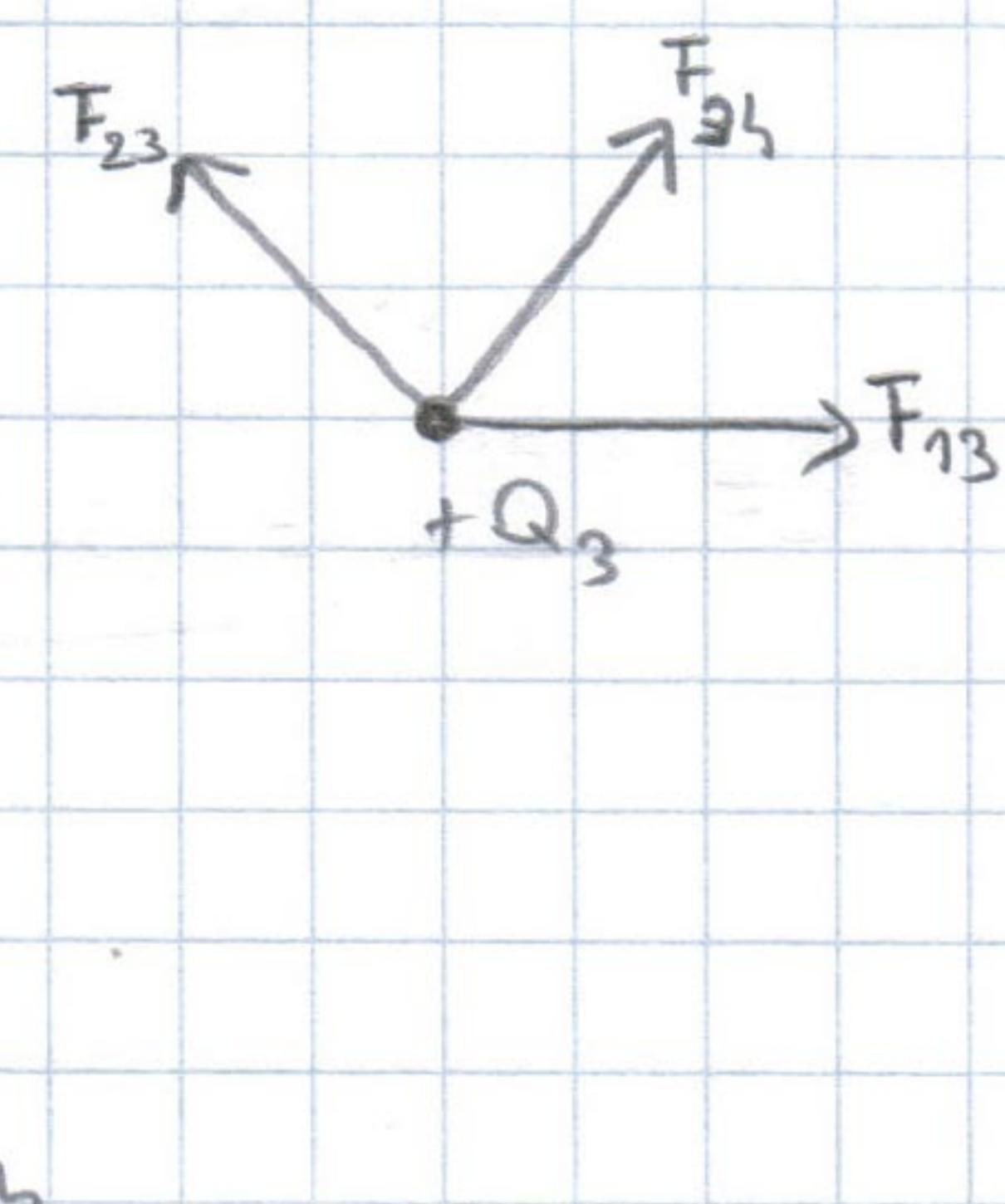
$$x = 0.058 \text{ m}$$



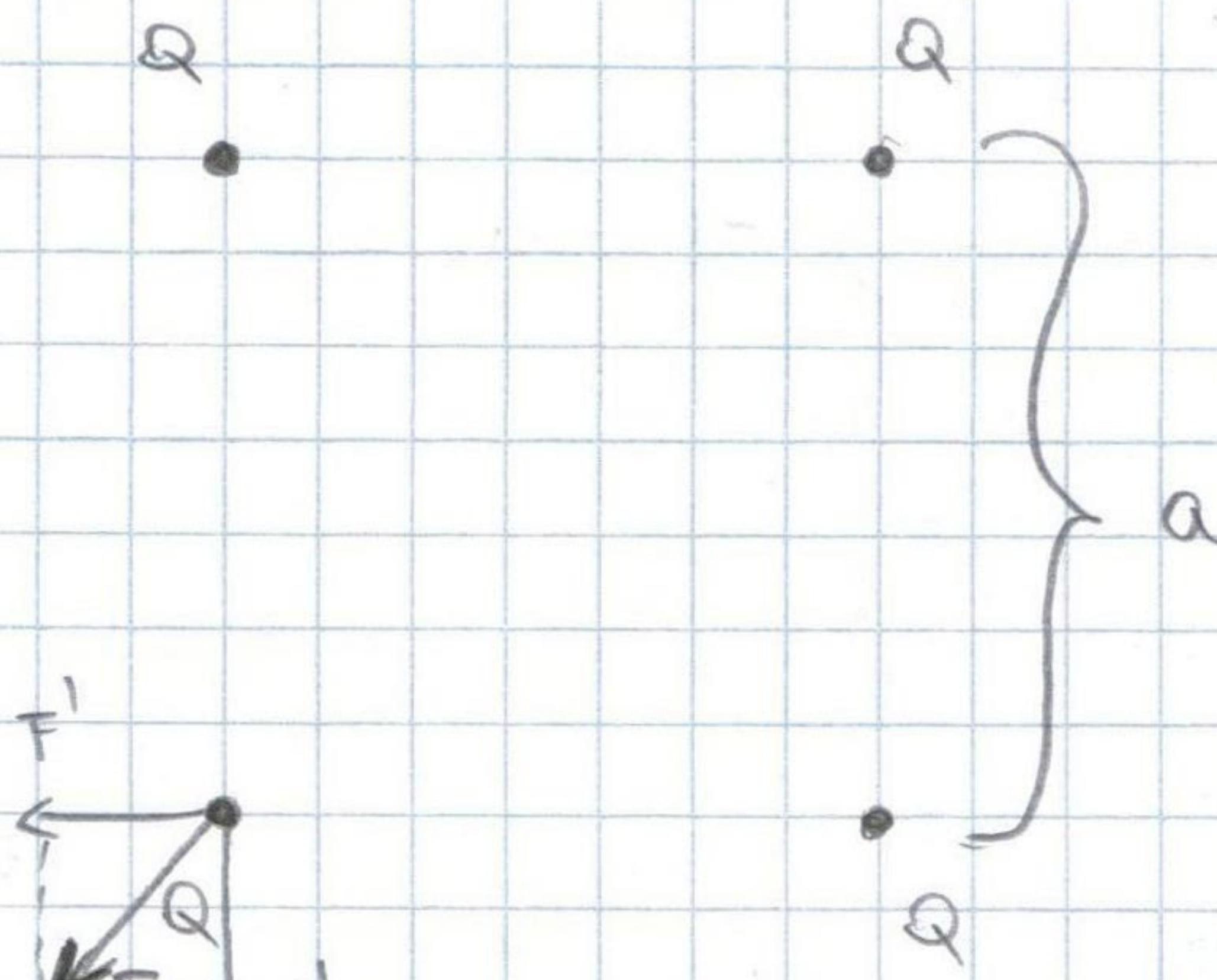
$$E = \frac{Q_1}{4\pi\epsilon_0 r^2}$$

$$F_{12} = E_1 \cdot Q_2 = \frac{Q_1 Q_2}{4\pi\epsilon_0 r^2}$$

$-Q_2$



2)



racinamo silu na 1 naboju jeju isti

$$F = \frac{Q^2}{4\pi\epsilon_0(a\sqrt{2})^2}$$

$$F' = \frac{Q^2}{4\pi\epsilon_0 \cdot a^2} = 2F$$

$$F_{uk} = \sqrt{2} F' + F = 2\sqrt{2} F + F = 3,82 F$$

$$E = \frac{Q_1}{4\pi\epsilon_0\epsilon_r \cdot r^2} = k \cdot \frac{Q}{\epsilon_r \cdot r^2}$$

$$\epsilon_r = 1$$

3)



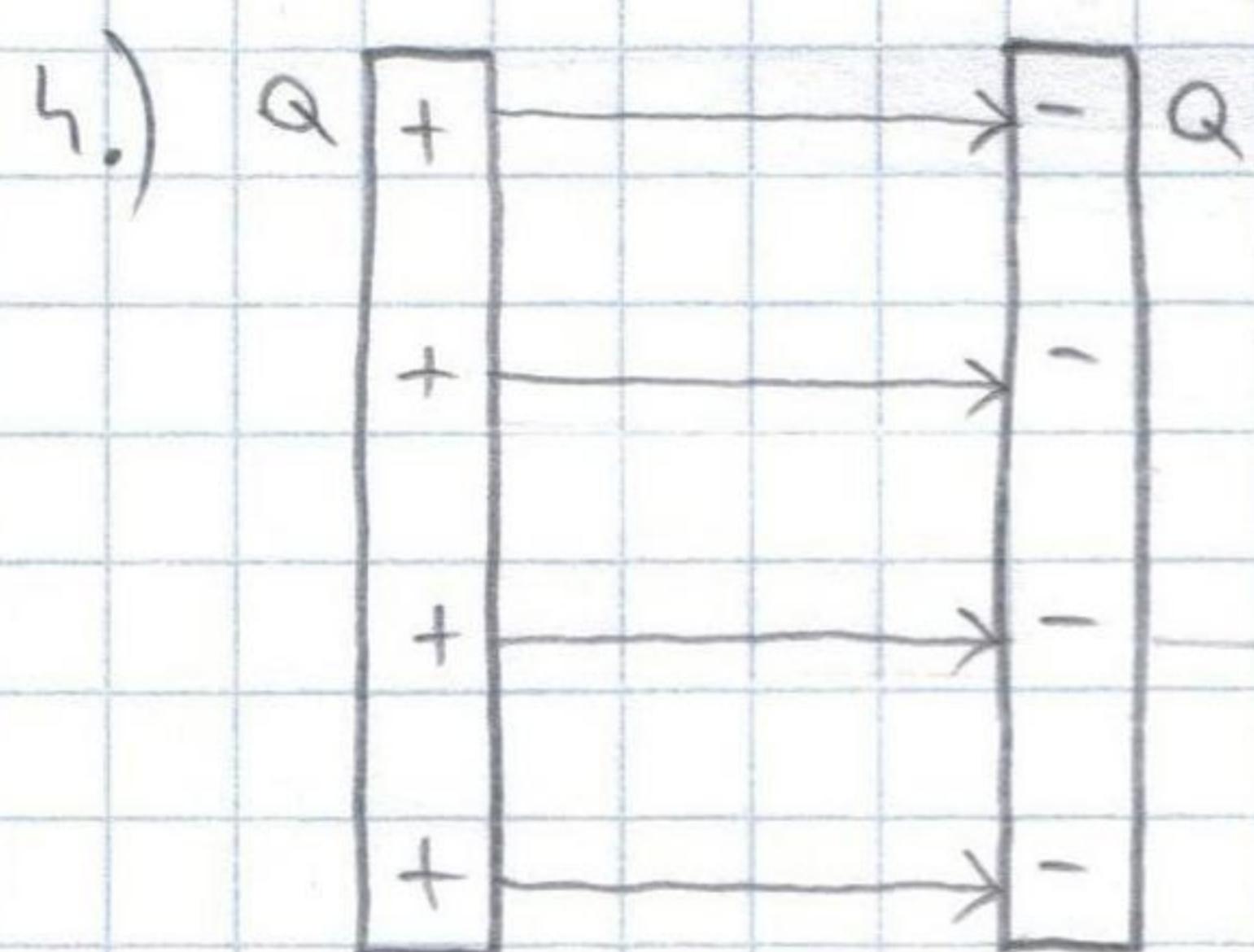
$$q = 3 \text{ mC}$$

$W = -60 \text{ mJ}$ \Rightarrow obavi se nad pri prenosi
jem q iz A u B

$$U_{AB} = ?$$

$$U_{AB} = \frac{W}{Q} = \frac{-60 \cdot 10^{-3}}{3 \cdot 10^{-9}} = -20 \cdot 10^6 \text{ V} \Rightarrow \text{mjenji je negativan, smaci da je B mjesto viseg potencijala na } 20 \cdot 10^6 \text{ V}$$

$$U_{AB} = l_A - l_B$$



$$Q = 200 \text{ mC}$$

$$F = 200 \mu\text{N} \Rightarrow \text{sila na svaku plochu}$$

$$d = 0,01 \text{ m}$$

$$E = \frac{Q}{\epsilon_0}$$

$$= 2 \text{ kV/m}$$

~~$$U = E \cdot d = 10 \text{ V}$$~~

~~$$C = \frac{Q}{U} = 20 \text{ F}$$~~

$$E = \frac{F}{Q}$$

~~$$E = 1 \text{ kV/m}$$~~

KRIVO ∇

$$U = E \cdot d = 20 \text{ V}$$

$$C = \frac{Q}{U} = 10 \text{ mF}$$



\Rightarrow izvan kondenzatora se polja poništavaju, a unutra se razvijaju

$$E = \frac{\sigma}{2\epsilon_0} = 1 \text{ kV/m}$$

ELEKTRIČNA STRUJA, OTPOR i ENERGIJA \Rightarrow

$$R = \frac{\rho \cdot l}{S}$$

$$R_v = R_{20} (1 + \alpha \cdot \Delta t)$$

$$1) R_{20} = 100 \Omega$$

$$\alpha = 0,004 \text{ } ^\circ\text{C}^{-1} \Rightarrow \text{temperaturni koeficijent}$$

$$T = 120^\circ\text{C}$$

$$R_v = 100 \cdot (1 + 0,004 \cdot (120 - 20)) = 140 \Omega$$

$$2.) S_{co} = 1,5 \text{ mm}^2$$

$$\frac{f_{co}}{f_{Al}} = 0,63$$

$$f = \frac{R \cdot S}{l} \Rightarrow \frac{\frac{R \cdot S_{co}}{l}}{\frac{R \cdot S_{Al}}{l}} = 0,63 \Rightarrow \frac{1,5}{S_{Al}} = 0,63$$

$$S_{Al} = 2,38 \text{ mm}^2$$

$$3.) R = R_{20} (1 + \alpha \Delta t)$$

$$\frac{\alpha_1}{\alpha_2} = \frac{\frac{3R_{20}B_{20}}{R_{20} \cdot \Delta t}}{\frac{2R_{20}B_{20}}{R_{20} \cdot \Delta t}} = \frac{3-1}{2-1} = 2$$

$$\alpha = \frac{R - R_{20}}{R_{20} \cdot \Delta t}$$

$$1) \quad \boxed{3 \cdot R_{20}}$$

$$2) \quad \boxed{2 \cdot R_{20}}$$

5.)
 (1-12) $I = \frac{Q}{t} \Rightarrow Q = I \cdot t$ vrijeme $t_1 = 5h \quad t_2 = 2h$

$$Q_1 = 2 \cdot 5 \cdot 3600 \quad Q_2 = 1 \cdot 2 \cdot 3600$$

da dobijemo
u sekundama

$$Q = Q_1 + Q_2 = 13200 \text{ As}$$

$$\boxed{Q = 12 \text{ Ah}}$$

5.)
 (1-13) $d = 0,05$ \cancel{d}
 $l = 33 \text{ m}$ $\Rightarrow S = \pi r^2 l$

$$\underline{R = 80 \Omega}$$

$$R = \frac{\rho \cdot l}{S}$$

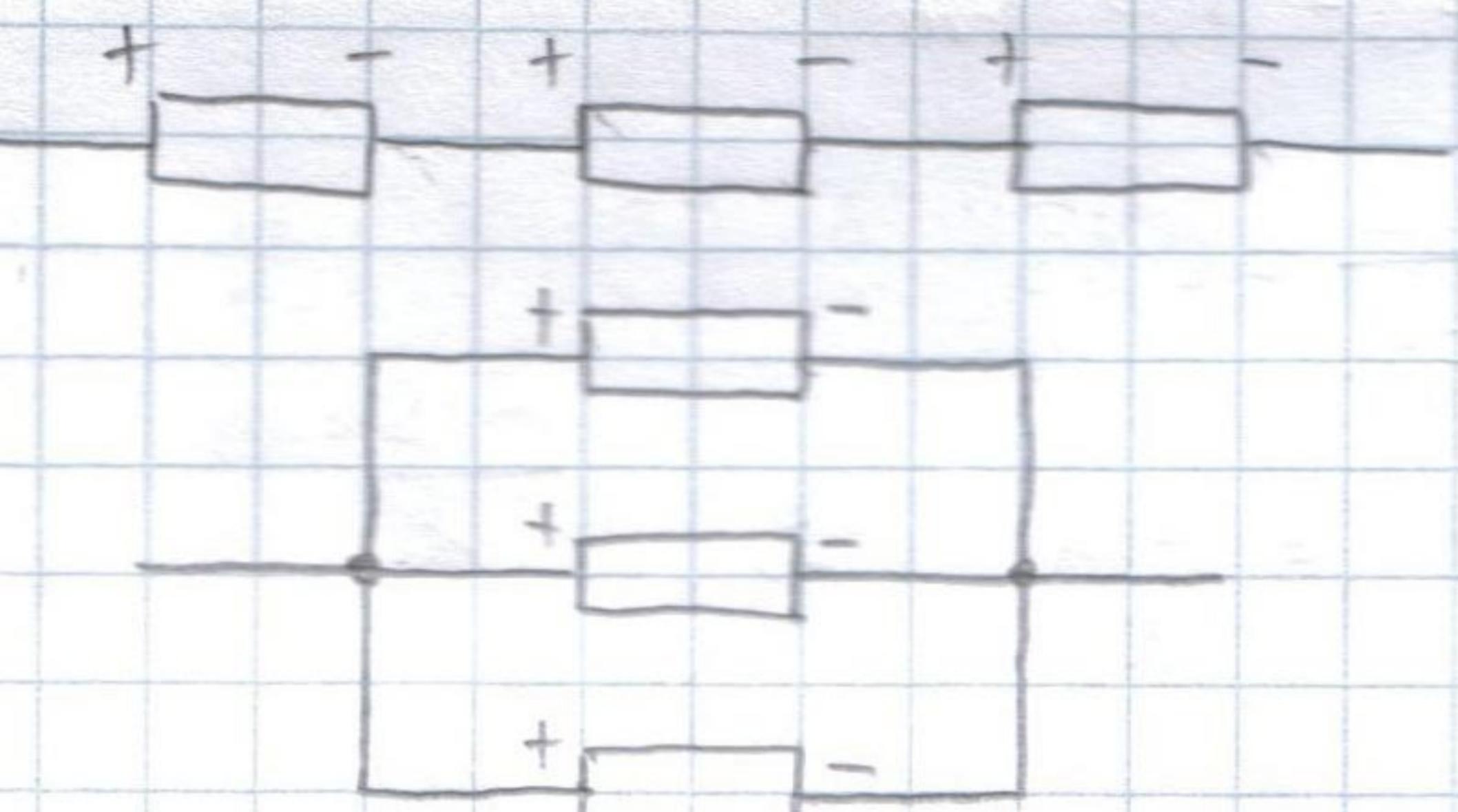
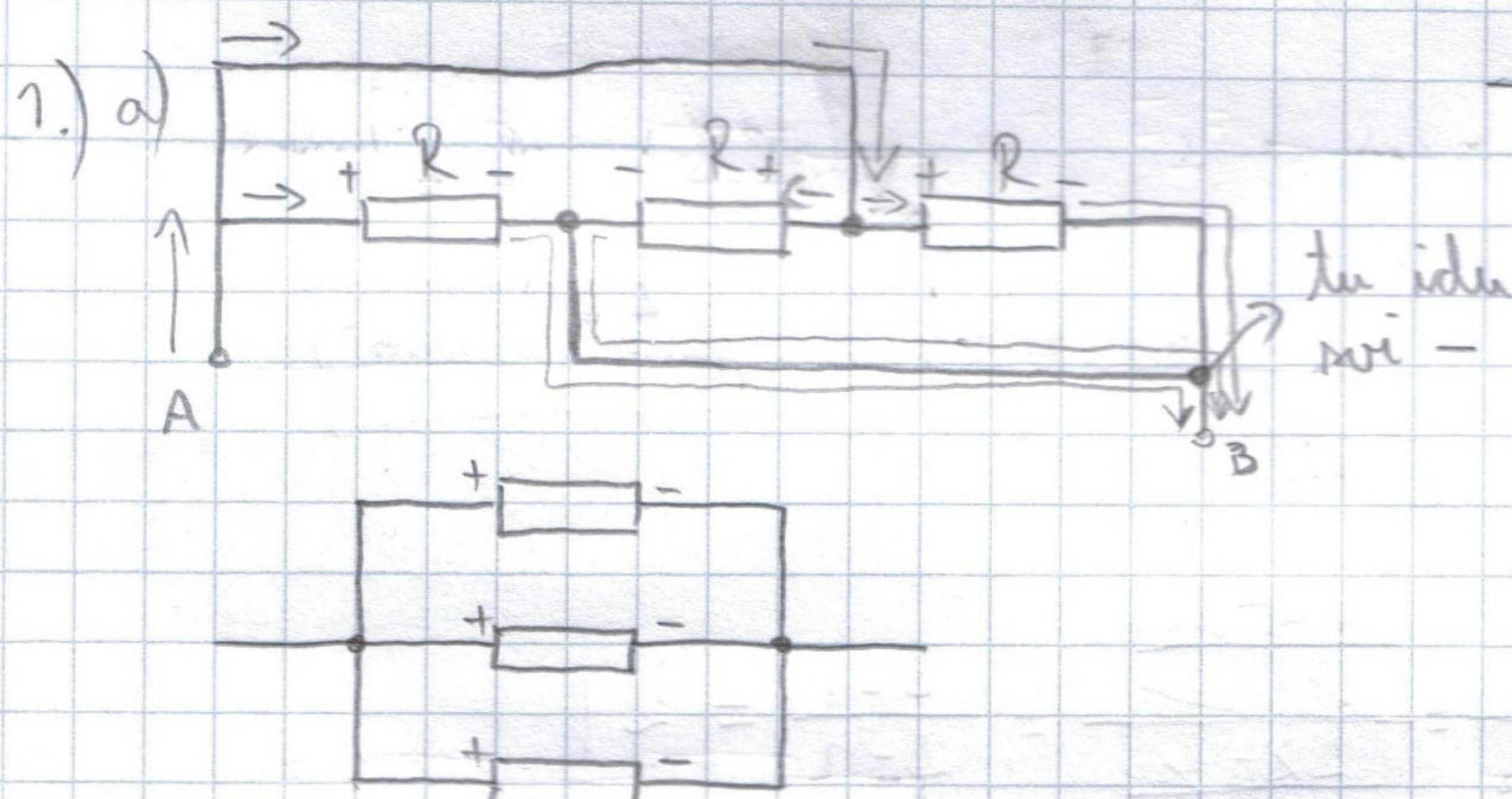
$$\rho = \frac{R \cdot S}{l}$$

$$\rho = \frac{1}{\sigma} [S]$$

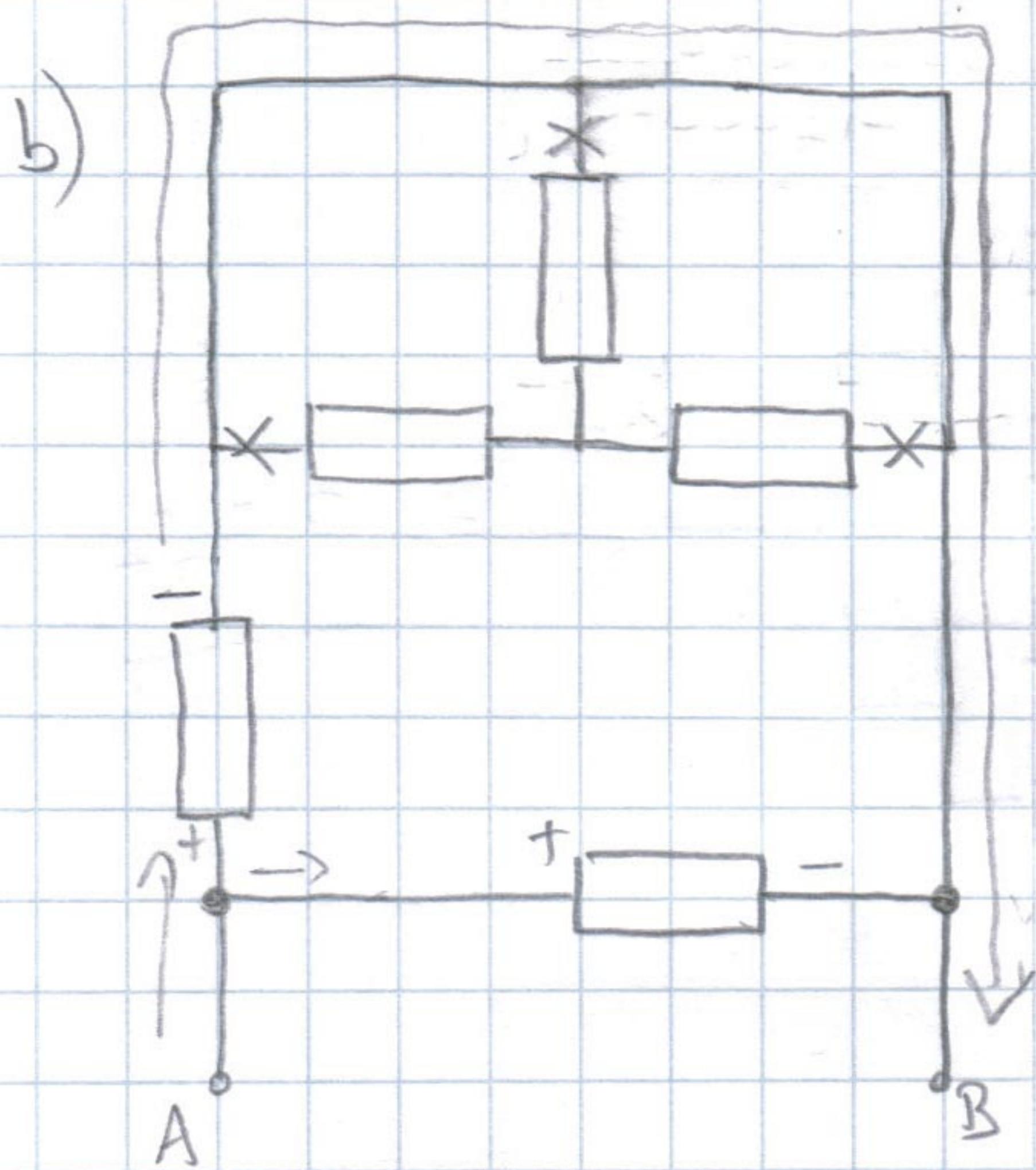
specifika vodljivost

PREDNSTAVLJENJE STRUJNIH KRUGOVA \Rightarrow

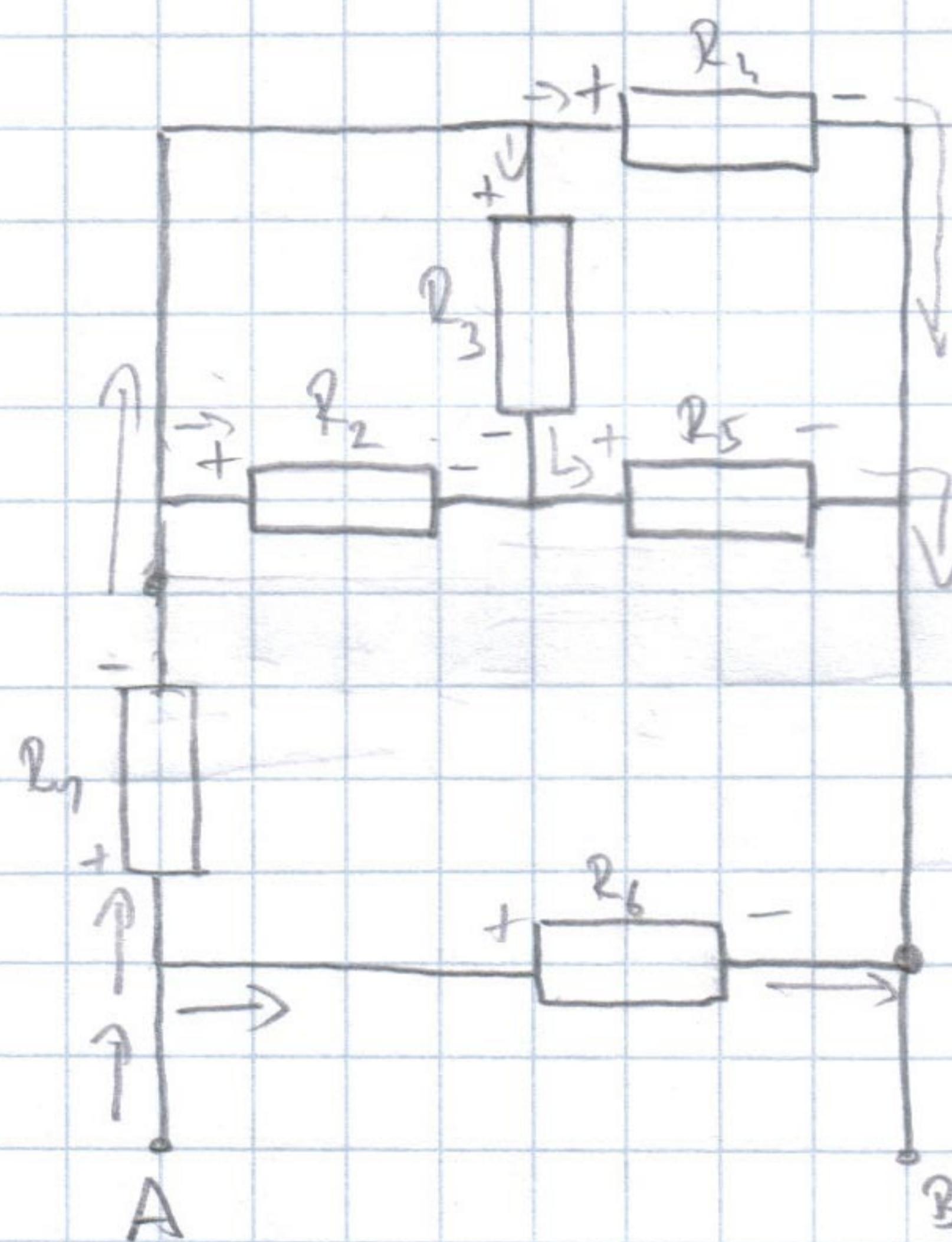
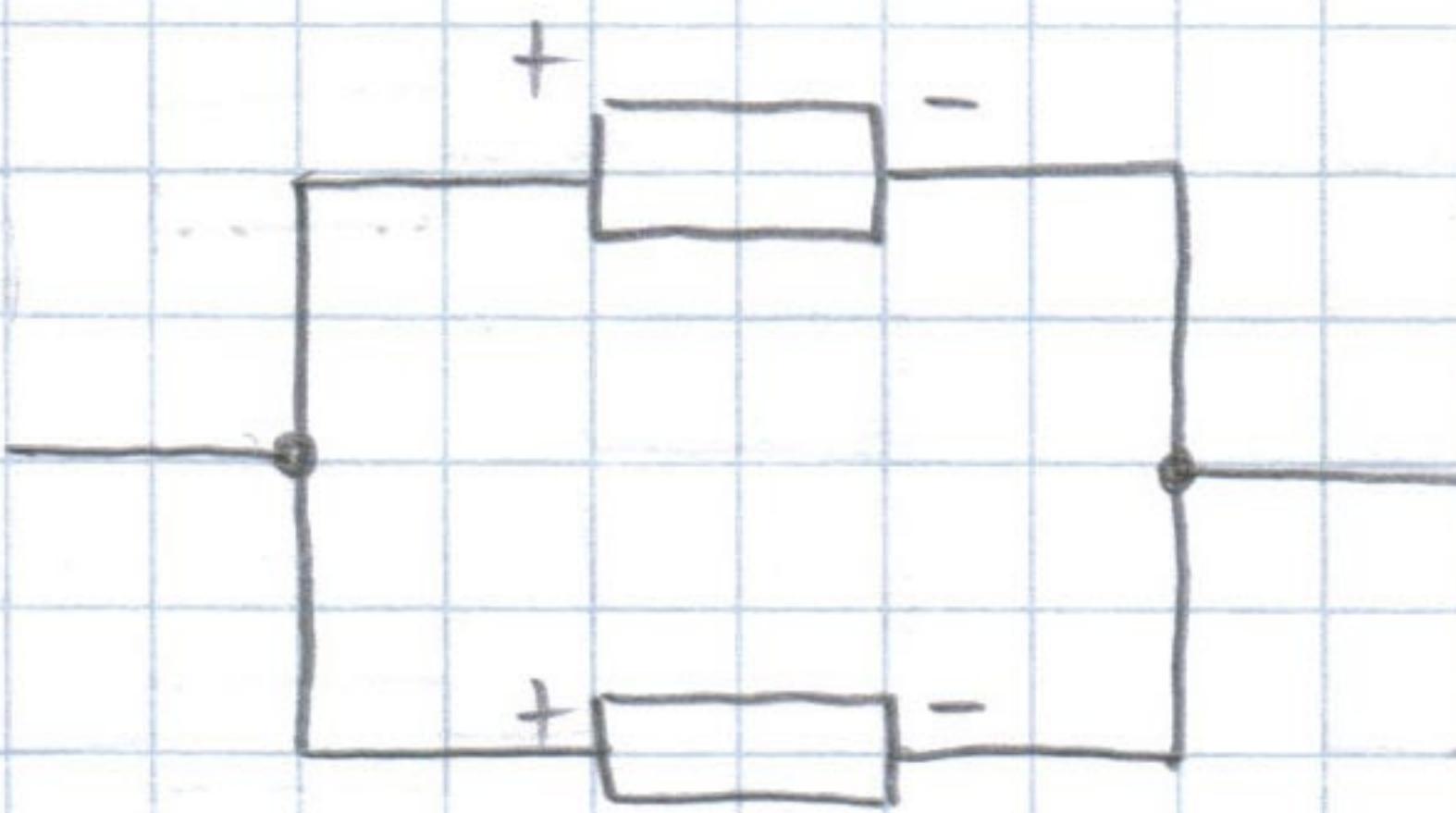
+ ma - \Rightarrow serijski spoj



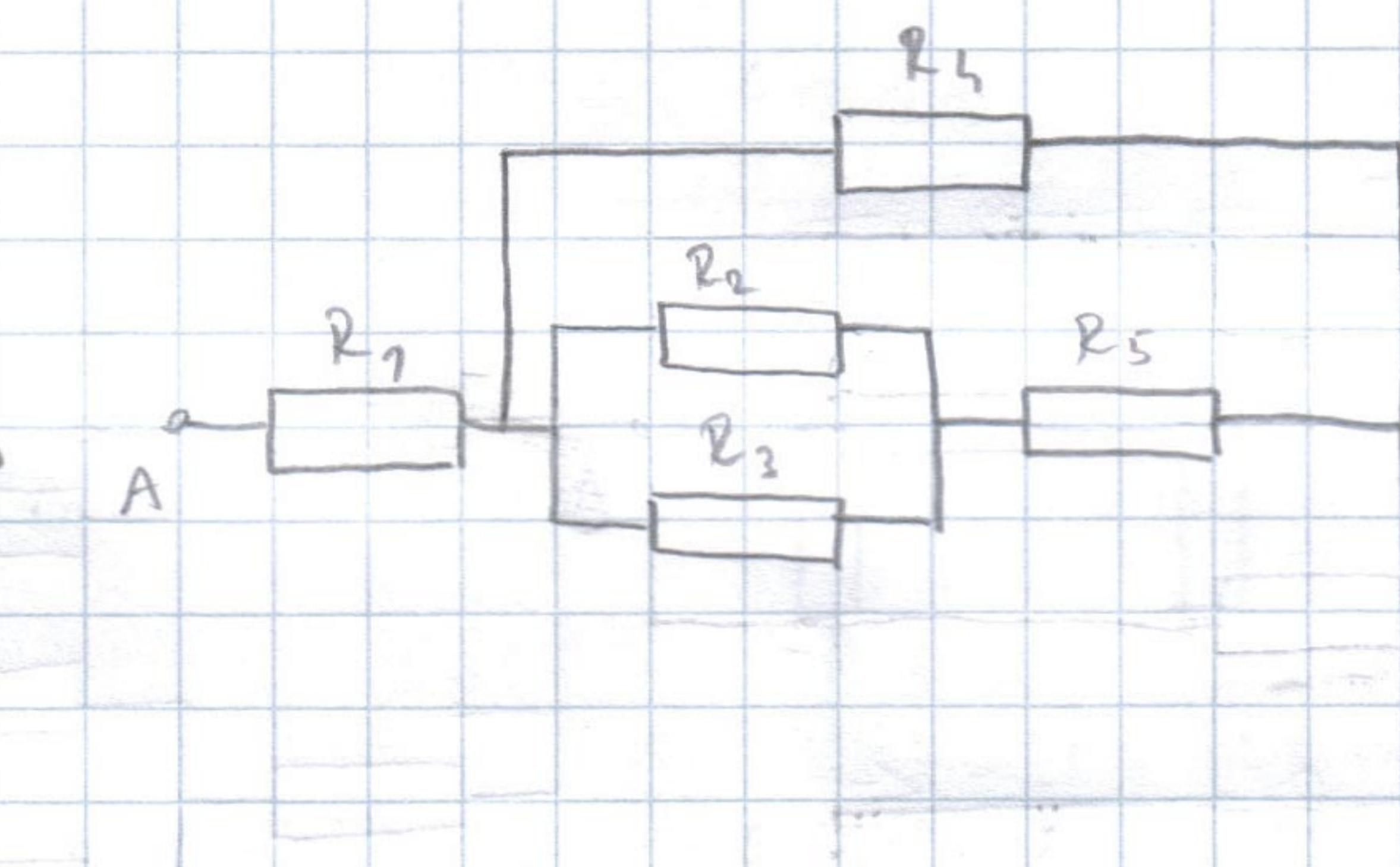
niti + u jednoj točki i niti - u jednoj točki \Rightarrow paralelni spoj



→ struja ide LINIJOM najmanjeg otpora ▽

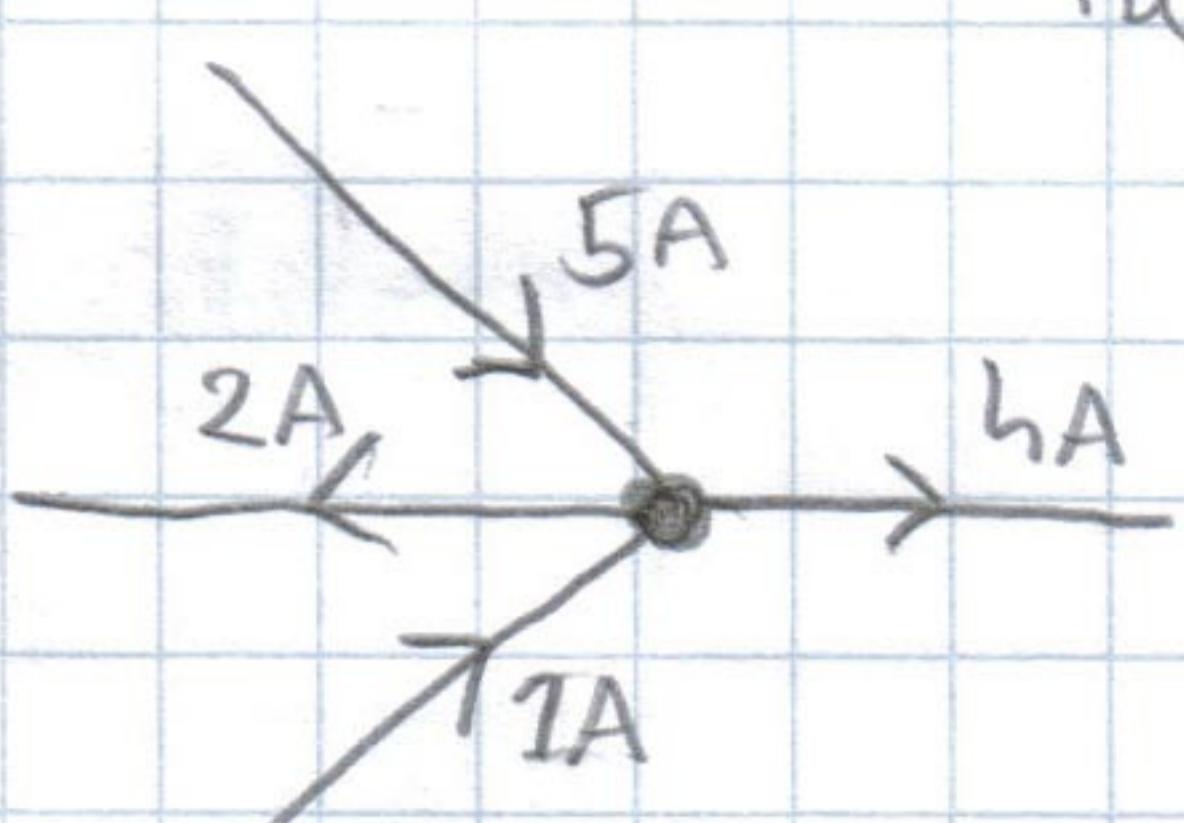


⇒



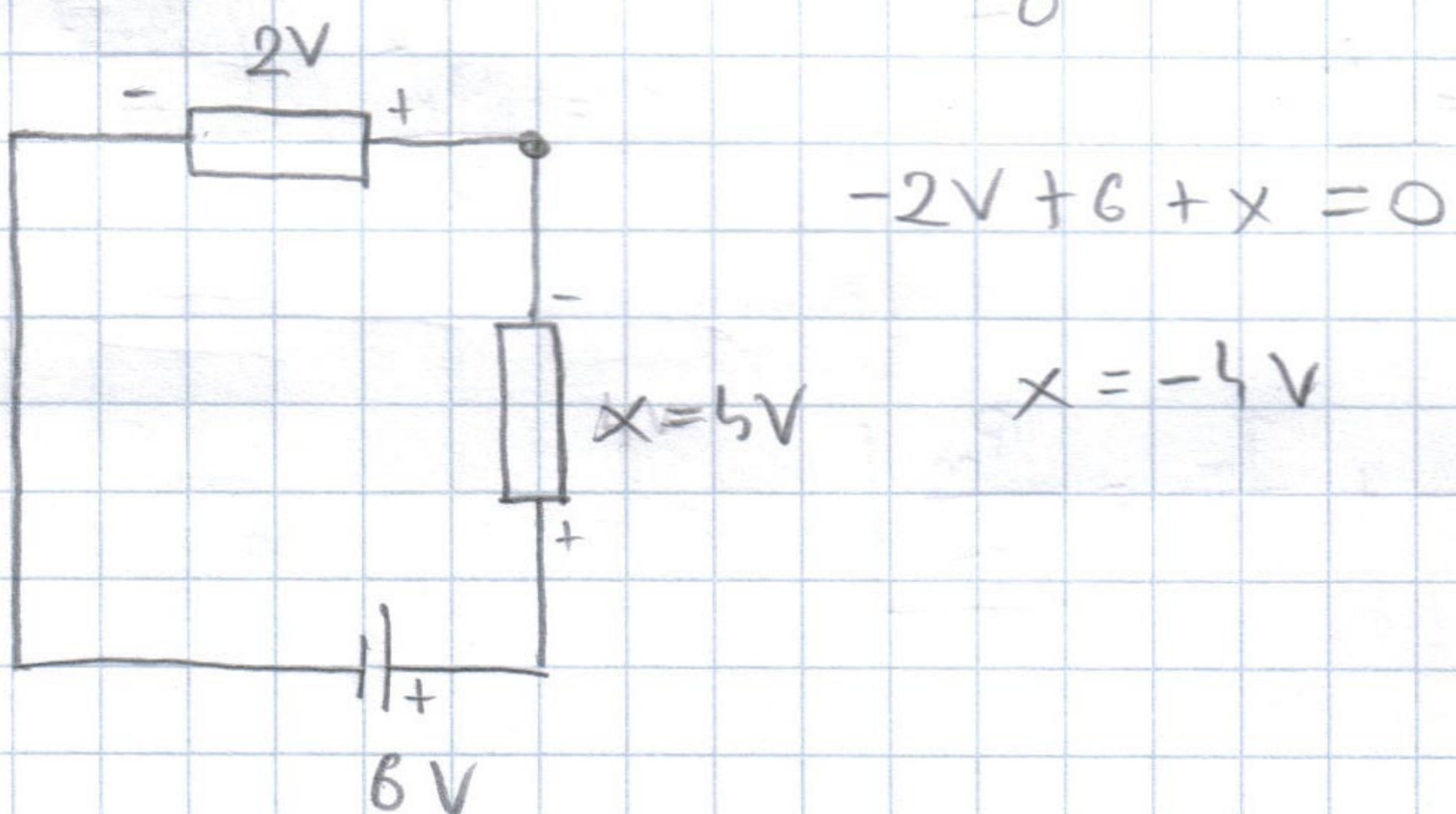
OHNOV ZAKON $\Rightarrow I = \frac{U}{R}$

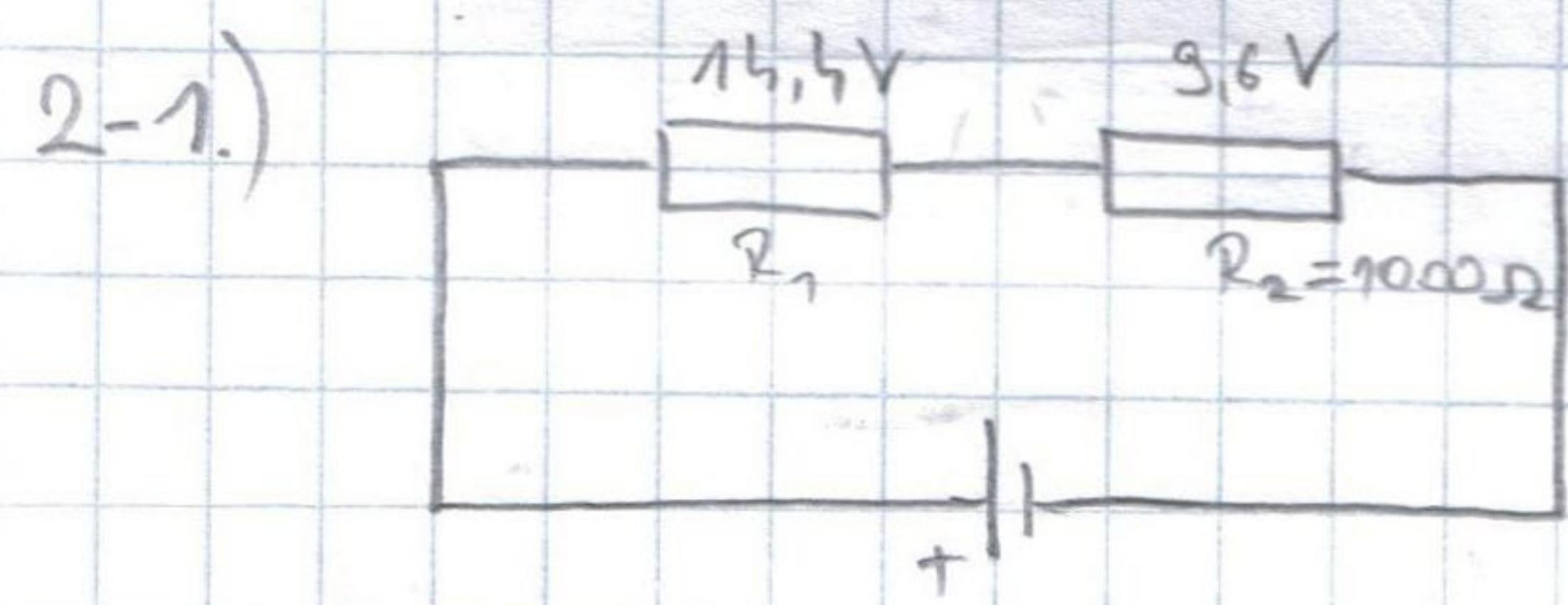
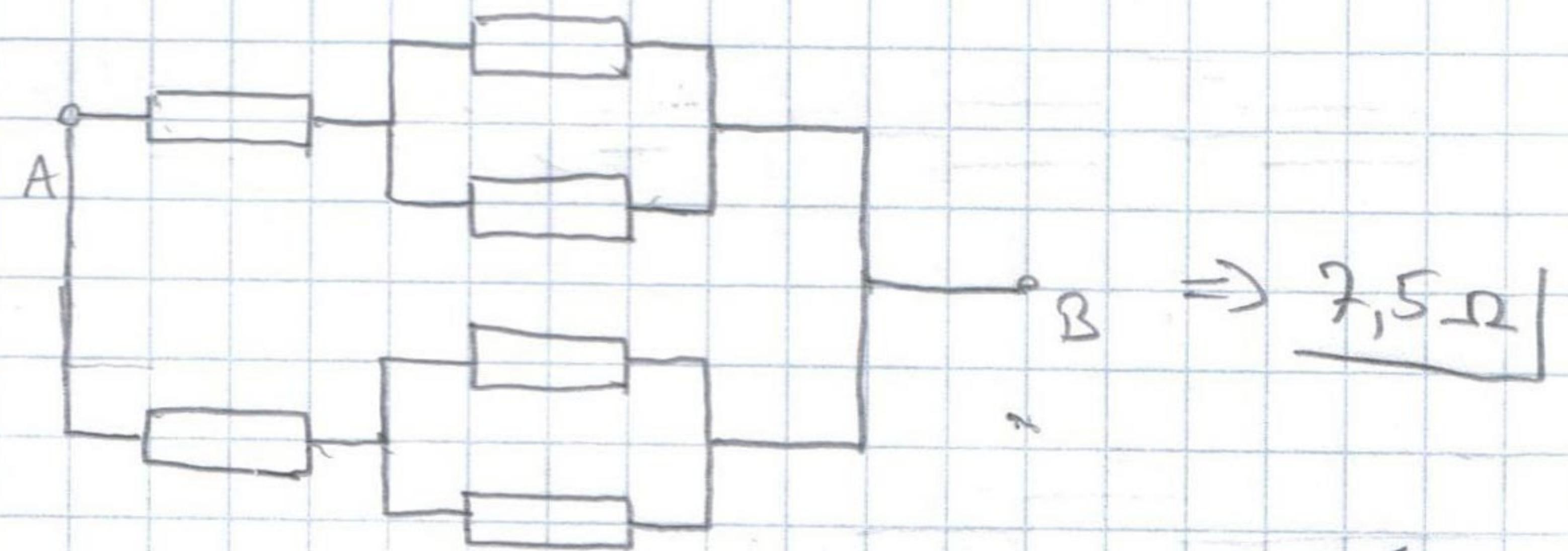
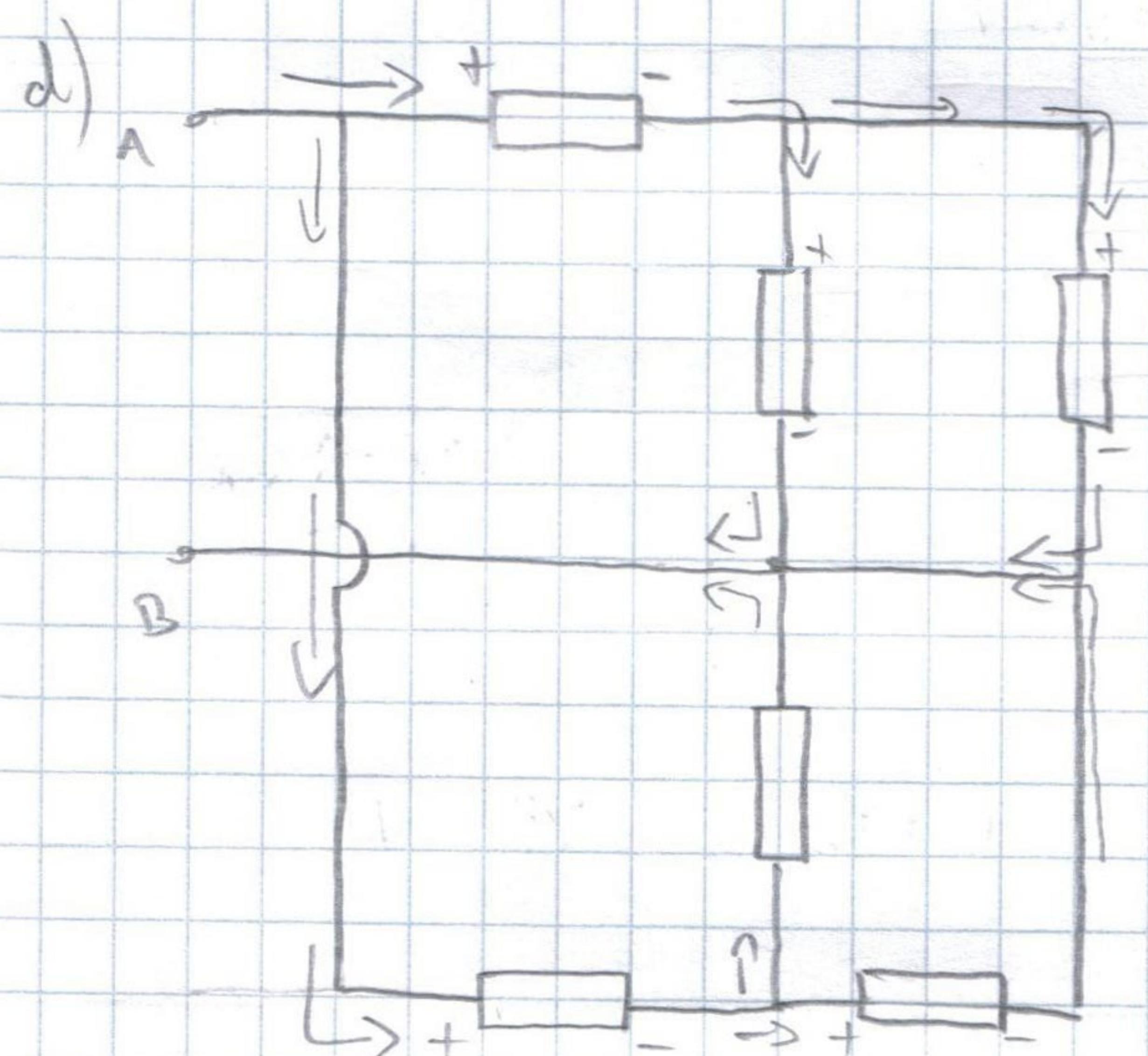
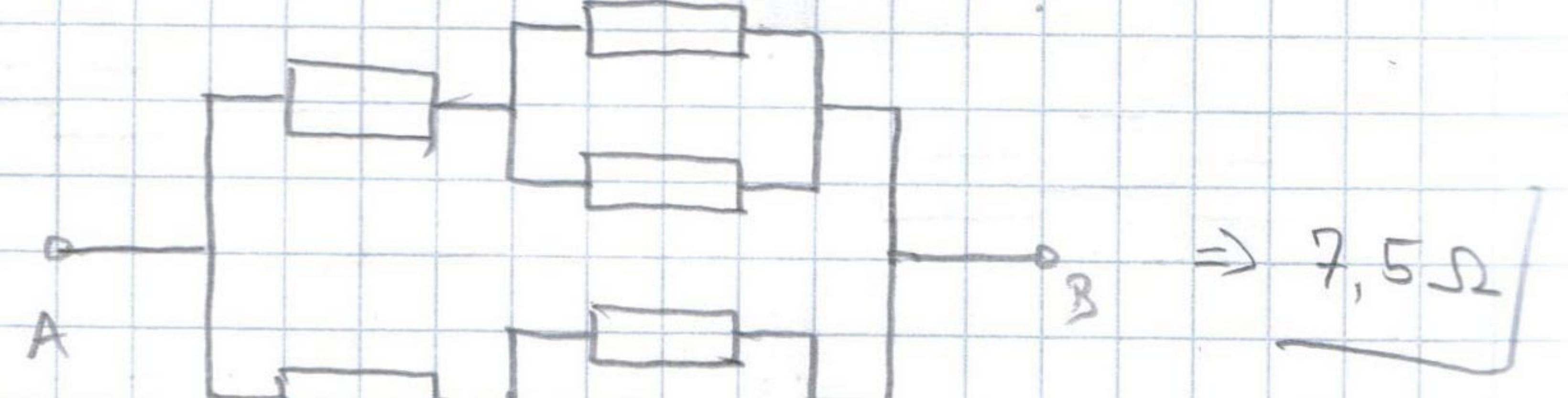
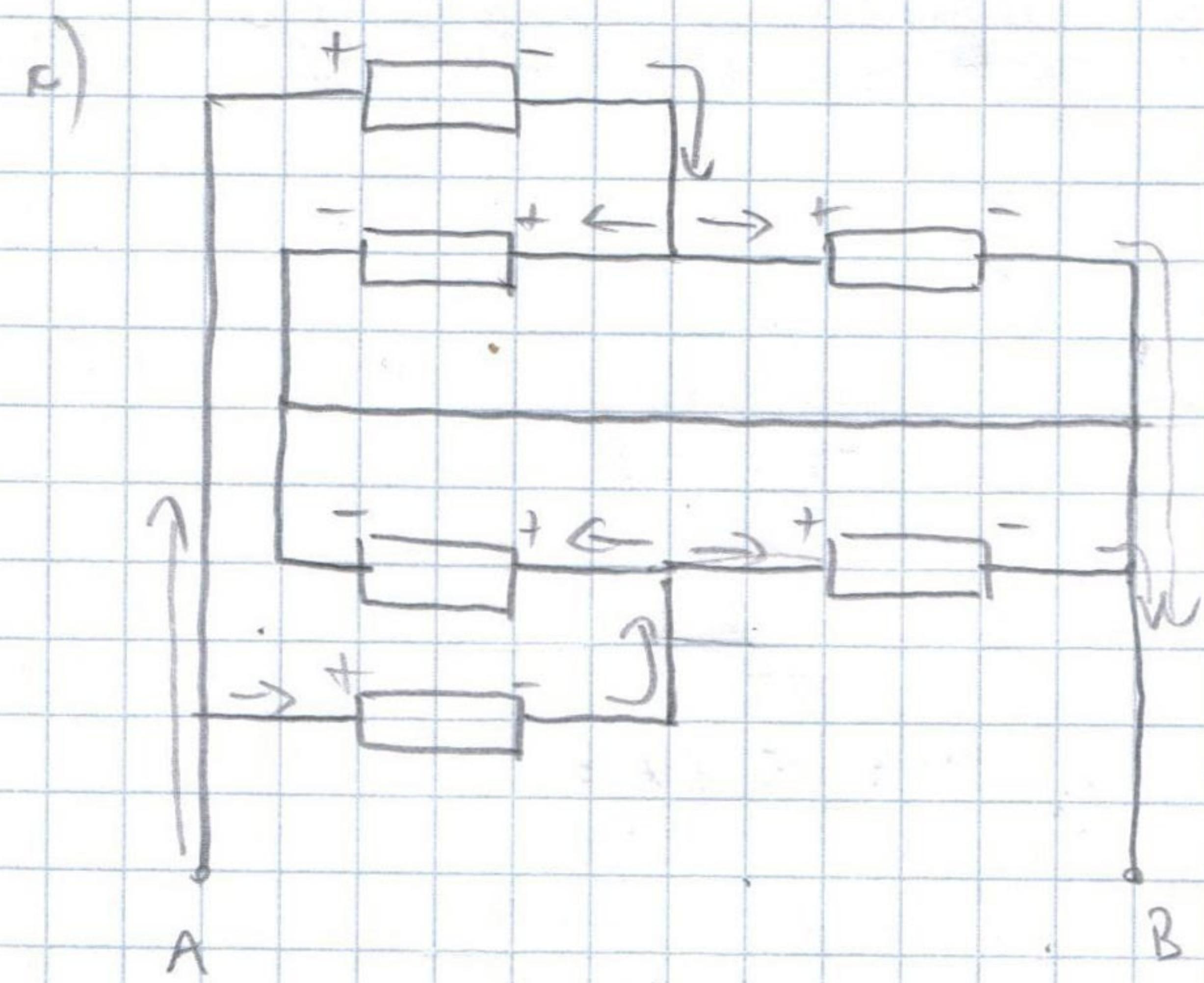
I. KIRCHHOFOV ZAKON \Rightarrow sbroj struja koje ulaze u čvor je jednake
sbroju struja koje izlaze iz čvora



$$\sum I_n = 0$$

II. KIRCHHOFOV ZAKON \Rightarrow sbroj svih napona je 0



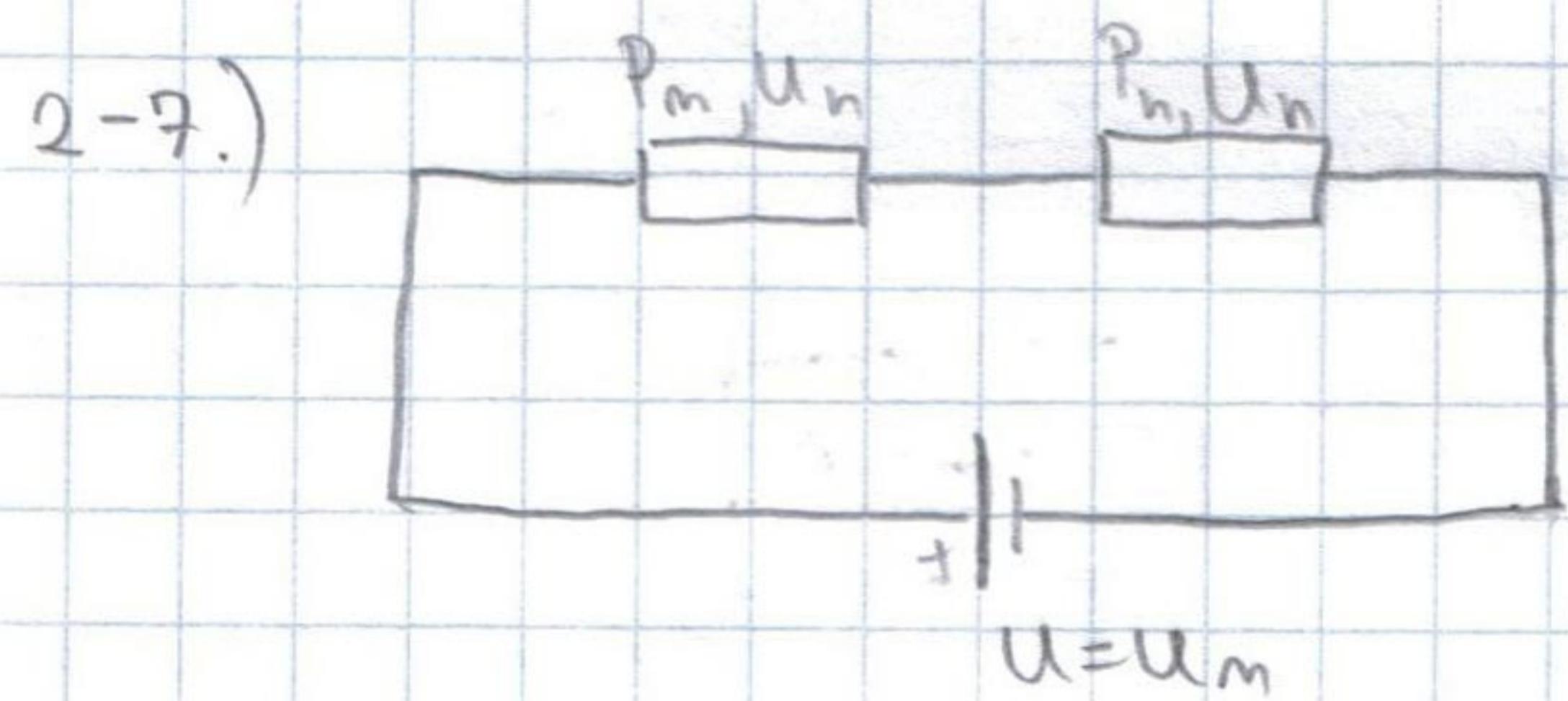
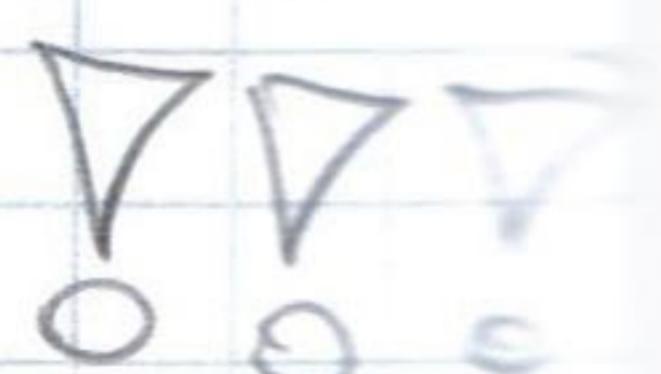


$$I_2 = \frac{9,6}{1000} = \dots$$

$$I_1 = I_2$$

$$R_1 = \frac{U_1}{I_2}$$

\Rightarrow
 ⇒ u serijski se čuva struja,
 u paralelnim mrežama!



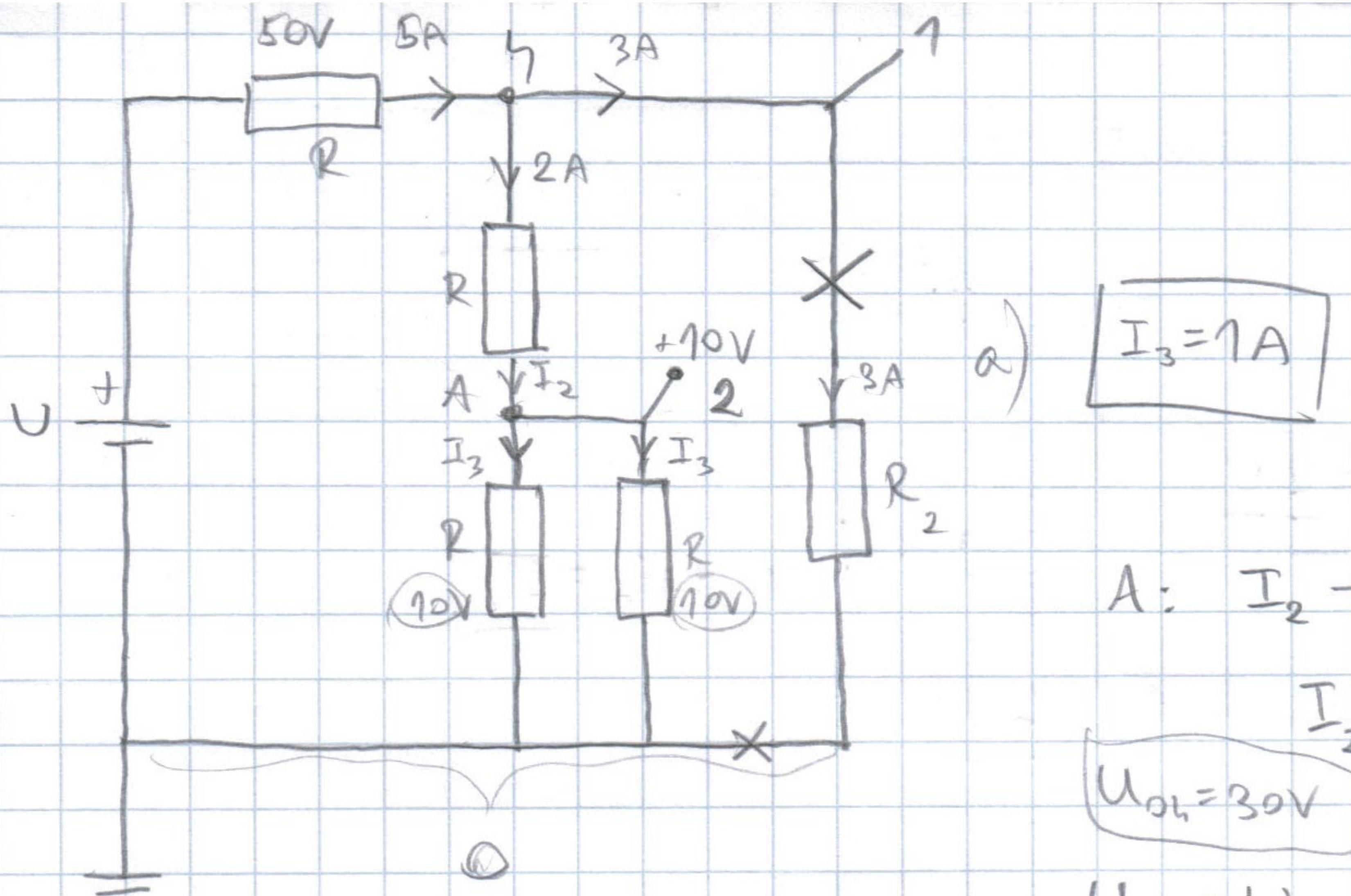
$$P = \frac{U^2}{R}$$

$$\frac{U_n}{2}$$

$$P_m = \frac{U_n^2}{R} = \left(\frac{U_n}{2}\right)^2 = \frac{U_m^2}{4R}$$

$$\frac{P_m}{4} + \frac{P_m}{4} = \frac{P_m}{2}$$

2-10.)



$$a) \boxed{I_3 = 1A}$$

$$A: I_2 - I_3 - I_3 = 0$$

$$I_2 = 2I_3 = 2A$$

$$U_{0L} = 30V$$

$$U_{0L} = U_{01}$$

$$\boxed{U_{01} = 30V}$$

$$\boxed{U_1 = +30V}$$

b)

$$\boxed{U = 80V}$$

$$\boxed{R_{\text{ex}} = 25\Omega}$$

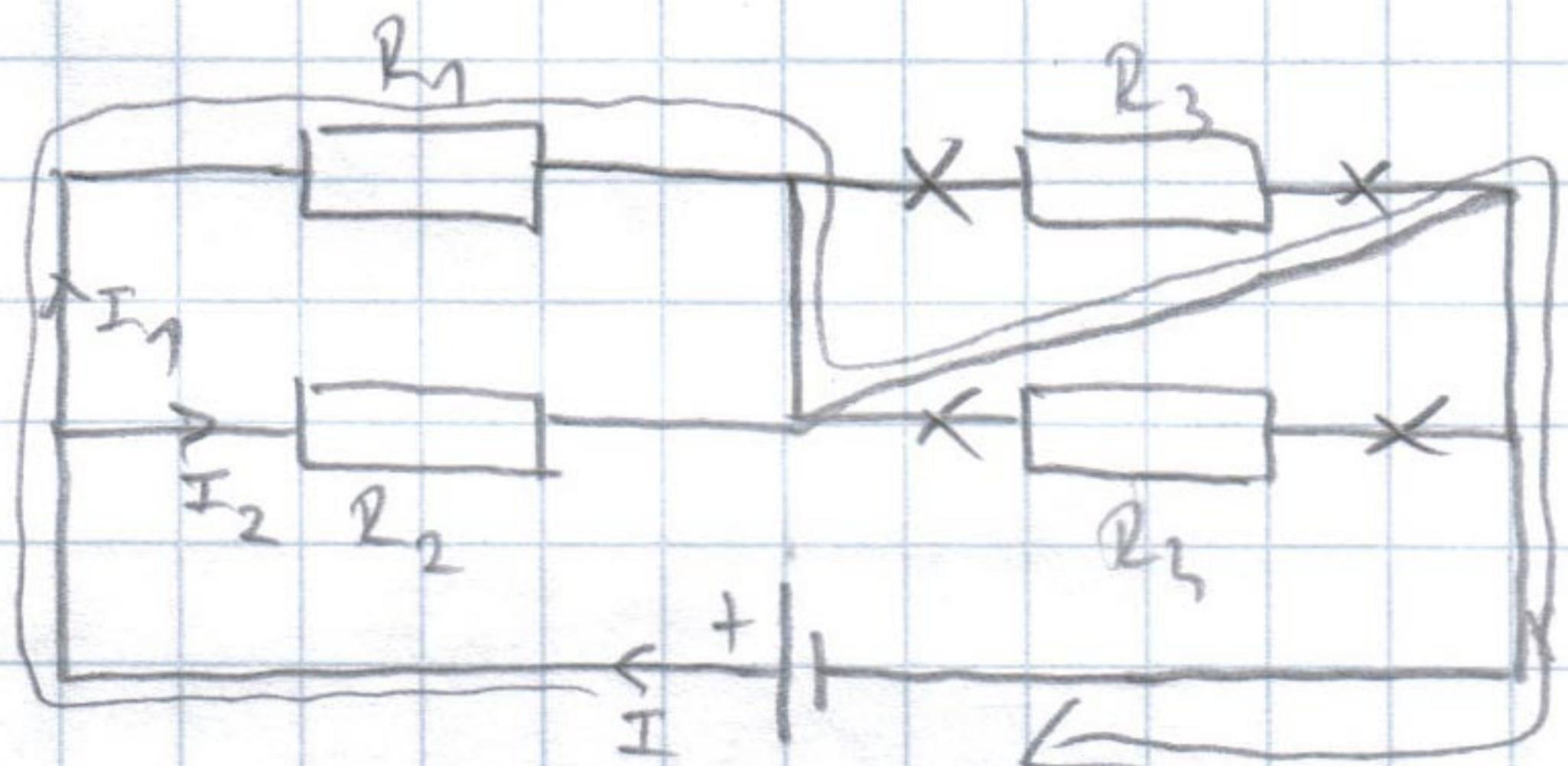
$$I = \frac{80}{25} = 3,2A$$

$$I_3 = \frac{I}{2} = 1,6A$$

$$U_{02} = 1,6A \cdot 10\Omega = 16V$$

$$\boxed{U_2 = 16V}$$

2-11.)



$$\begin{aligned} R_1 &= 6\Omega \\ R_2 &= 3\Omega \\ R_3 &= 8\Omega \\ R_4 &= 8\Omega \end{aligned}$$

$$I_1 = 1A$$

$$U_1 = I_1 \cdot R_1 = 6V$$

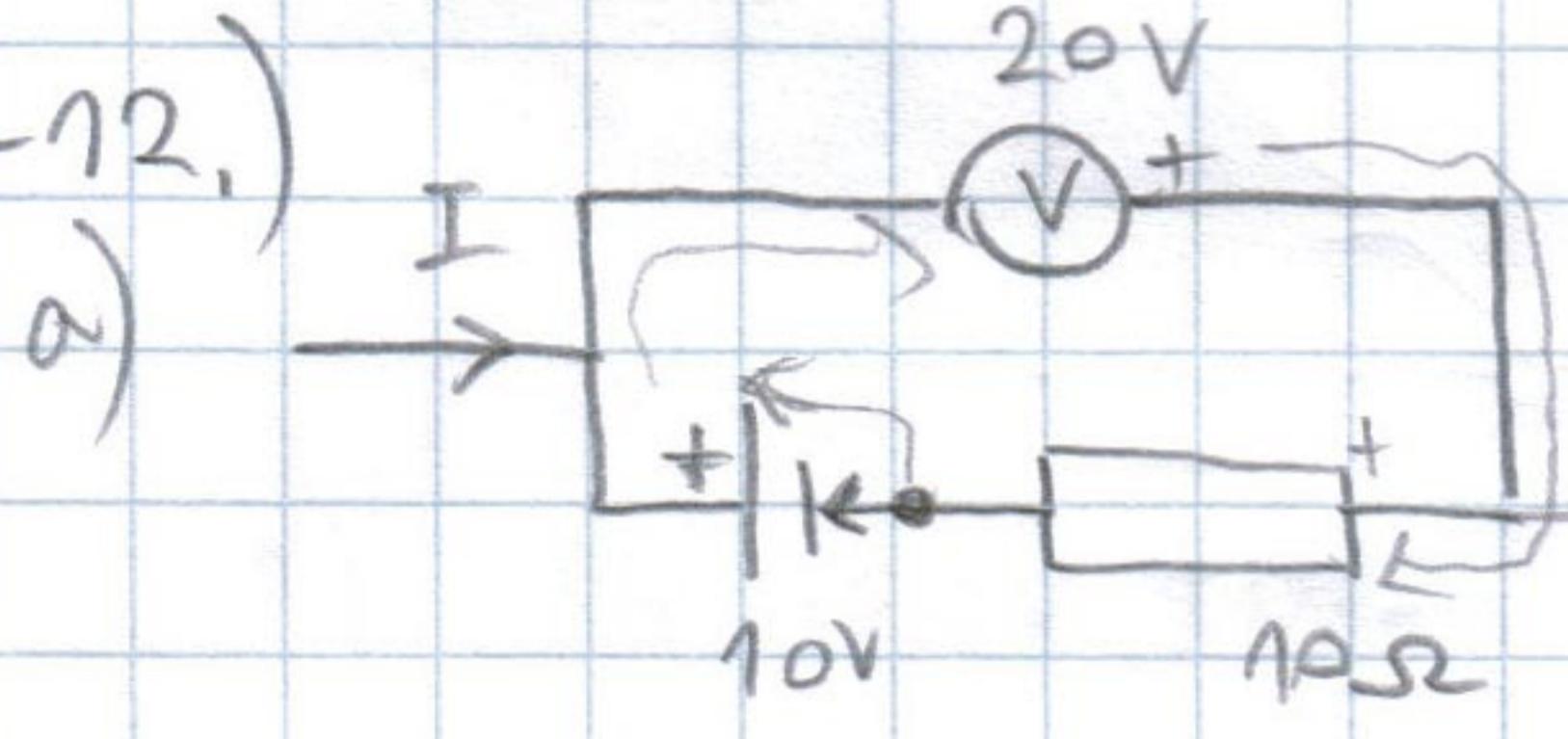
$$\boxed{U_1 = U_2}$$

$$U_2 = 6V$$

$$I_2 = \frac{6V}{3\Omega} = 2A$$

$$I = I_1 + I_2 = 3A$$

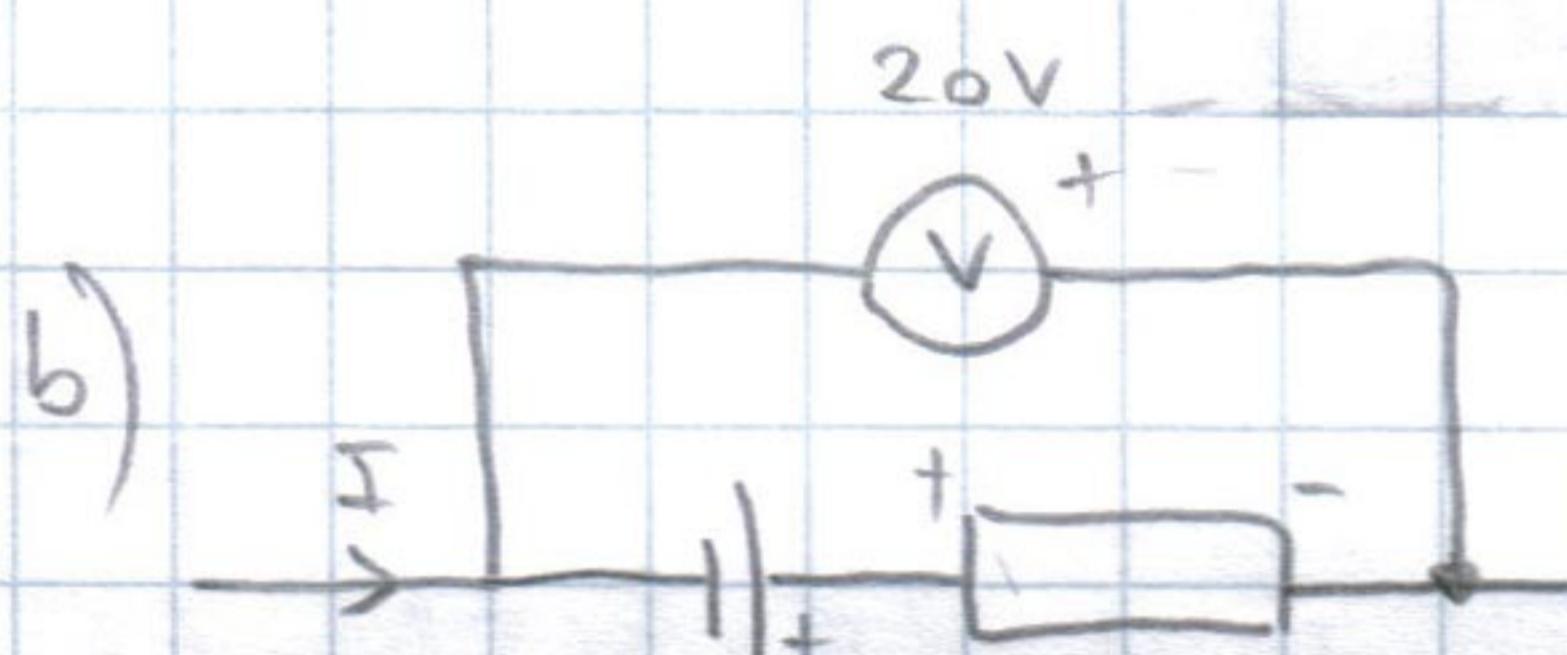
2-12.)



$$+10V + 20V + I \cdot 10\Omega = 0V$$

$$-10I = 30V$$

$$\boxed{I = -3A}$$



$$+10I - 10V + 20V = 0$$

$$10I = -10V$$

$$\boxed{I = -1A}$$

2-13)

$$I = k_1 \cdot U$$

$$U = k_2 \cdot I^2$$

$$k_1 = 1 \text{ A/V}$$

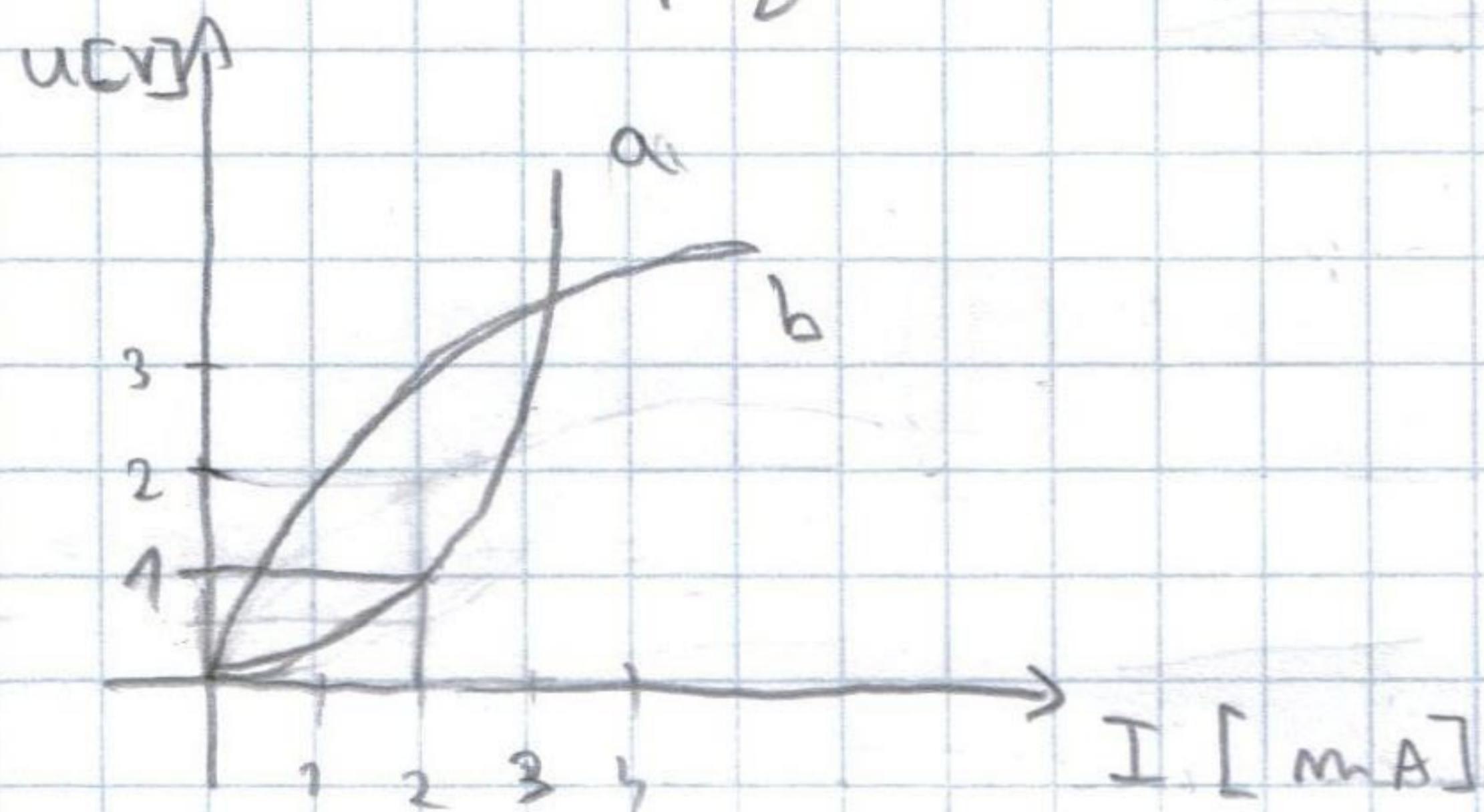
$$k_2 = 1 \text{ V/A}^2$$

$$U_1 = \frac{I}{k_1} = \frac{2\text{A}}{1\text{A/V}} = 2\text{V}$$

$$U_2 = k_2 \cdot I^2 = 1\text{ V/A}^2 \cdot 4\text{A}^2 = 4\text{V}$$

$$\left. \begin{array}{l} \\ \end{array} \right\} U_1 + U_2 = 6\text{V}$$

1. A i B spojeni u paralelu

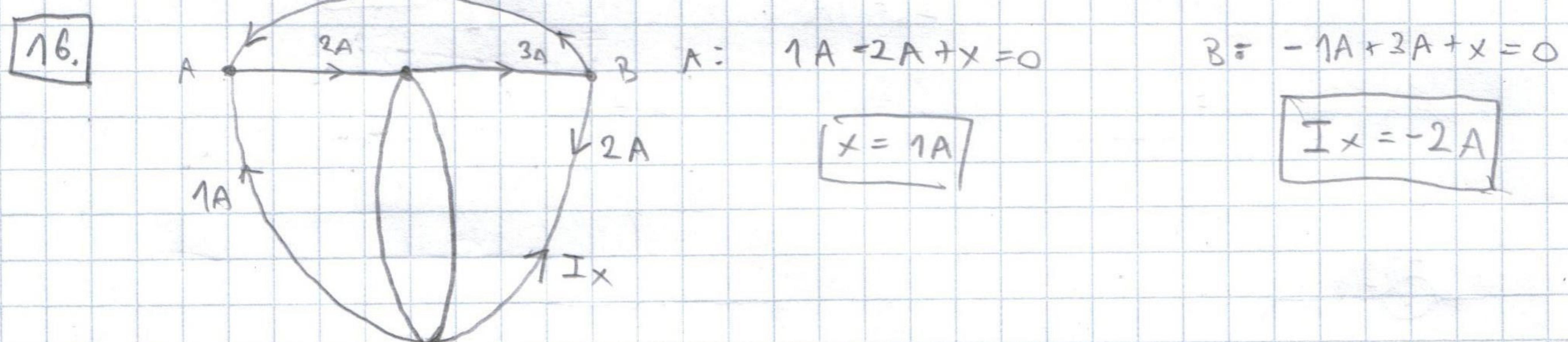


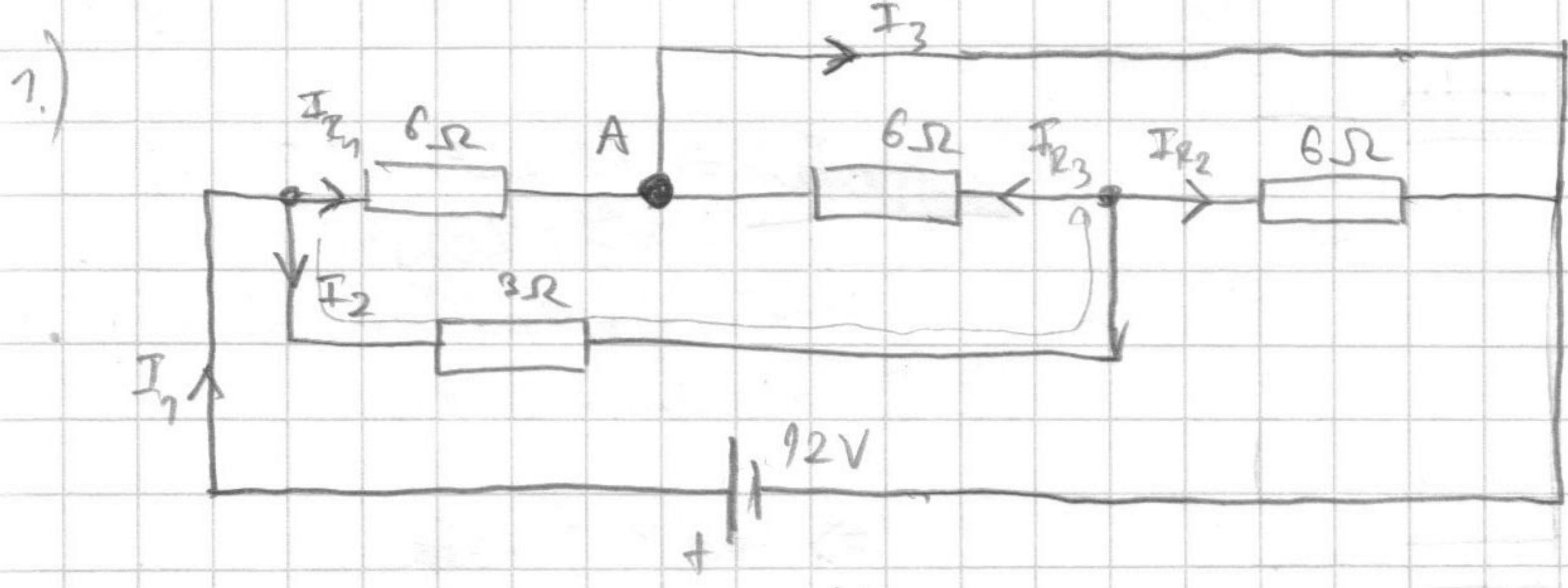
$$\Rightarrow \text{ako je } I_a = 2 \text{ mA}$$

kolika je vlastna struja?

$$I_a = 2 \text{ mA} \rightarrow U_a = 1 \text{ V}$$

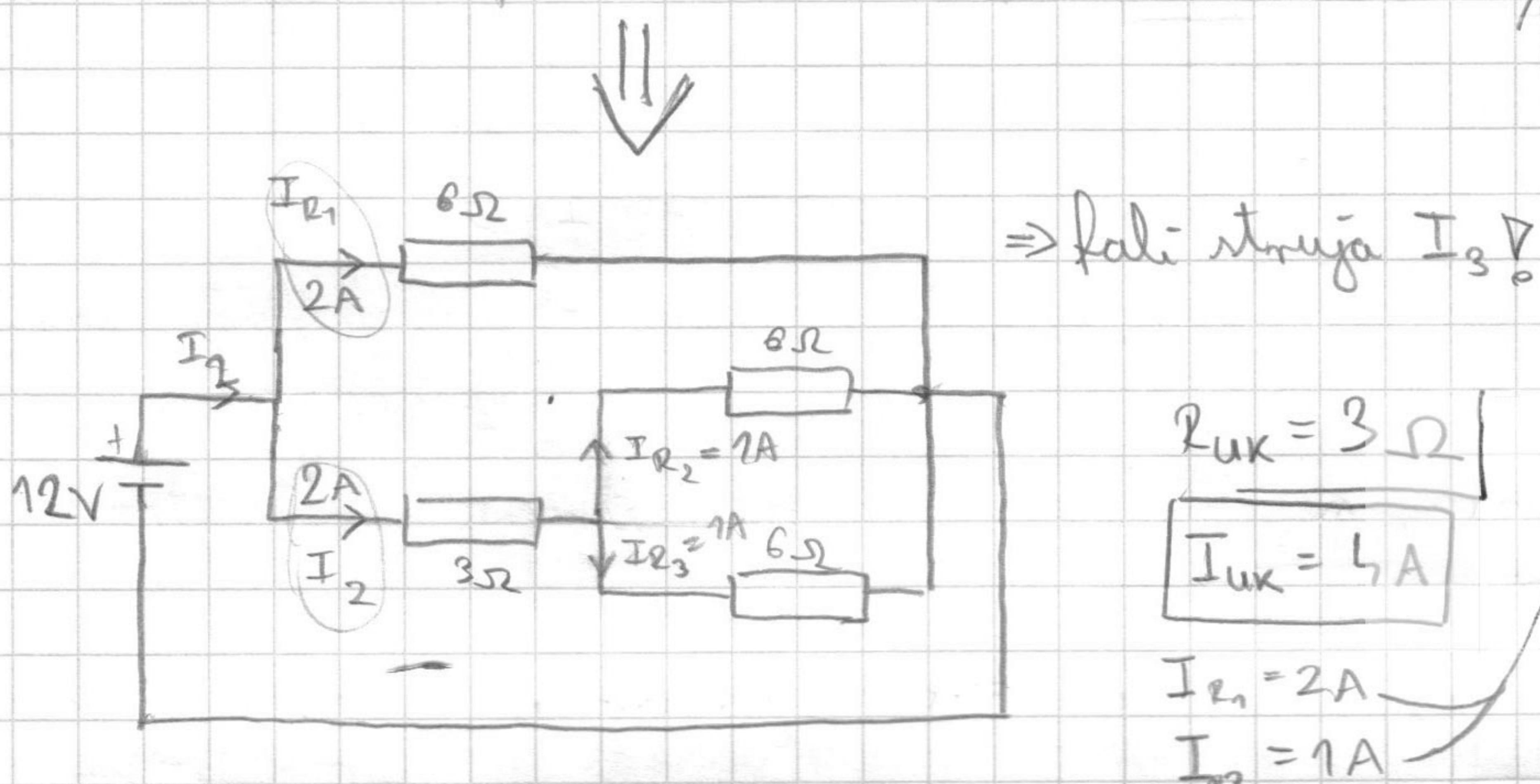
$$U_b = 1 \text{ V} \rightarrow I_b = 0,5 \text{ mA}$$





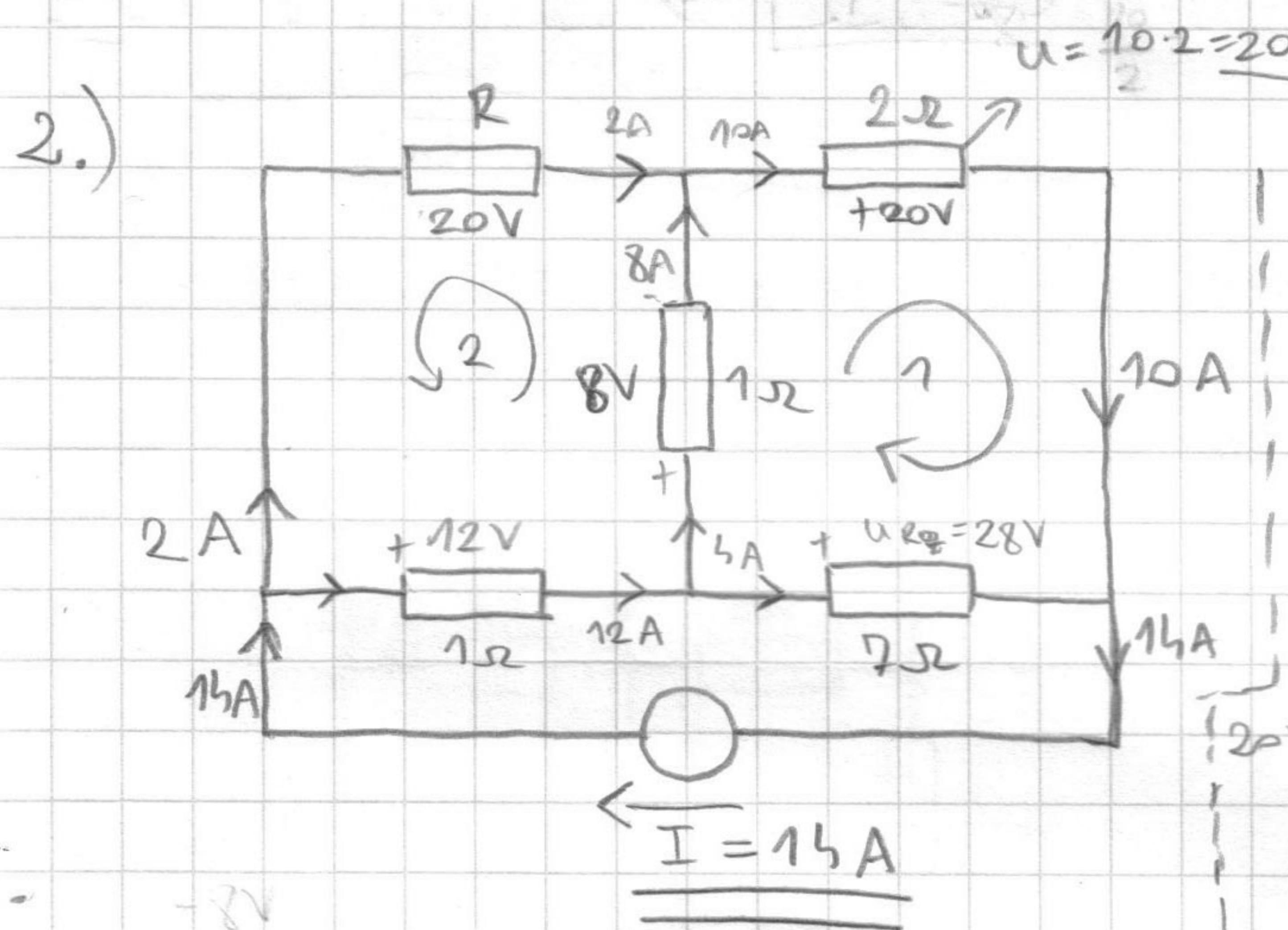
$$A: I_{R_1} + I_{R_2} = I_3$$

$$\begin{aligned} 2 + 1 &= I_3 \\ I_3 &= 3 \text{ A} \end{aligned}$$



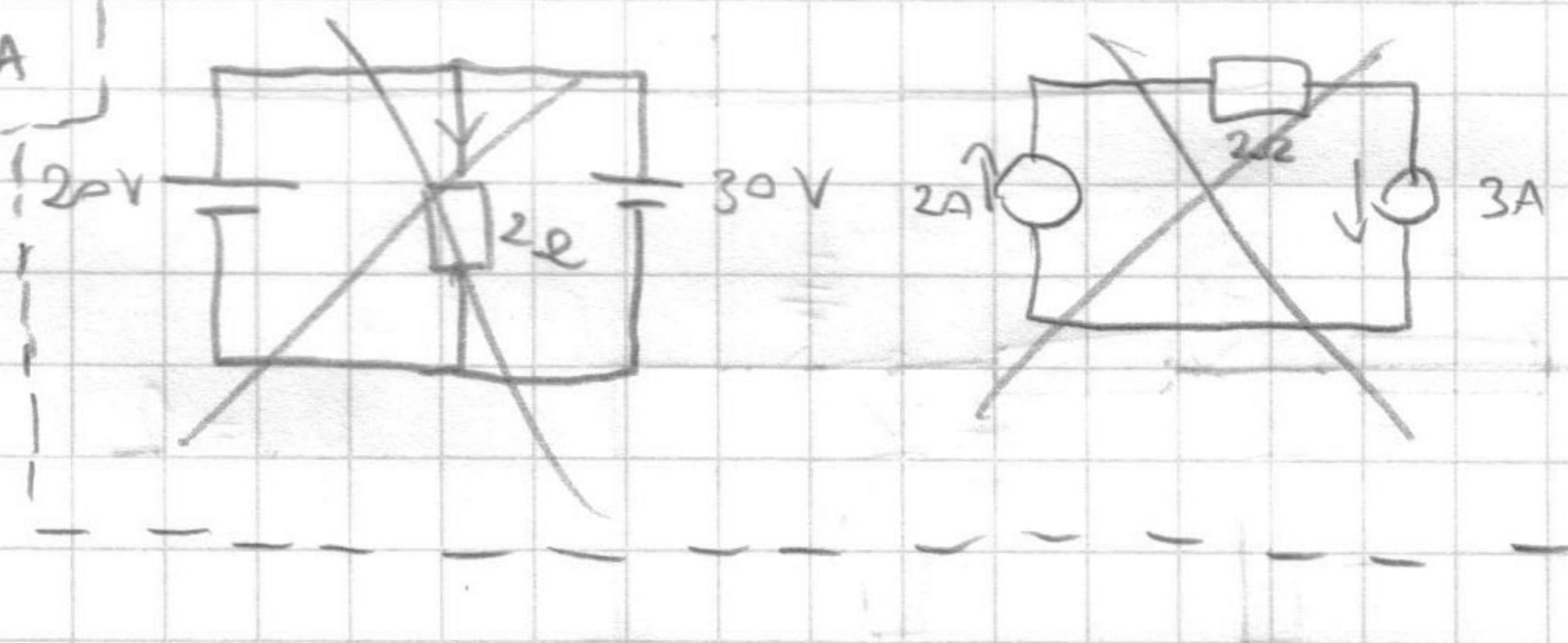
$$\begin{aligned} R_{uk} &= 3 \Omega \\ I_{uk} &= 4 \text{ A} \end{aligned}$$

$$\begin{aligned} I_{R_1} &= 2 \text{ A} \\ I_{R_3} &= 1 \text{ A} \end{aligned}$$



→ naponski inver \Rightarrow izmedu pribljučenica je samo njezin napon

→ strujni inver \Rightarrow u njegovoj grani može biti samo njegova struja



$$2A - 10A + x = 0$$

$$x = 8 \text{ A}$$

$$1) -8V - 20V + U_{R7} = 0$$

$$U_{R7} = 28V$$

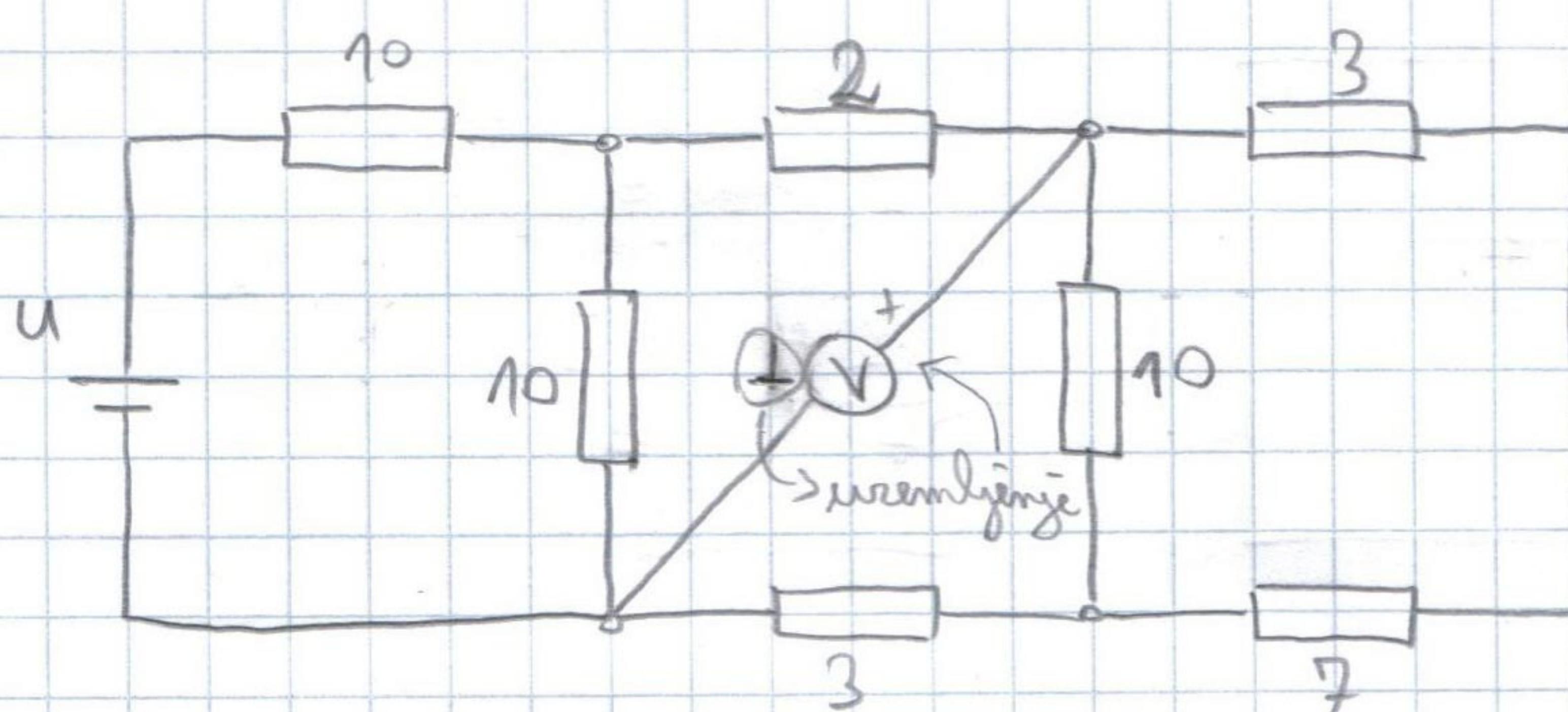
$$I_{R7} = 4 \text{ A}$$

$$2) -12V - 8V + U_R = 0$$

$$U_R = 20V$$

$$R = \frac{20V}{2A} = 10 \Omega$$

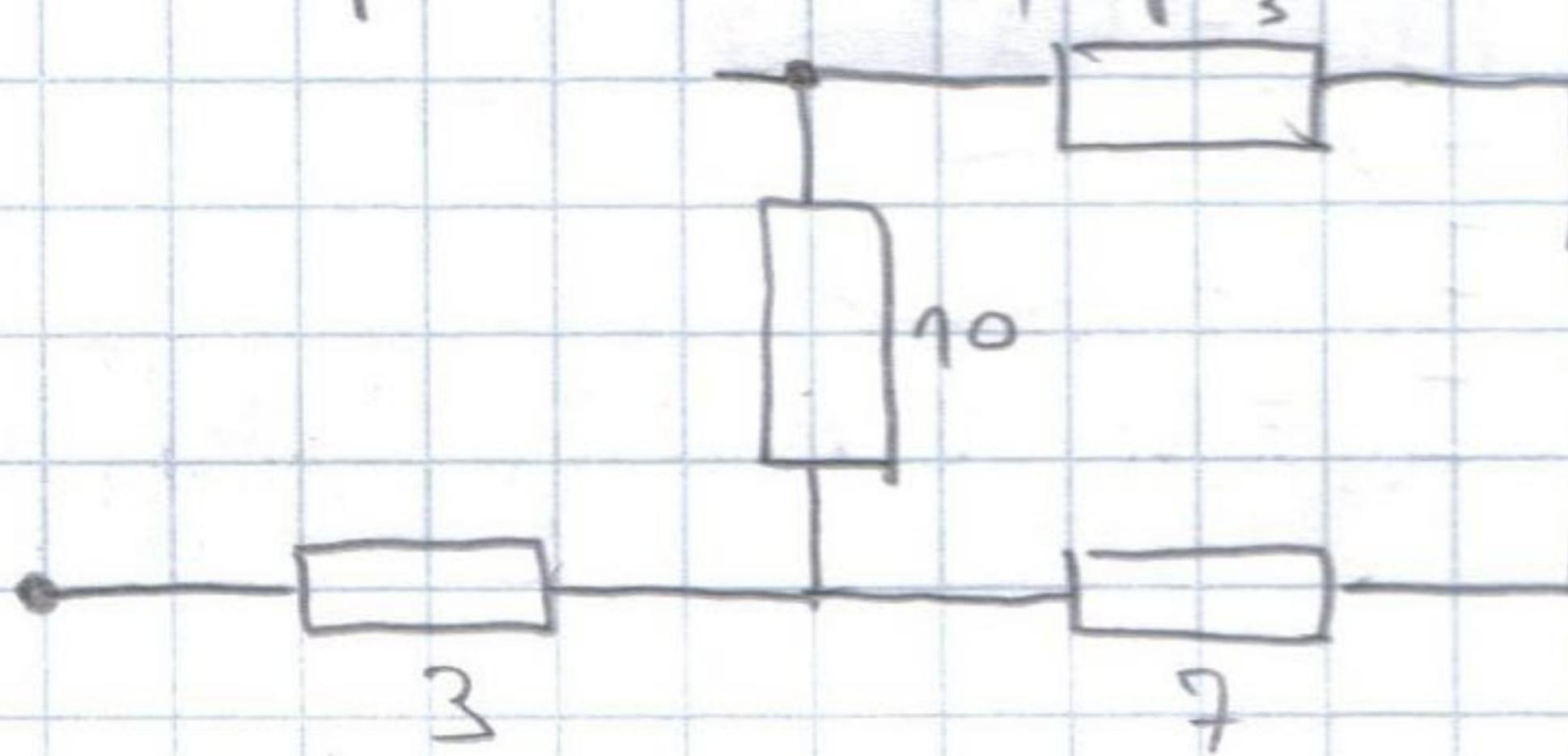
3.)

1. mācīm \Rightarrow KIRCHHOFF OVI

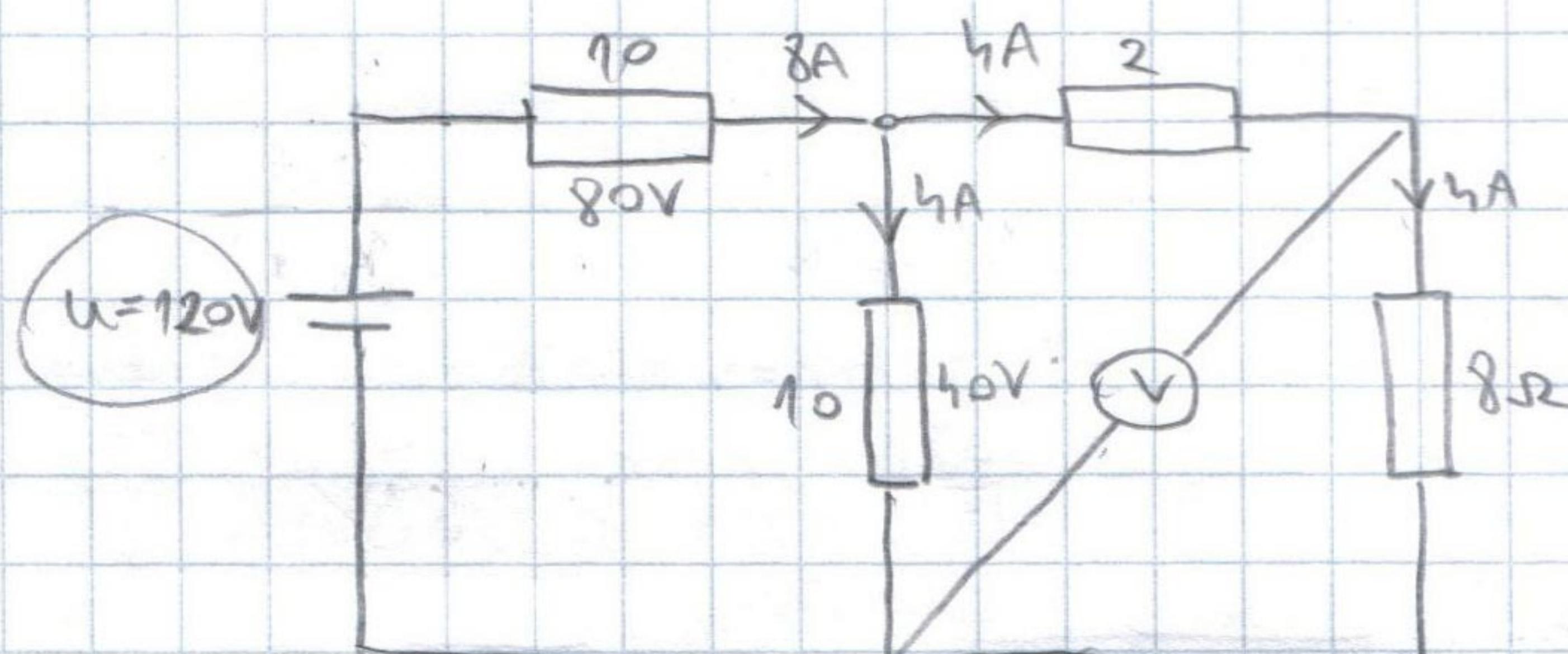
ZAKONI

→ vise jednadiobi s vise nepravimica

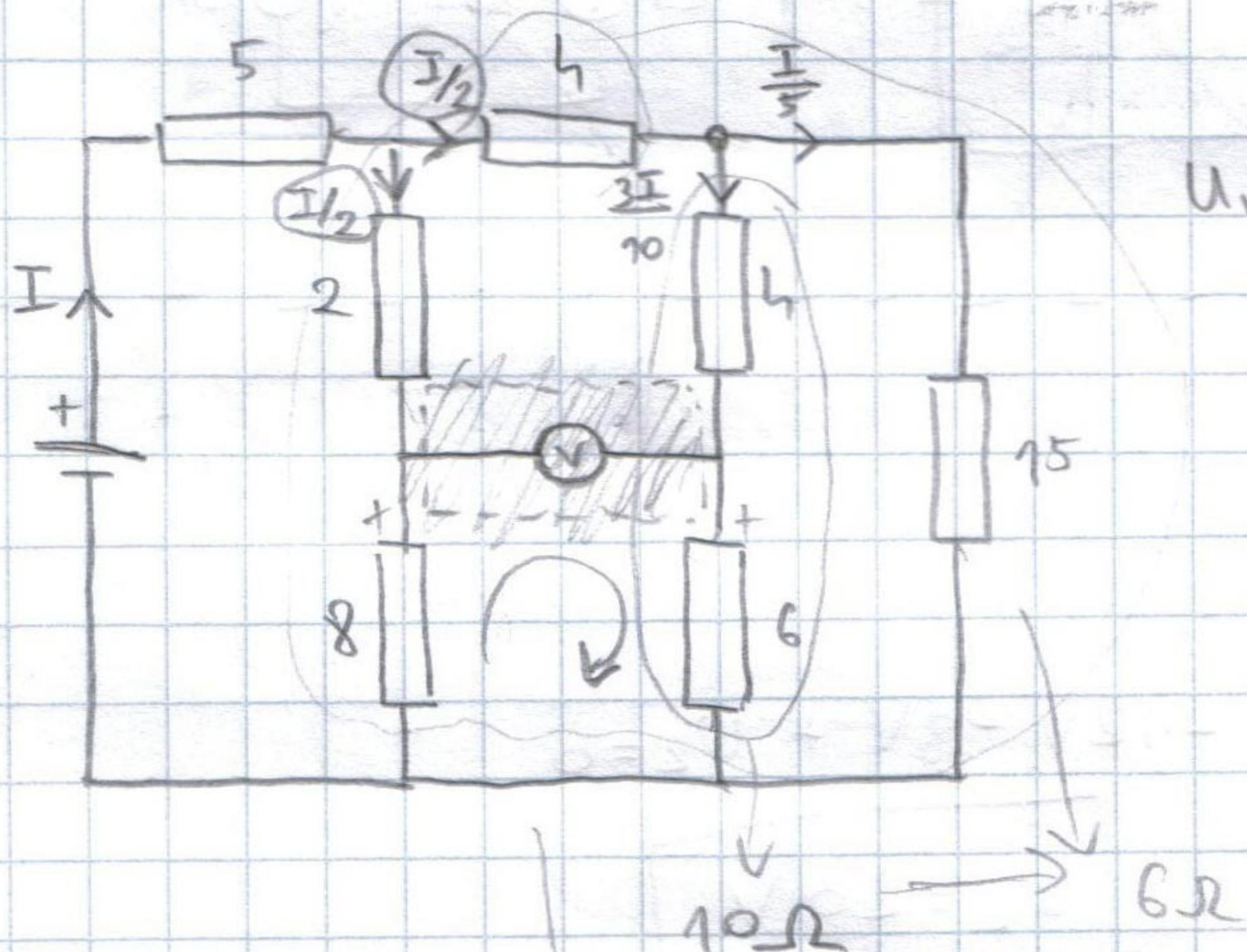
⇒ dugo traje

→ vremļējējā snaiči dī
īs gore +2. mācīm \Rightarrow nepravimois atpori divora, pa ideino \Rightarrow druge strone voltmetra⇒ namiņinimo \Rightarrow jednīm atpori

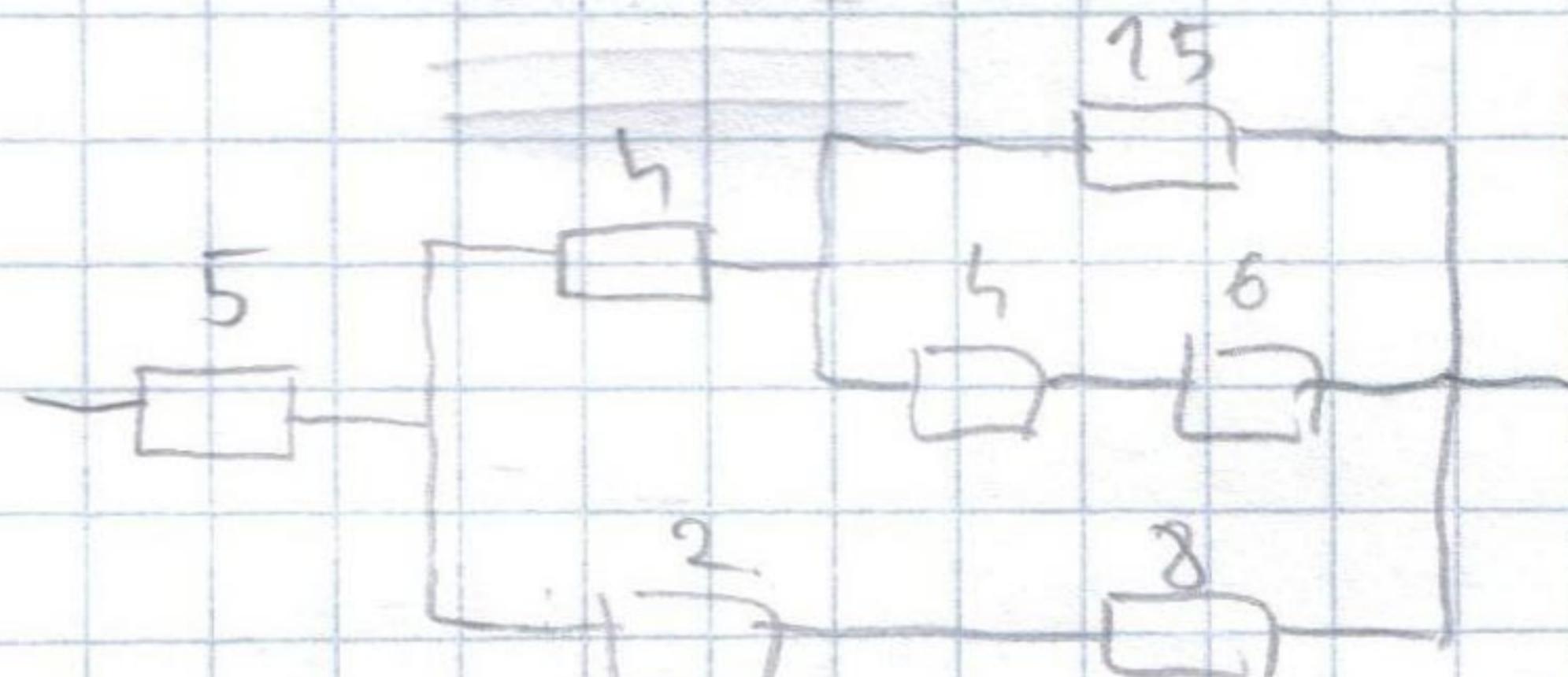
$$R_{VK} = 8 \Omega \Rightarrow$$



4.)



U_V = 2 V



R_{VK} = 10 \Omega

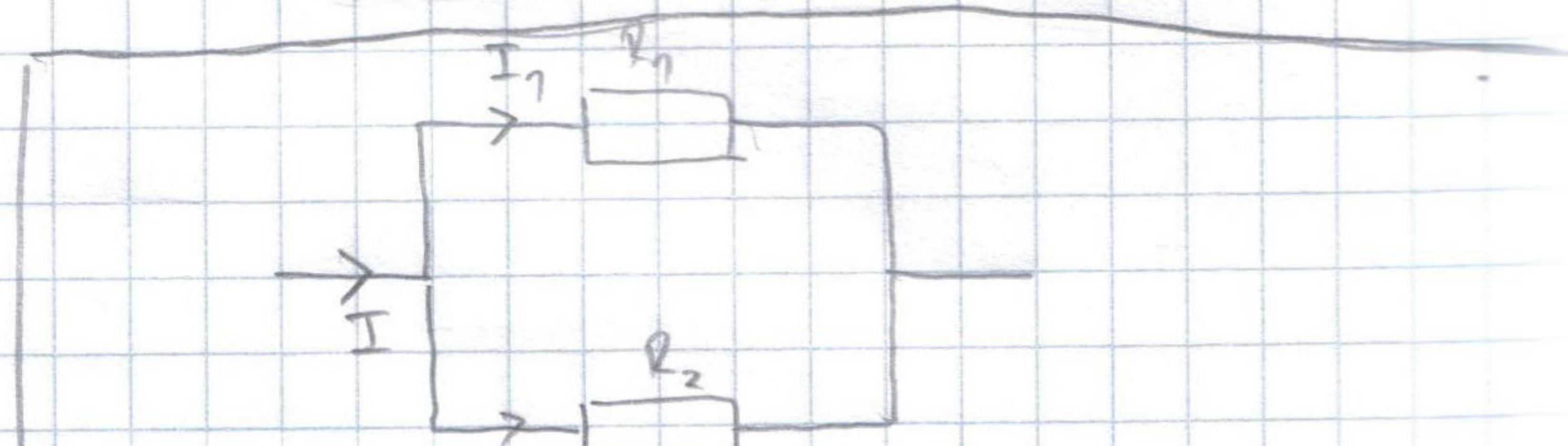
$$\frac{I}{2} = \frac{10}{25} I$$

$$\frac{I}{2} = \frac{25}{25} I$$

$$8 \frac{I}{2} + U_V - 6 \cdot \frac{3I}{25} = 0$$

$$U_V = 11.8I - 4I = 2.2I$$

$$I = \frac{2}{2.2} = 0.91 A$$



⇒ aks m 2 atporu stogo m paraleli i

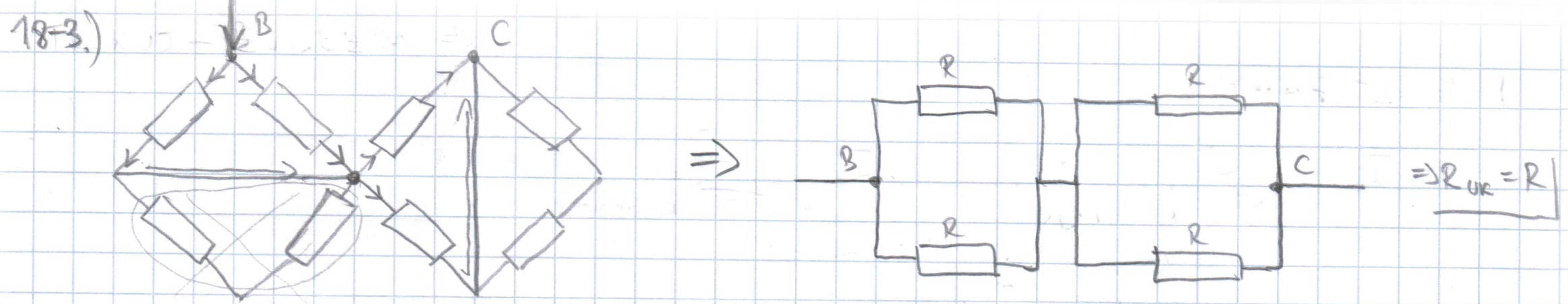
mano I_1, R_1, R_2 i traīmo npr. $I_1 =$

$$I_1 = I \cdot \frac{R_2}{R_1 + R_2} \rightarrow$$

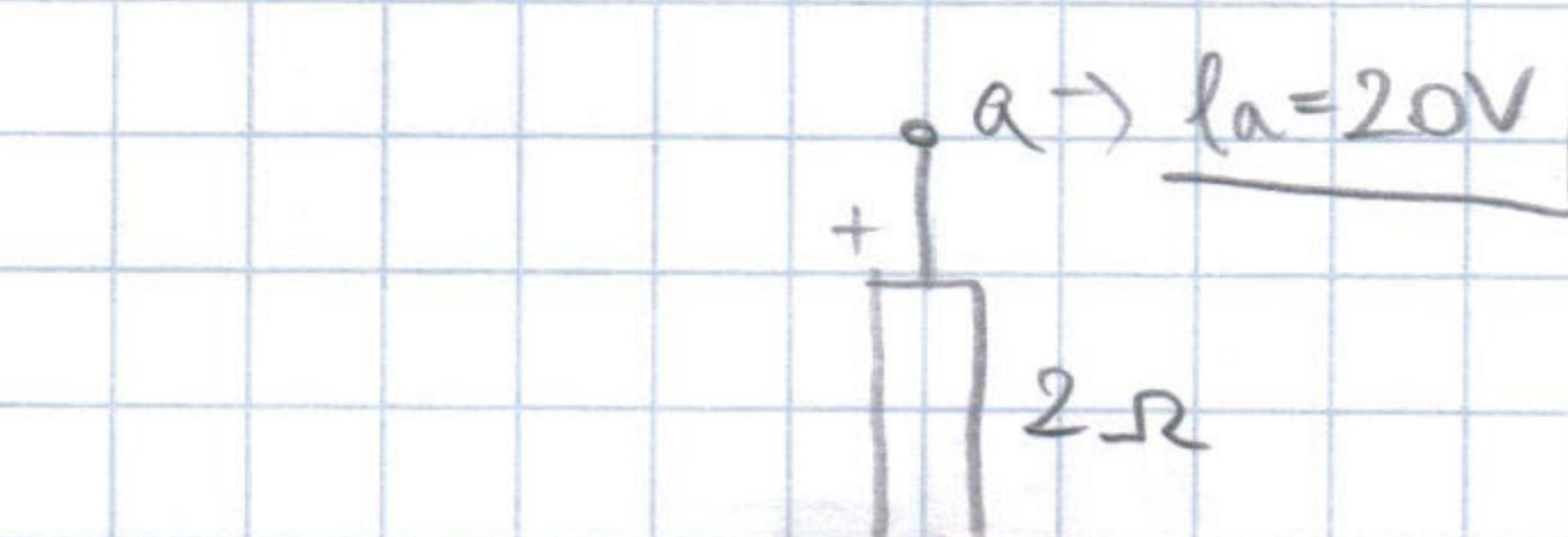
atpori kura kuri I_1 , ne
paraleli / atbilst atporu
pulta I

$$I_2 = I \cdot \frac{R_1}{R_1 + R_2}$$

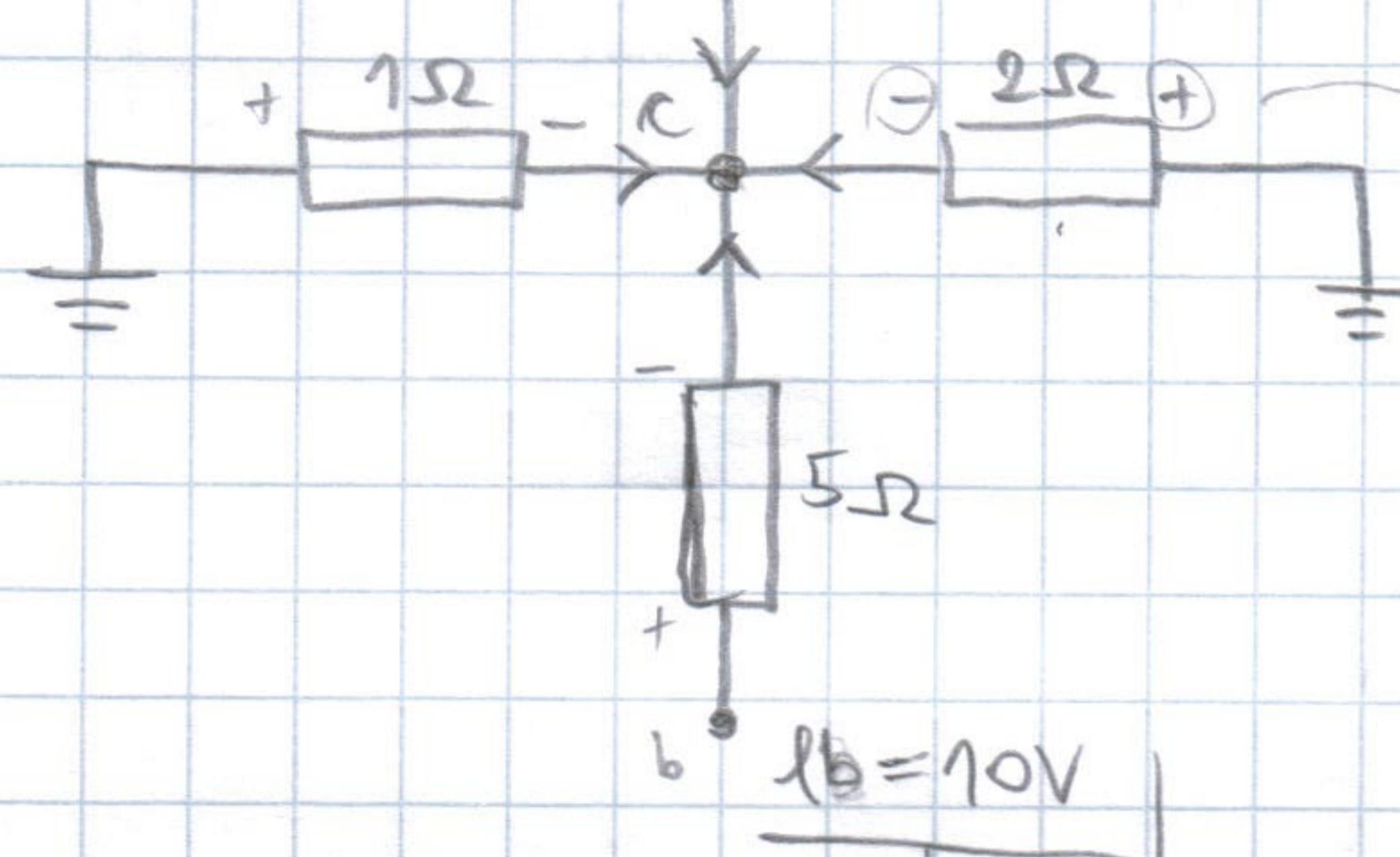
10



1.)



$$l_c = ?$$



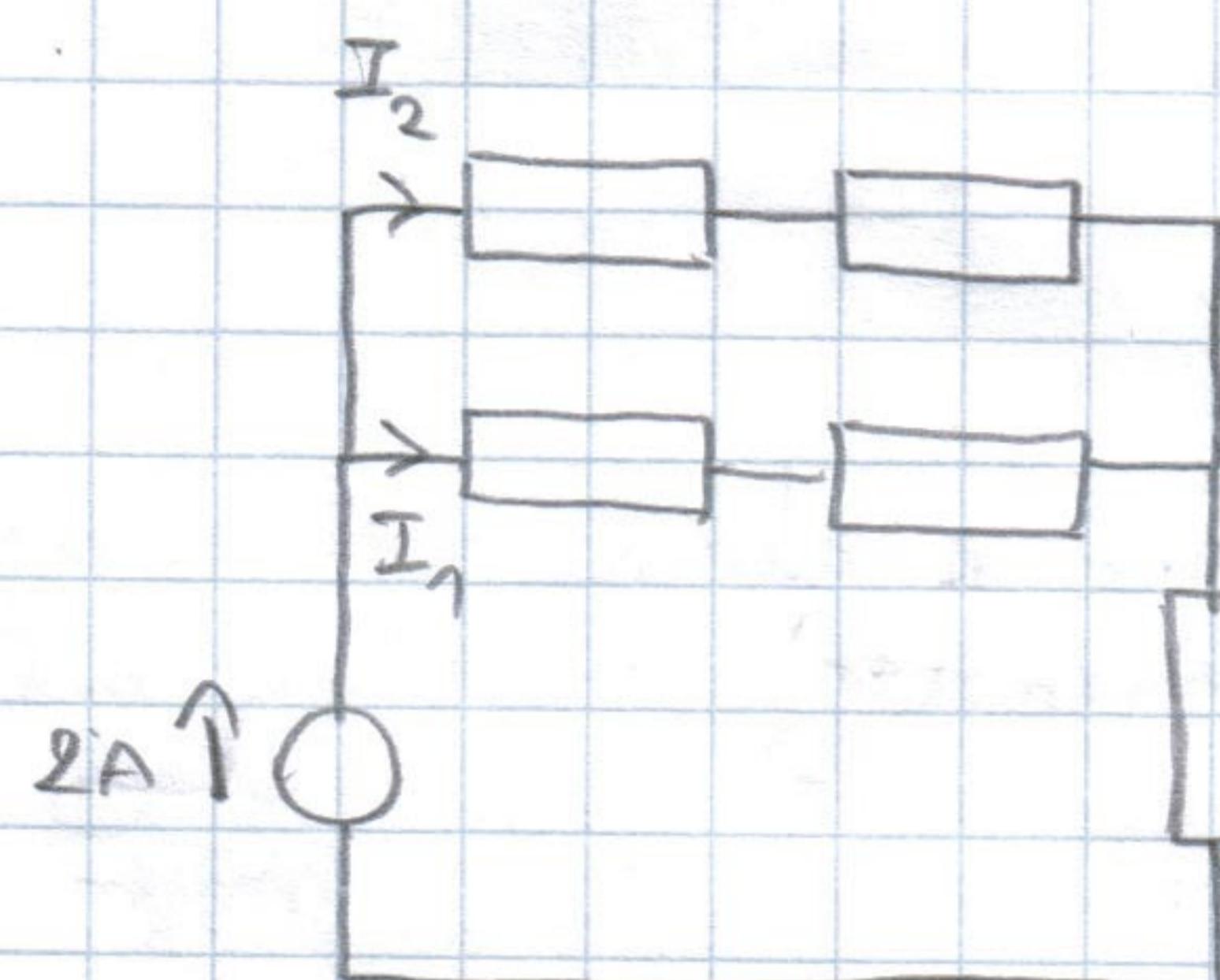
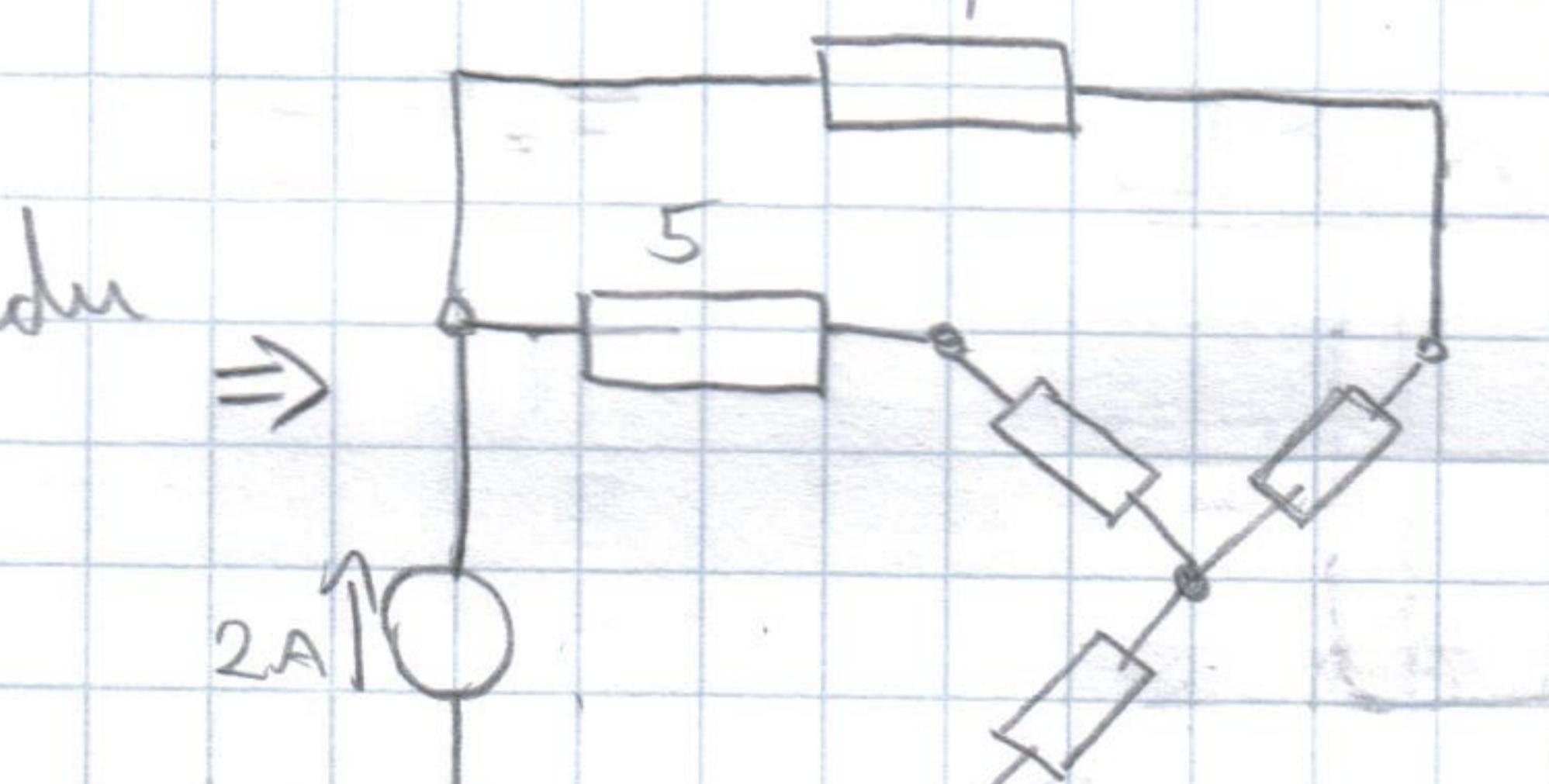
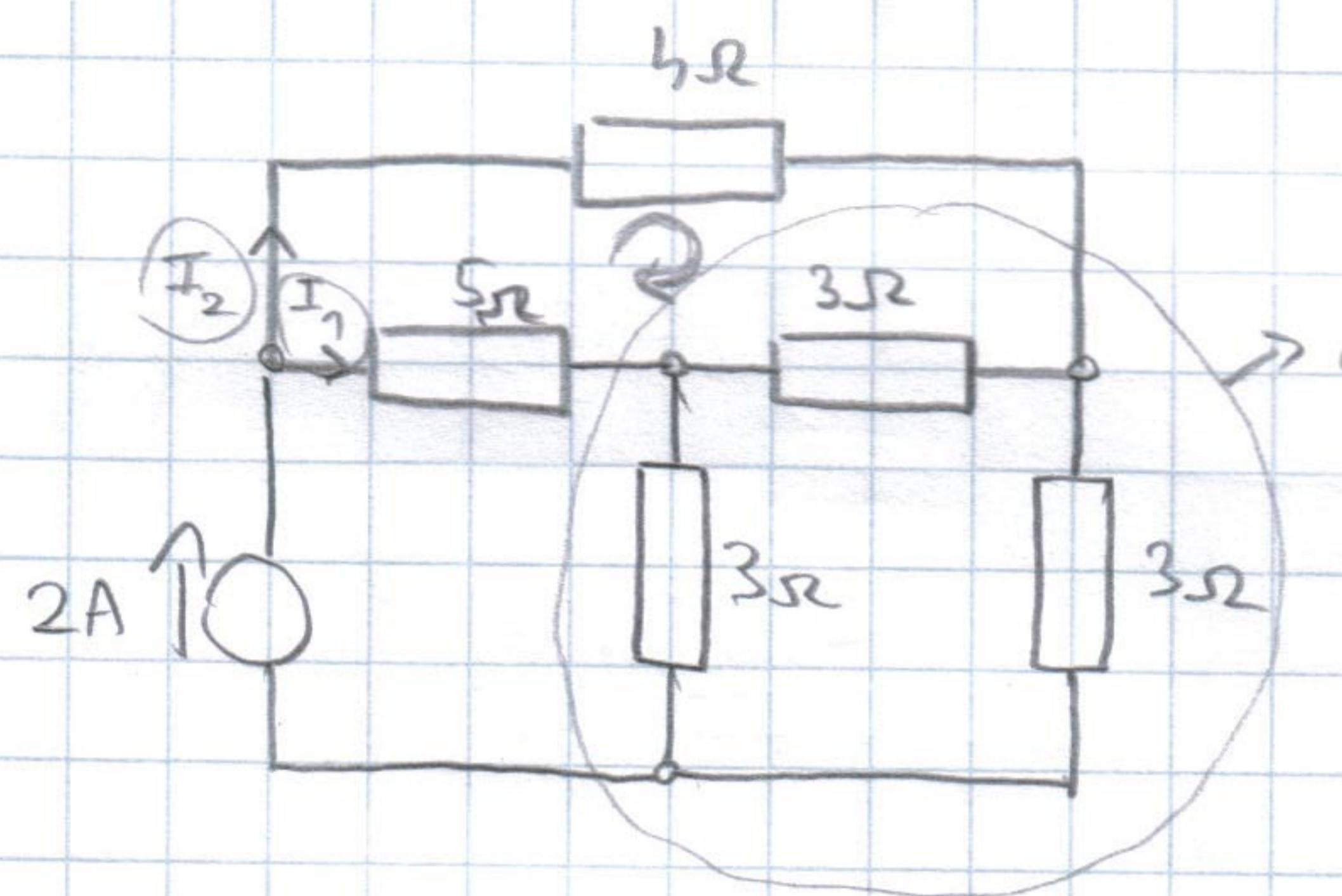
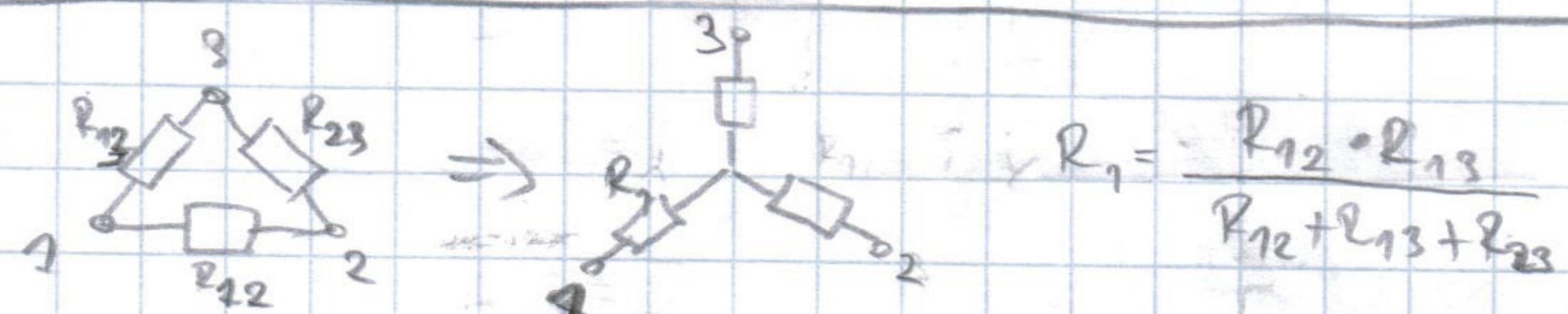
$$I_1 + I_2 + I_3 + I_4 = 0$$

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

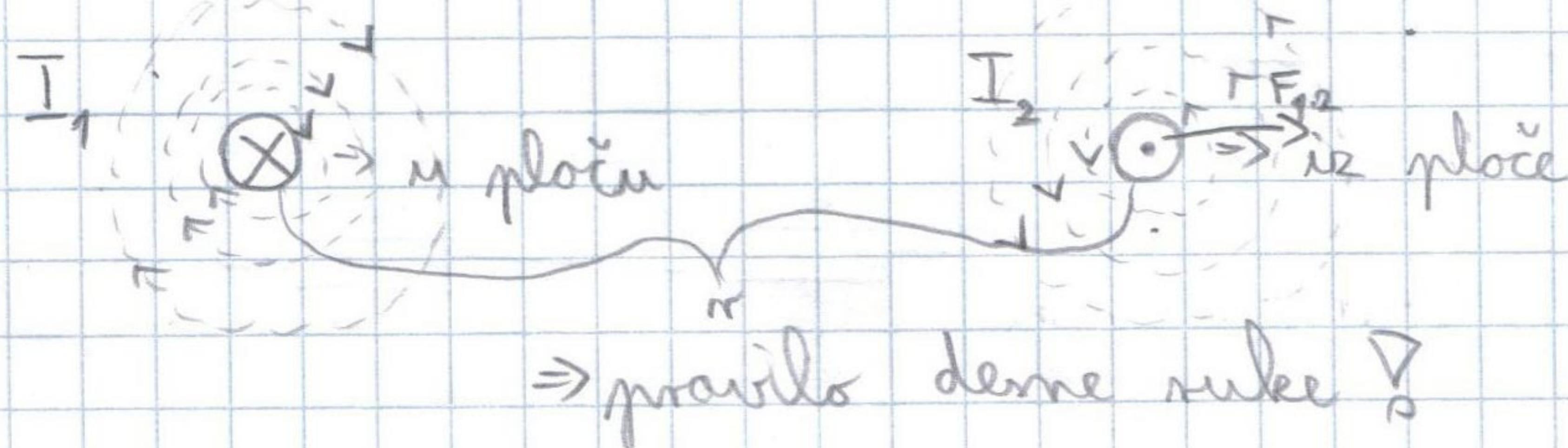
$$\frac{0-l_c}{2} + \frac{l_a-l_c}{2} + \frac{0-l_c}{1} + \frac{l_b-l_c}{5} = 0$$

$$-\frac{l_c}{2} + \frac{20-l_c}{2} - l_c + \frac{10-l_c}{5} = 0$$

TROJKUT - 2 VÍJEZDA \Rightarrow



MAGNETIZAM



$$B = \frac{I \cdot \mu_0}{2\pi \cdot r}$$

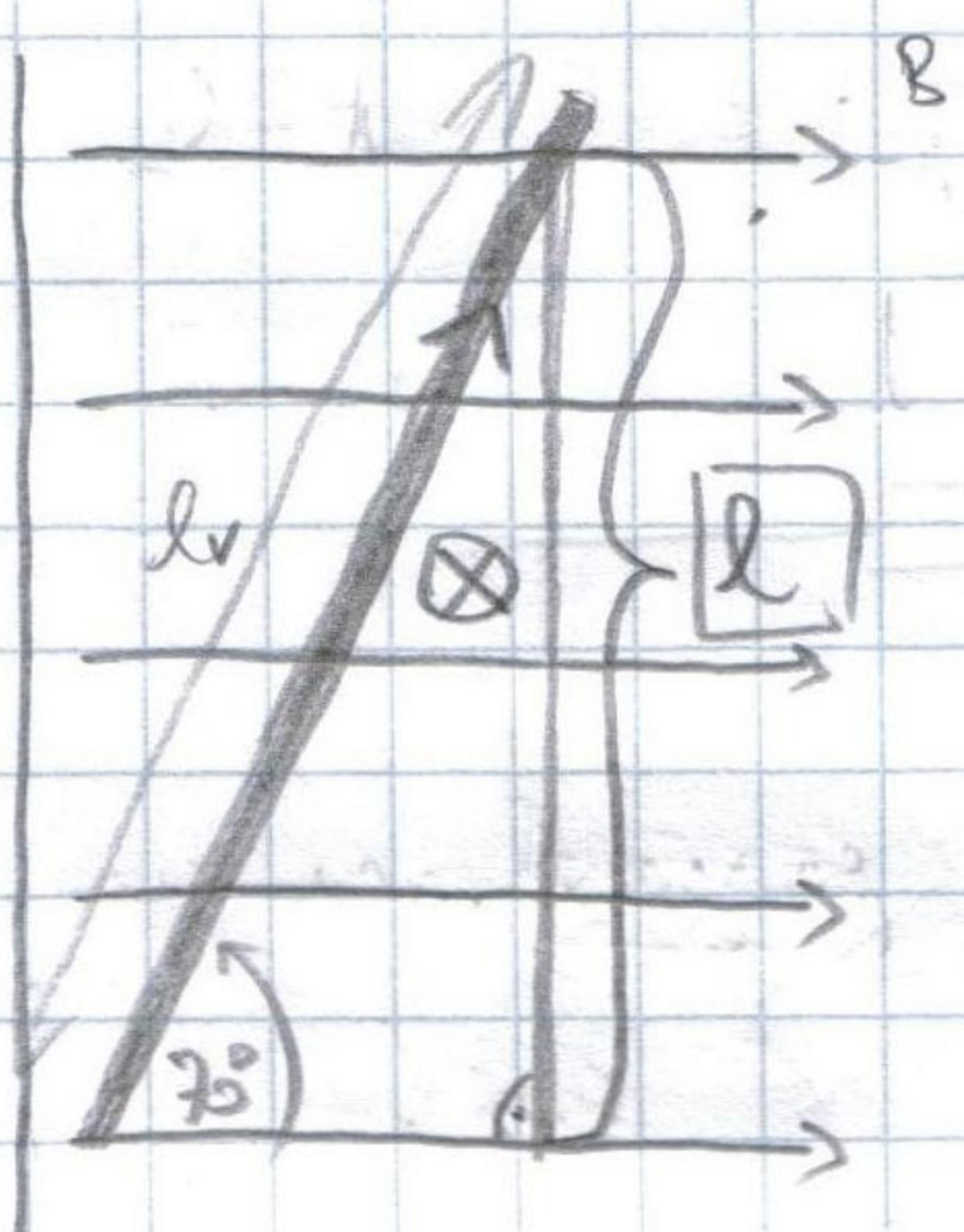
↳ magnetska indukcija

$$F_{12} = B \cdot I \cdot l$$

↳ magnetske silnice ulaze u dlan
struja teče u smjeru protiv
polac polarizuje mjer sile F !

\Rightarrow PRAVILA LIJEVE RUKE

1.)

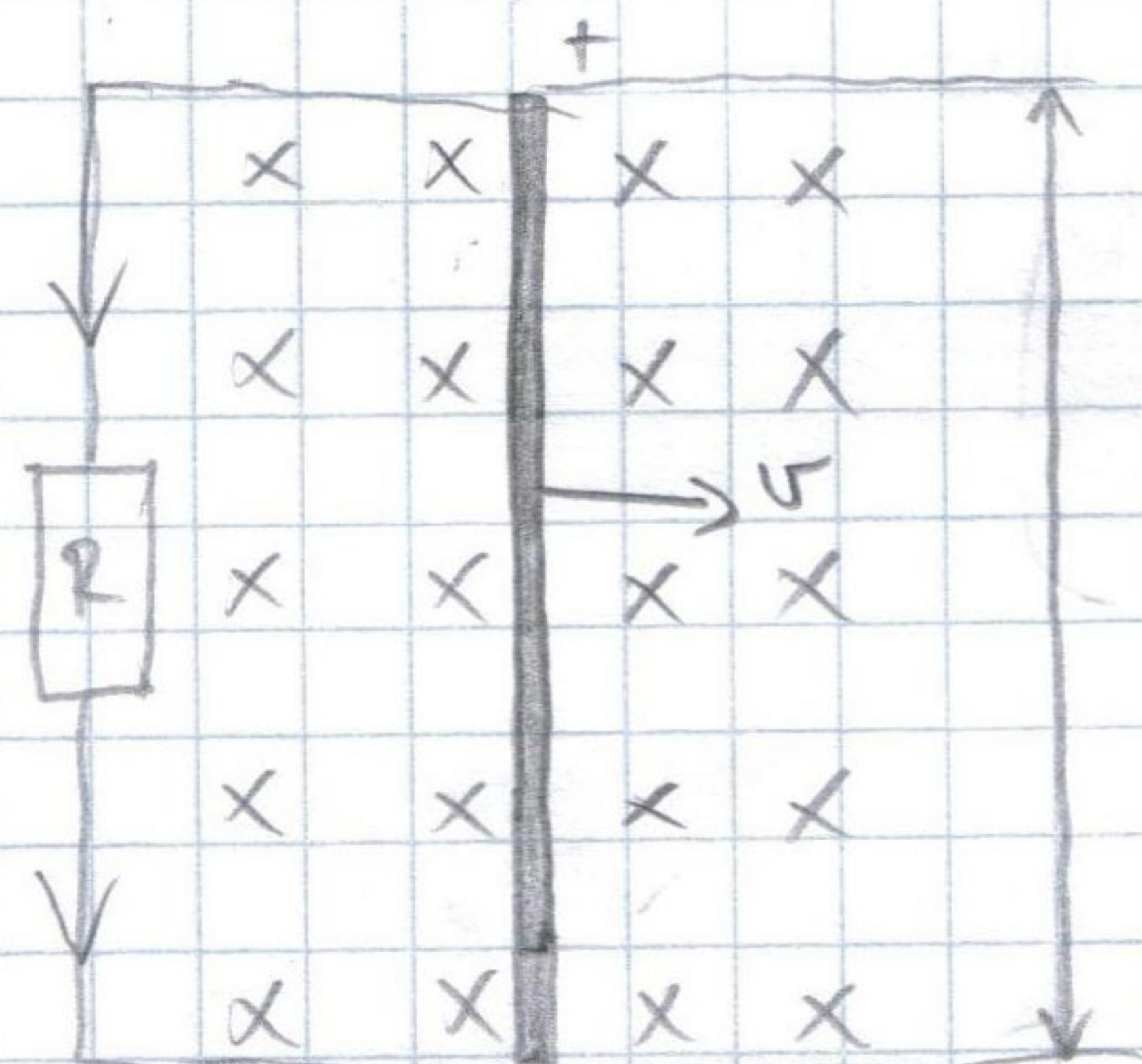


$$l_v = 1 \text{ m}$$

$$I = 2 \text{ A}$$

$$F = B \cdot I \cdot l_v \cdot \sin(70^\circ)$$

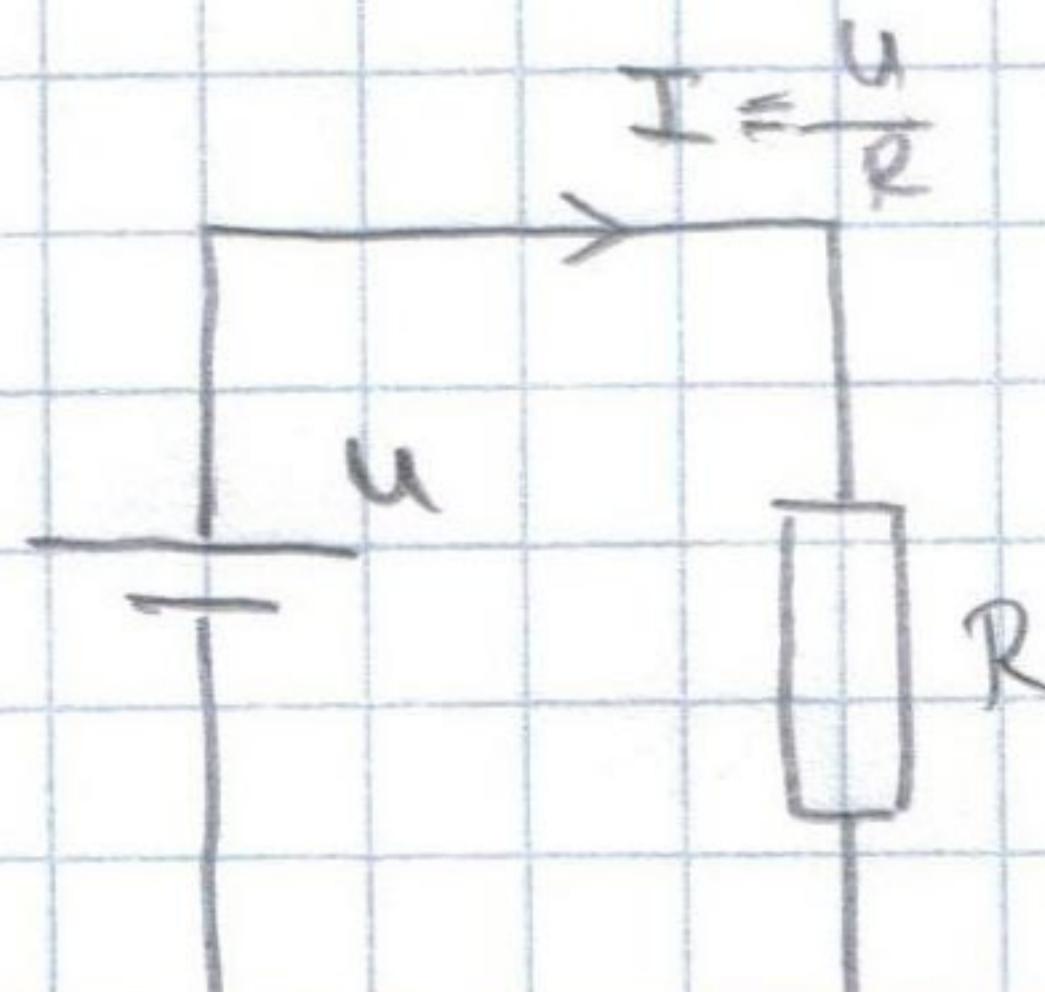
\rightarrow MAGNETSKA INDUKCIJA



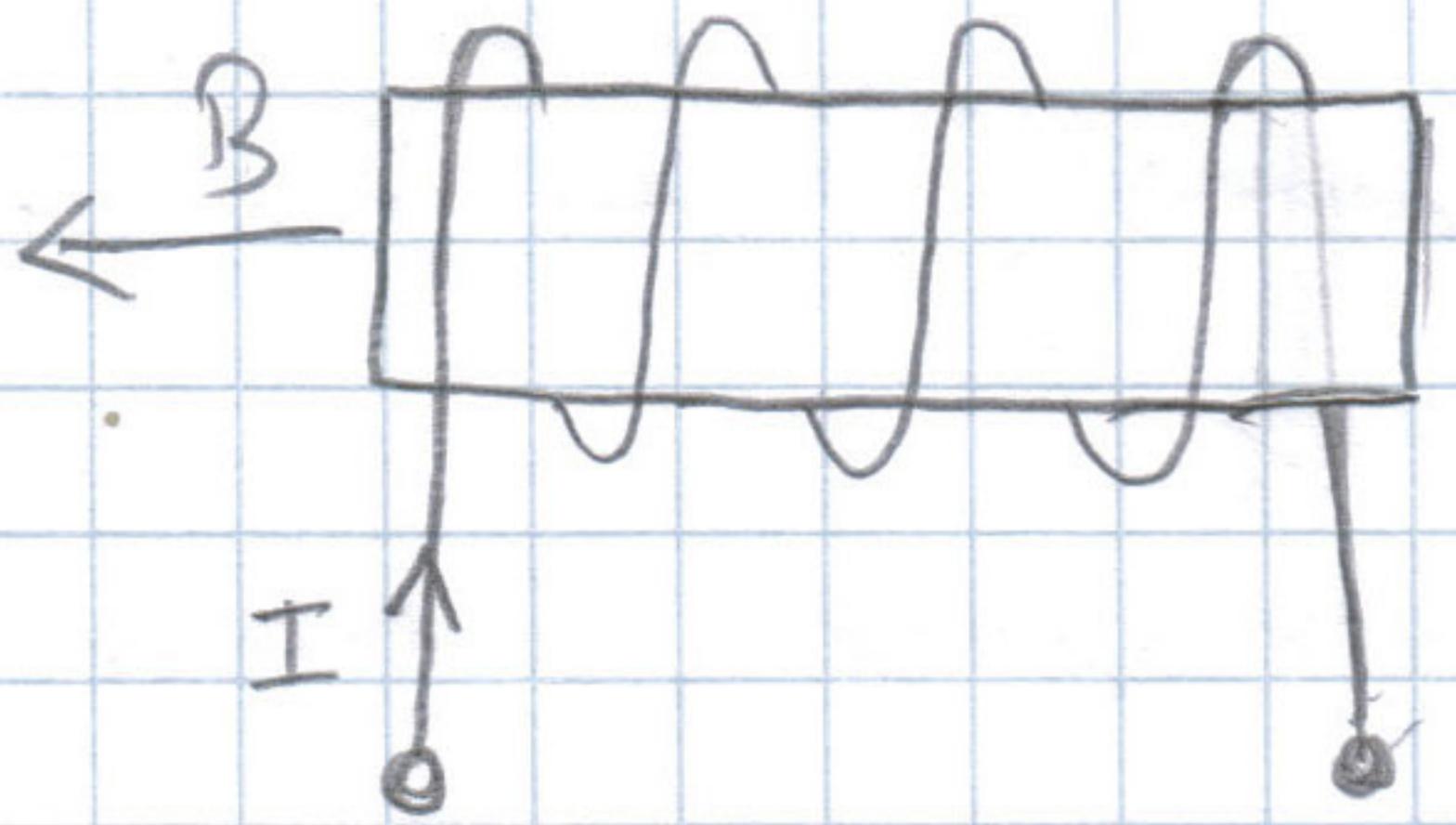
$$u = B \cdot l \cdot v$$

\rightarrow pravilo lijeve ruke \Rightarrow silnice u dlan, mjer gibanja (v), a polac inducirane napona (+) mijer

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



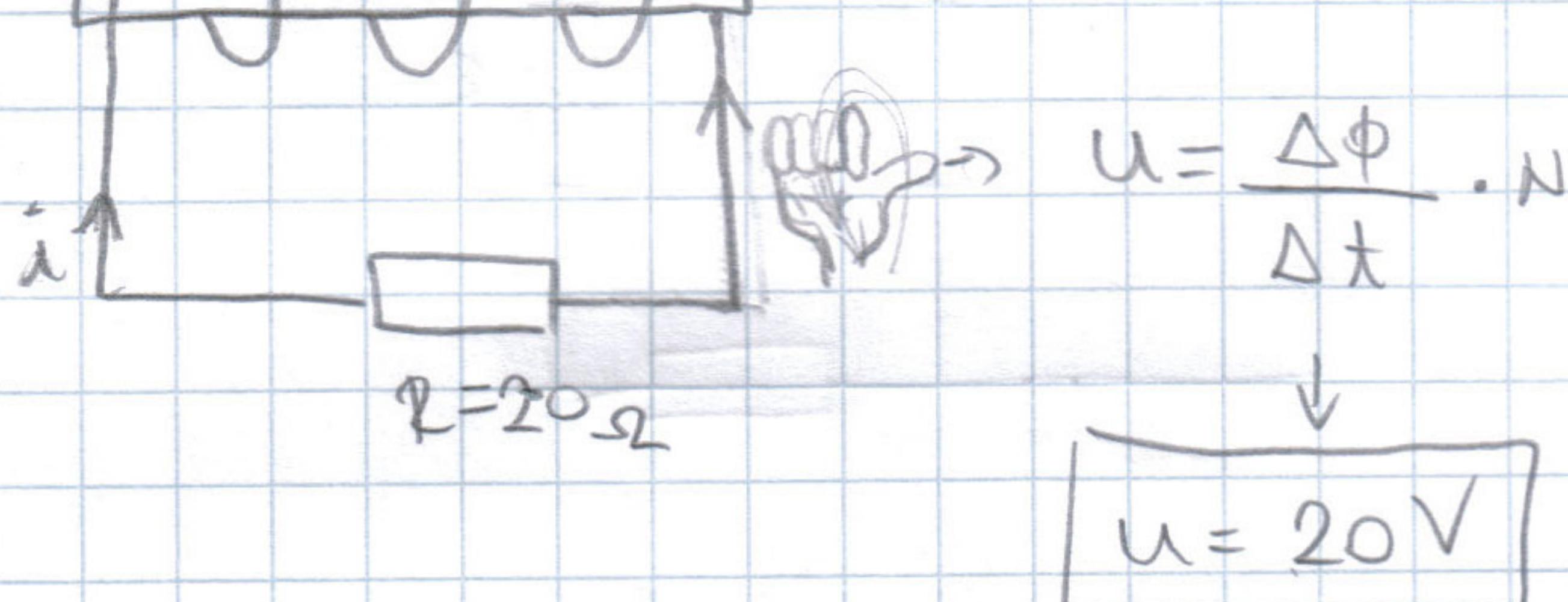
2.) \Rightarrow pravilo derme ruke ?



$$\Phi = B \cdot S$$

\hookrightarrow magnetski tok

tok navojnice (Φ_2) kojim pomaže polje da ostane u istom mjestu i u istog smjera
 $\Phi = 10 \text{ mWb}$ $\Delta t = 5 \text{ ms} \Rightarrow$ u nekome trenutku



$$U = \frac{\Delta \Phi}{\Delta t} \cdot N$$

$$\downarrow$$

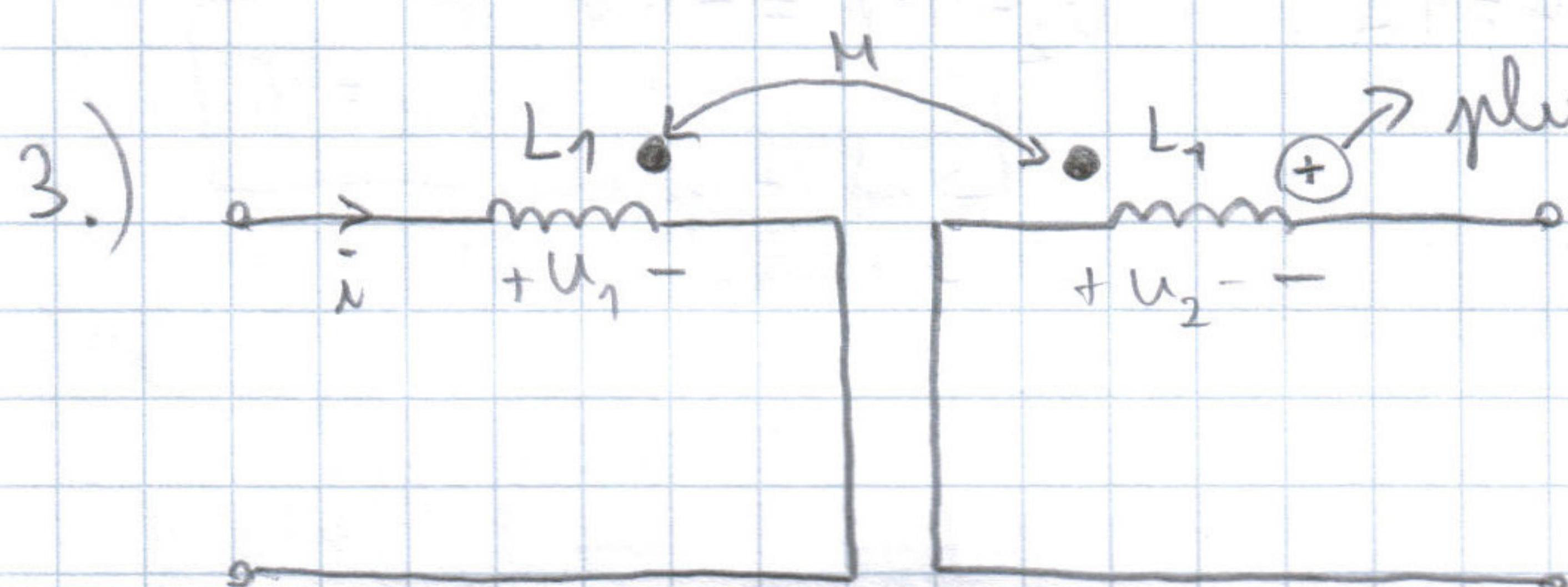
$$U = 20 \text{ V}$$

$$N = 10 \text{ navoja}$$

Φ pada na 0

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

\rightarrow navojnica se trudi da tole bude u istom mjestu



\rightarrow plus na suprotnom mjestu od točke

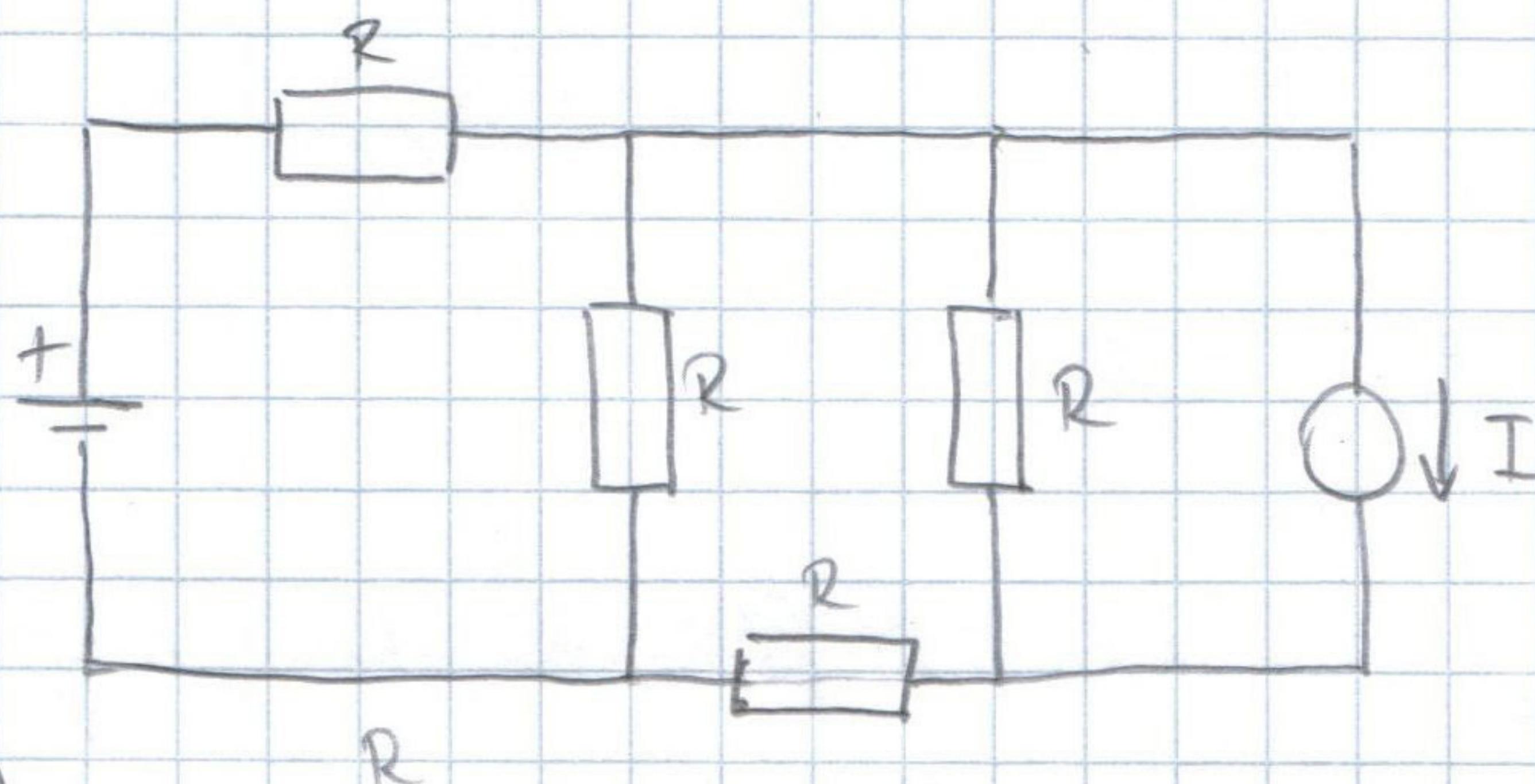
\rightarrow ako struja teče navojnicom i promjenjivog je oblika, onda će i polje promjenjivo, ali navojnicu to nitić, pa će POKUŠATI TO kompenzirati

$$U_1 = -L_1 \cdot \frac{\Delta i}{\Delta t}$$

$$U_2 = +L_2 \cdot \frac{\Delta i}{\Delta t}$$

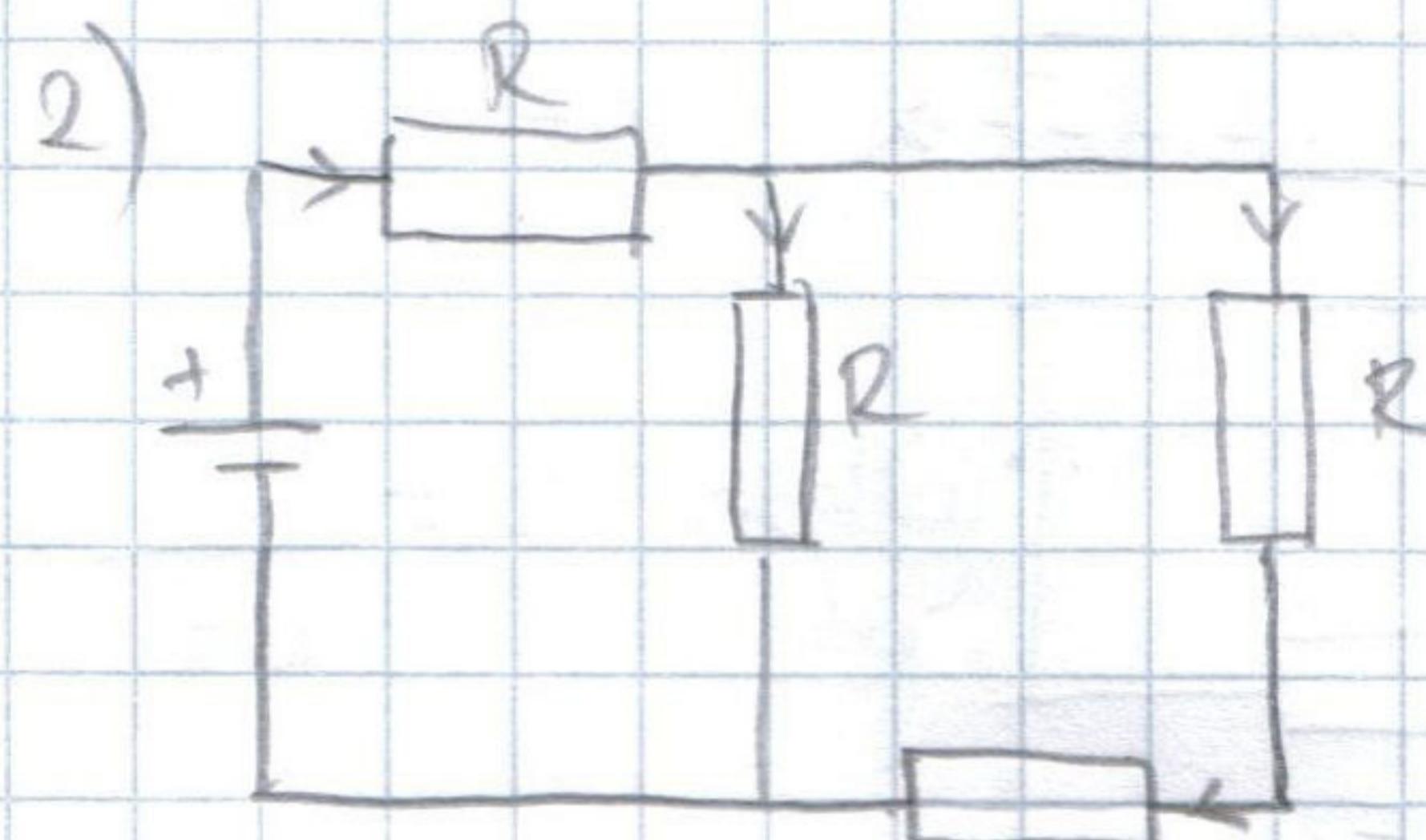
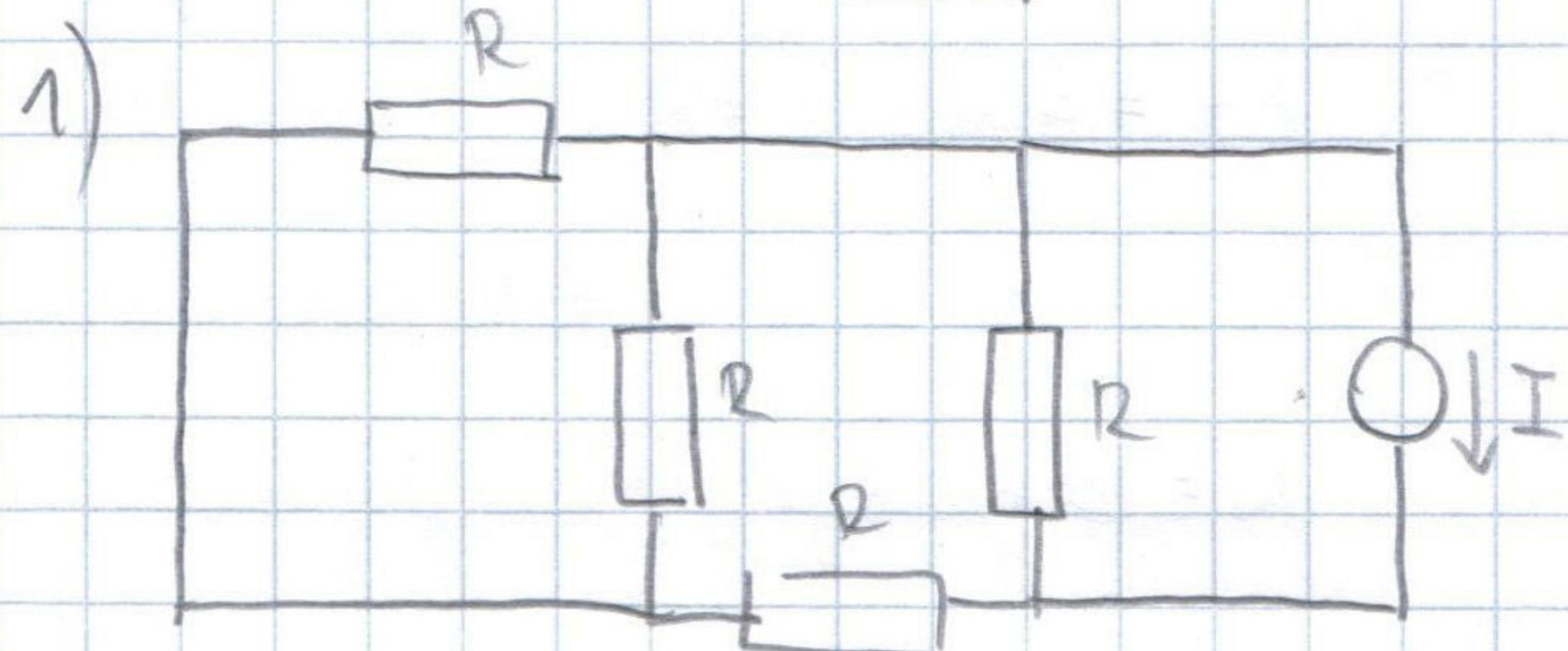
\rightarrow u 2. navojnici će se inducirati napon, ali on je inducirani strujom iz 1. navojnice

SUPERPOZIJA \Rightarrow

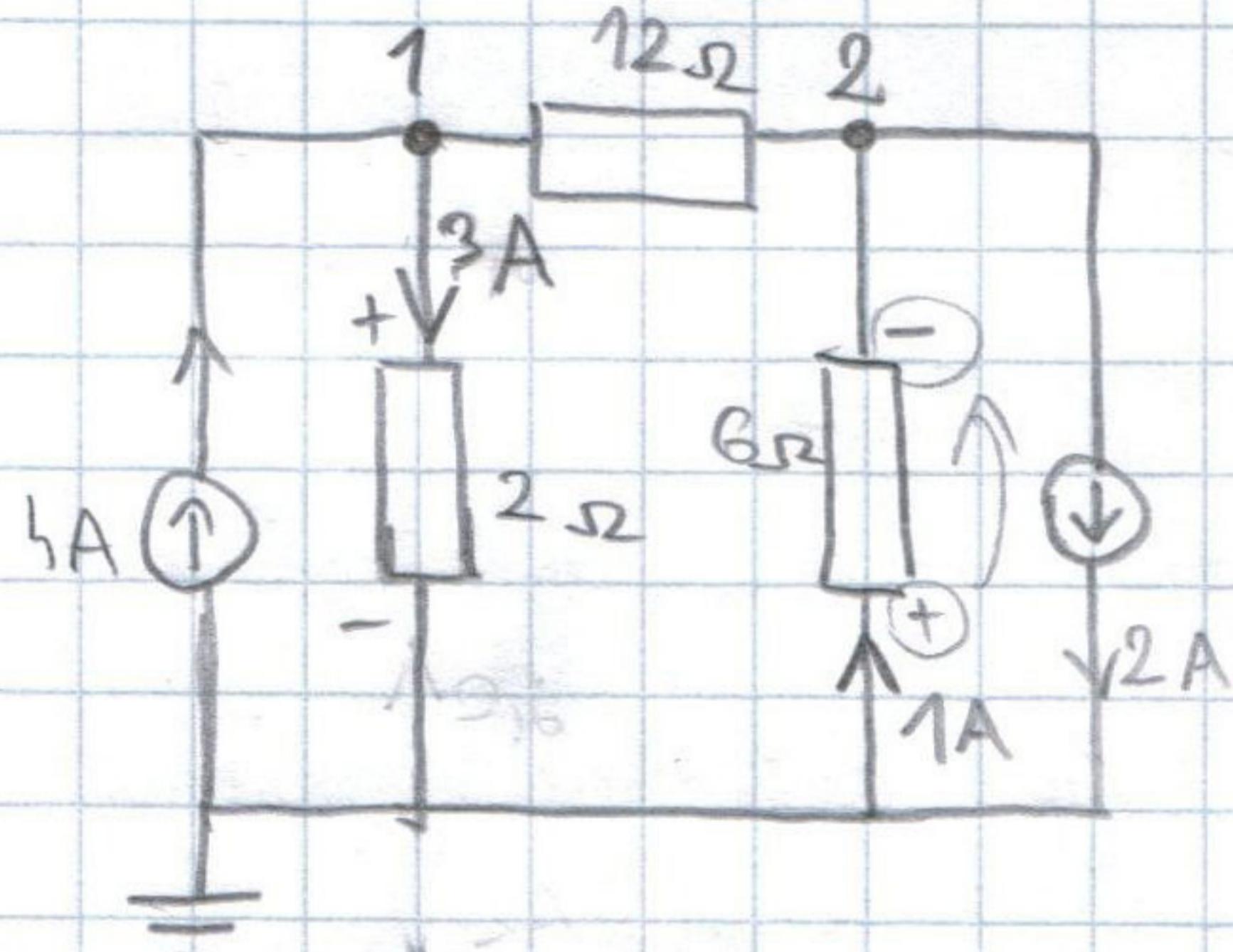


\rightarrow iskopčamo mapovski izvor i kratek spojimo

\rightarrow strujni izvor samo iskopčamo



1-5)



$$I_1 = 3,6 - 0,6 = 3 \text{ A}$$

$$U_1 = 3 \text{ A} \cdot 2 \Omega = 6 \text{ V}$$

$$l_1 = 6 \text{ V}$$

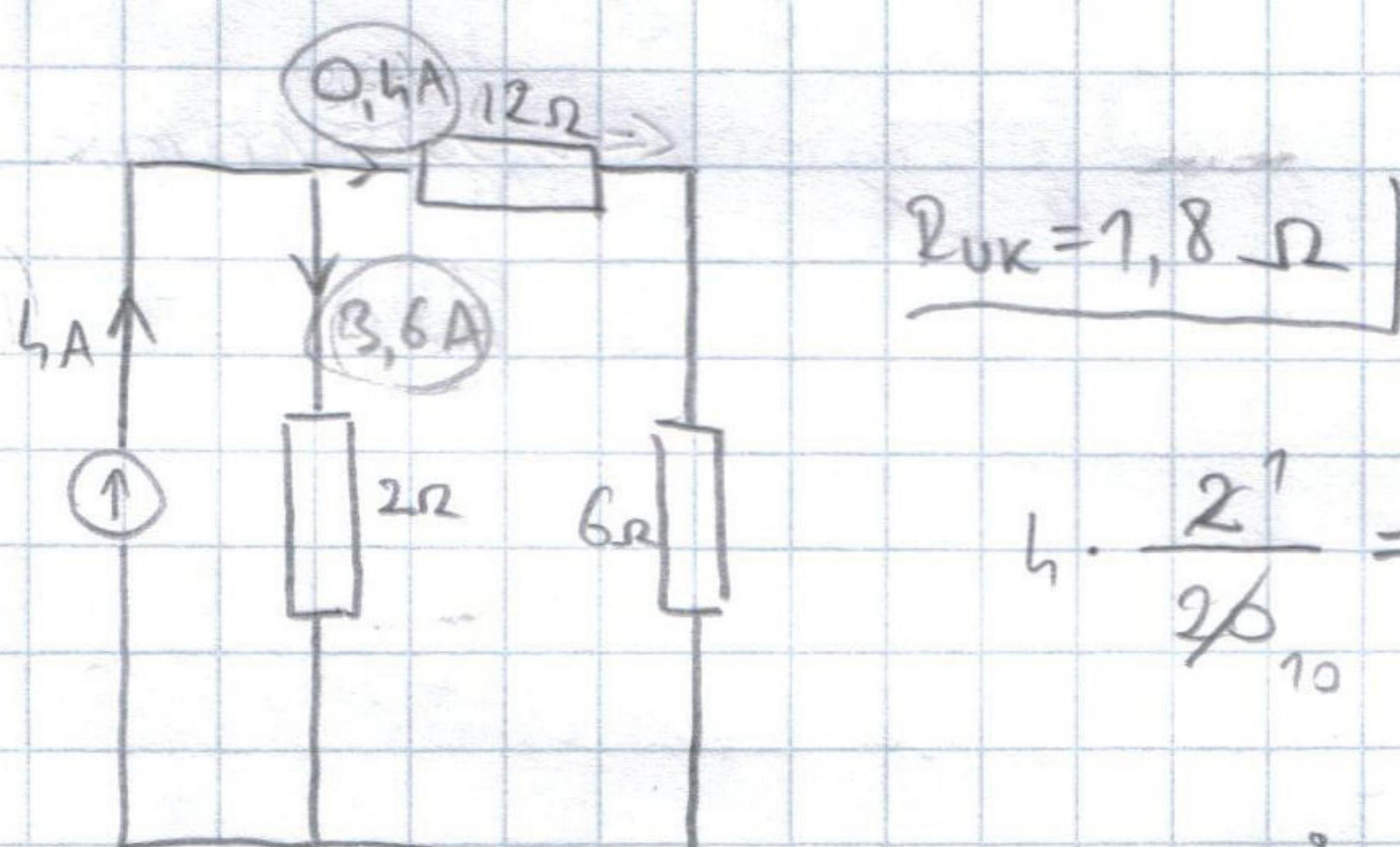
$$I_2 = 1,4 - 0,4 = 1 \text{ A}$$

$$U_2 = 1 \cdot 6 = -6 \text{ V}$$

$$l_2 = -6$$

\hookrightarrow od + prema
 \hookrightarrow mapom prada

1)

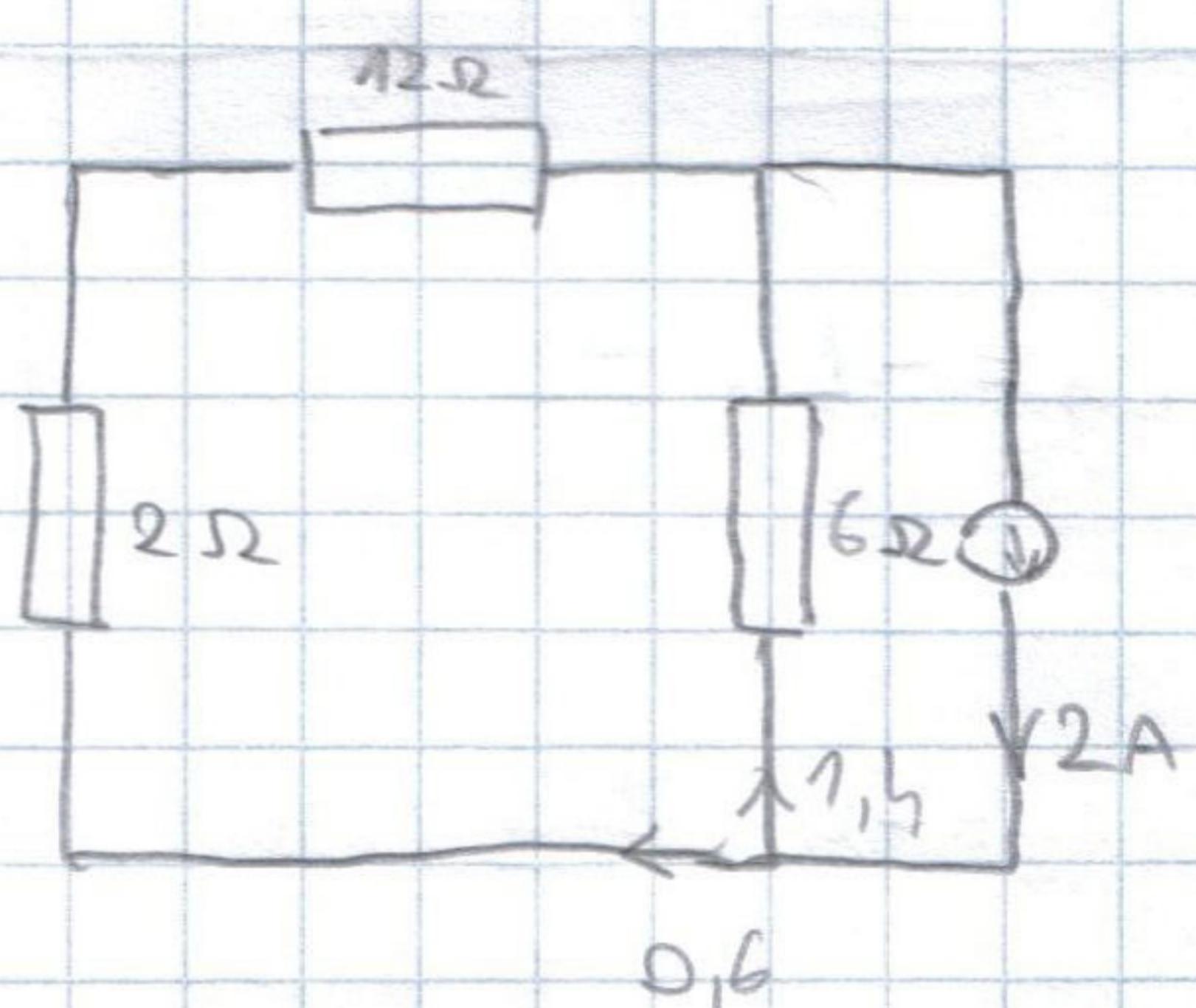


$$R_{UK} = 1,8 \Omega$$

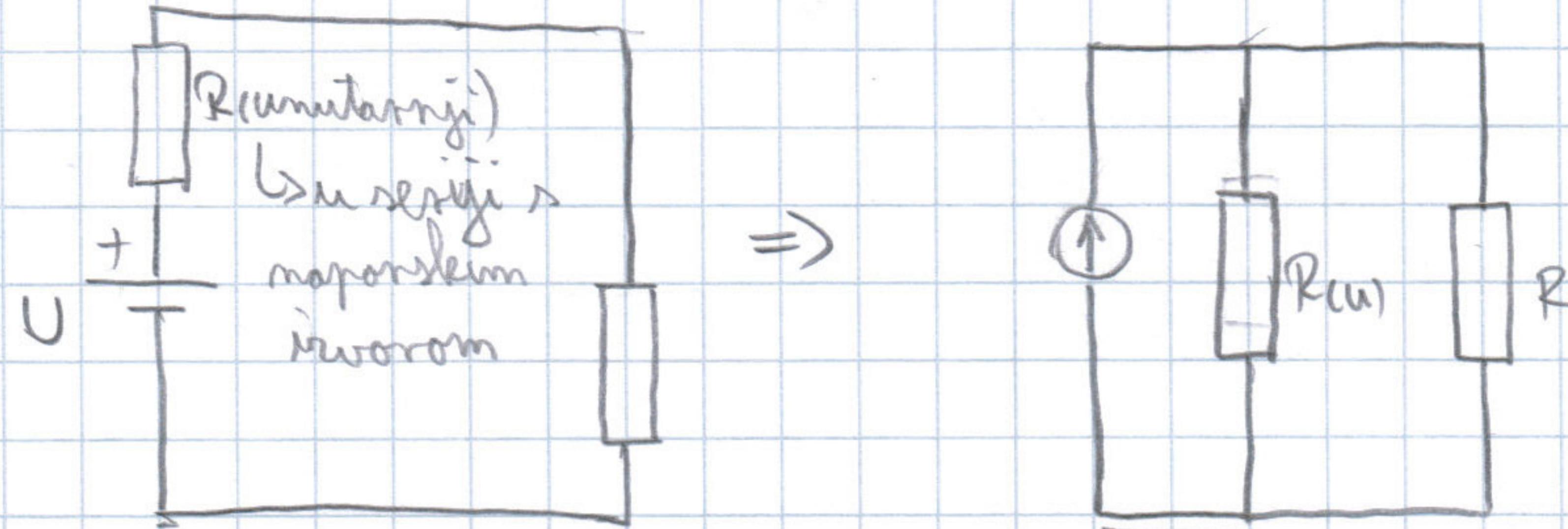
$$I_h \cdot \frac{2}{20} = 0,4 \text{ A}$$

$$I_h \cdot \frac{18}{20} = 3,6 \text{ A}$$

2)



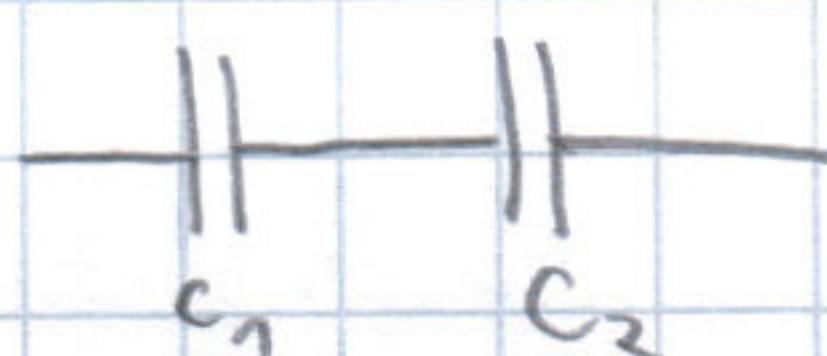
PRETVO RBA STRUJNOG U NAPONSKI IZVOR => (i obrnuto)



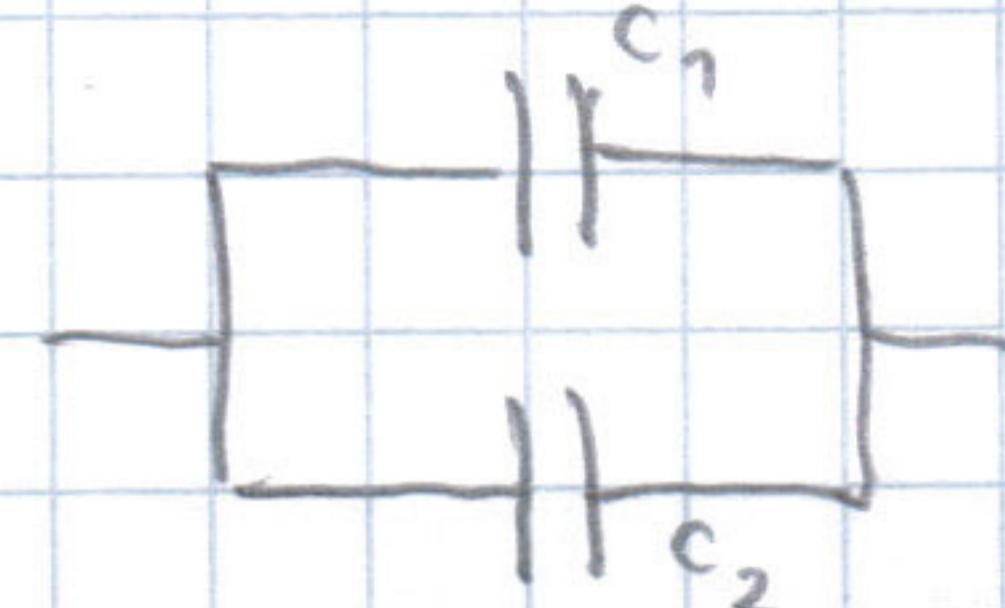
→ strujni izvor ima unutarnji otpor u paraleli

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

KAPACITET → kapacitet u paralelu je zbroj svih ili u najmanjem kapacitetu

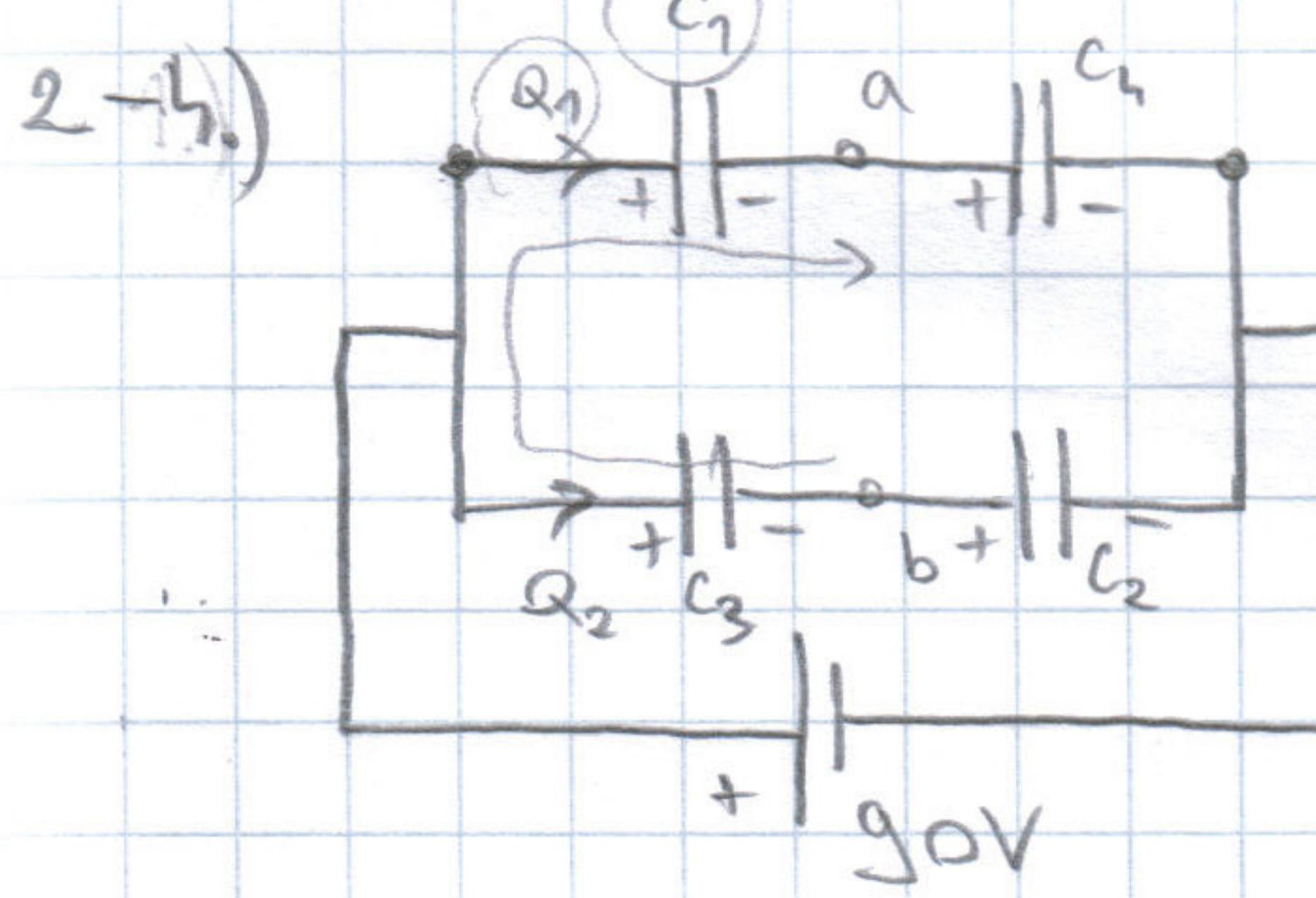


$$\frac{1}{C_{\text{UK}}} = \frac{C_1 + C_2}{C_1 \cdot C_2} \Rightarrow C_{\text{UK}} = \frac{C_1 C_2}{C_1 + C_2}$$



$$C_{\text{UK}} = C_1 + C_2$$

$$Q = C \cdot U$$



$$C_1 = C_3 = 30 \text{ mF}$$

$$C_2 = C_4 = 60 \text{ mF}$$

$$Q = C \cdot U$$

$$C_{\text{UK}} = \frac{1800}{90} = 20 \text{ mF}$$

$$C_{32} = 20 \text{ mF}$$

$$U_{ab} = ? \Rightarrow \text{od } b \text{ prema } a \quad Q = C \cdot U = 20 \text{ mF} \cdot 90 \text{ V} = 1800 \text{ mC} \Rightarrow 1,8 \mu \text{C} = Q_2$$

$$U = \frac{Q}{C}$$

$$U_{ab} = U_{C_3} - U_{C_1} =$$

$$U_{ab} = 0 \text{ V}$$