

LASKE  $U_{AB}$

$V_A = 10V$       $V_B = 4V$

JÄNNITE     POTENTIAALIEN  
 ↓     ↙     ↓     ERO  
 $U_{AB} = V_A - V_B$   
 $= 10V - 4V = 6V$

$12V$       $7V$

$U_{AB} = 5V$

$7V$       $12V$

$U_{AB} = V_A - V_B = -5V$

$5V$       $3V$

$U_{AB} = 2V$

$\int_1$      a  
 $\int_2$      b  
 $\int_3$      c

$-4V$       $-7V$

$U_{AB} = 3V$

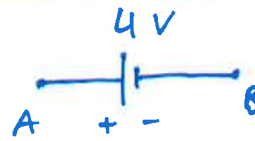
$28V$       $-9V$

$U_{AB} = 37V$

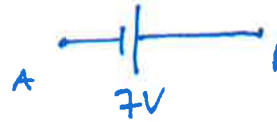
$-13V$       $-12V$

$U_{AB} = -1V$

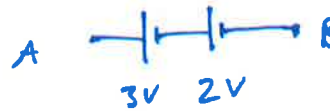
LASKE  $U_{AB}$



Koska A on  $\oplus$ -puolella,  
 niin  
 $U_{AB} = 4V$

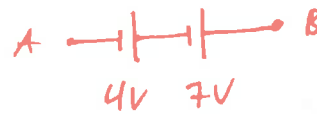


$U_{AB} = -7V$

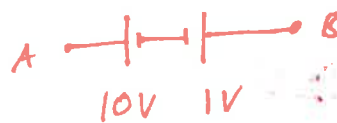


$U_{AB} = 5V$

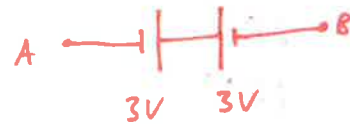
$\omega^2 = \frac{1}{LC}$



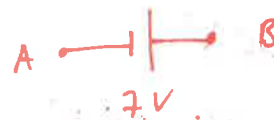
$U_{AB} = -11V$



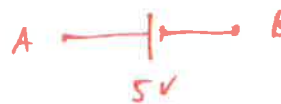
$U_{AB} = 9V$



$U_{AB} = 0V$



$U_{AB} = -7V$



$U_{AB} = 5V$



$U_{AB} = 3 + 3 - 2 = 4V$

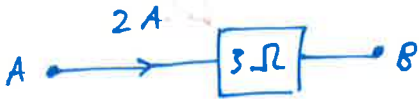
LASKE  $U_{AB}$

JÄNNITEHÄVIÖ  $U = R \cdot I$   
VASTUKSESSA

KOSKA VIRTA ON  $A \rightarrow B$ ,  
TÄYTYY OLLA  $V_A > V_B$

$\Rightarrow U_{AB} = V_A - V_B > 0$

SIIIS  $U_{AB} = + R \cdot I$



$U_{AB} = 3\Omega \cdot 2A = 6V$



$U_{AB} = -4 \cdot 3 = -12$

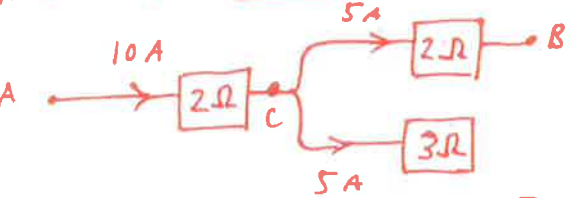
$A \rightarrow B$  VIRTA VASTAAN



$U_{AB} = 21V$



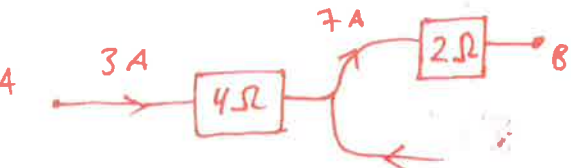
$U_{AB} = -32V$



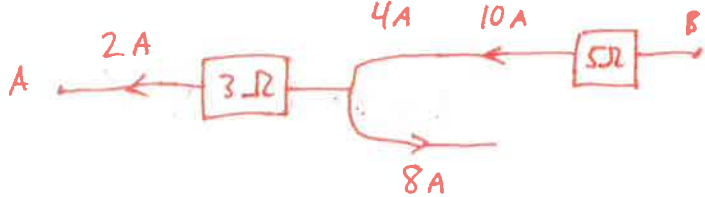
$U_{AC} = 20V$

$U_{CB} = 10V$

$\Rightarrow U_{AB} = U_{AC} + U_{CB} = 30V$

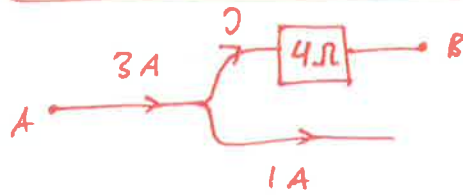


$U_{AB} = 12 + 14 = 26V$

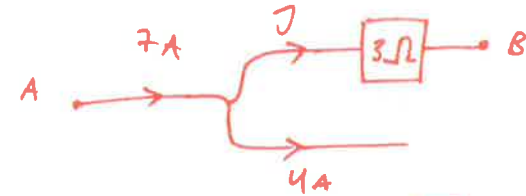


$U_{AB} = -50 - 6 = -56V$

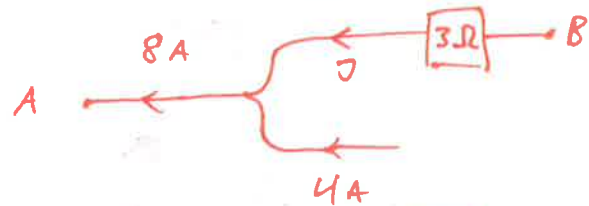
LASKE  $I$  JA  $U_{AB}$



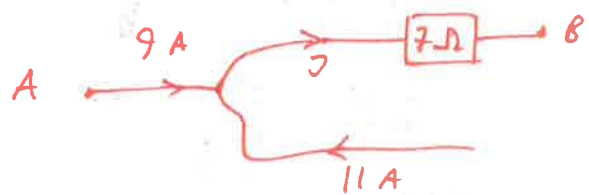
$I = 3A$   
 $U_{AB} = 12V$



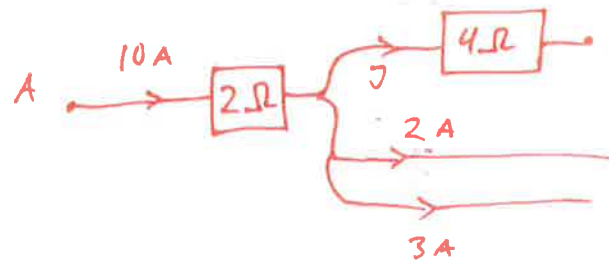
$I = 3A$   
 $U_{AB} = 9V$



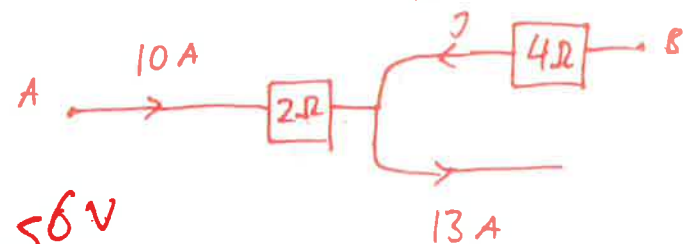
$I = 4A$   
 $U_{AB} = -12V$



$I = 20A$   
 $U_{AB} = 140V$

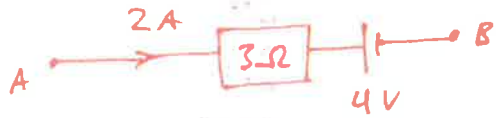


$I = 5A$   
 $U_{AB} = 20V + 20V = 40V$



$I = 3A$   
 $U_{AB} = 20V - 12V = 8V$

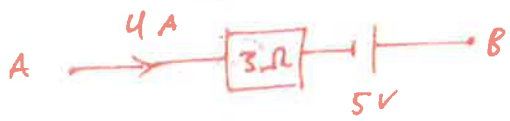
LAŠKE  $U_{AB}$



$$U_{AB} = 6 + 4 = 10V$$



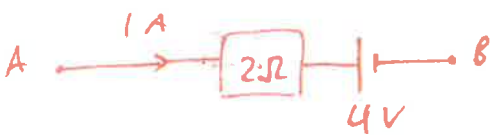
$$U_{AB} = -8 - 5 = -13V$$



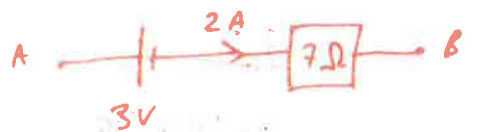
$$U_{AB} = 12 - 5 = 7V$$



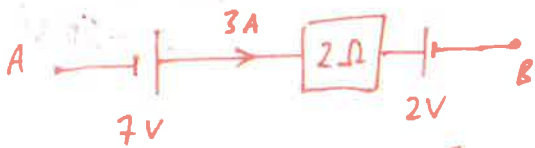
$$U_{AB} = -8 - 6 = -14V$$



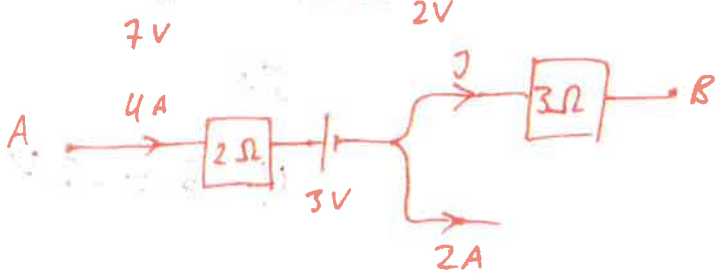
$$U_{AB} = 2 + 4 = 6V$$



$$U_{AB} = 3 + 14 = 17V$$



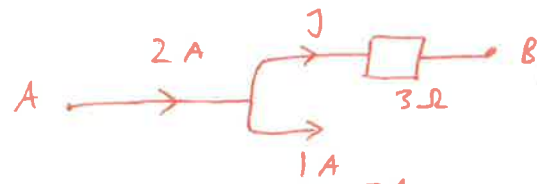
$$U_{AB} = -7 + 6 + 2 = 1V$$



$$J = 8 + 3 + 3$$

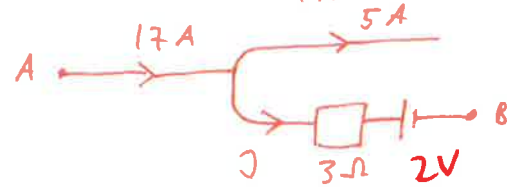
$$U_{AB} = 8 + 3 + 3$$

$$= \underline{17V}$$



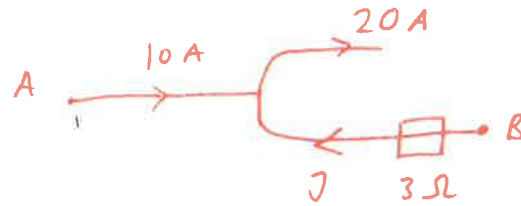
$$U_{AB} = 3V$$

$$J = 1A$$



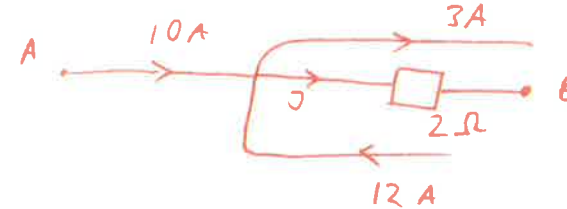
$$J = 12A$$

$$U_{AB} = 36 + 2 = 38V$$



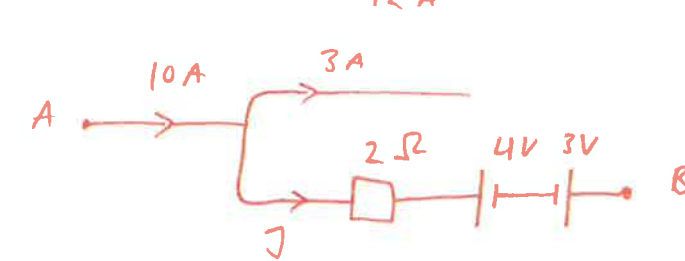
$$J = 10A$$

$$U_{AB} = \underline{\underline{-30AV}}$$



$$J = 19A$$

$$U_{AB} = 38V$$

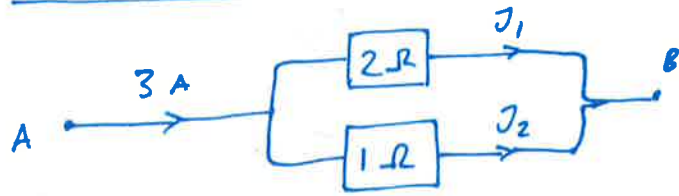


$$J = 9A$$

$$U_{AB} = 18 + 4 - 3$$

$$= 19V$$

# VIRTOJEN JAKAUTUMINEN



KOSKA 1Ω VASTUS ON PIENEMPI, NIIN SEN KAUTTA KULKEE SUUREMPI VIRTA  
 $\Rightarrow J_2 > J_1$

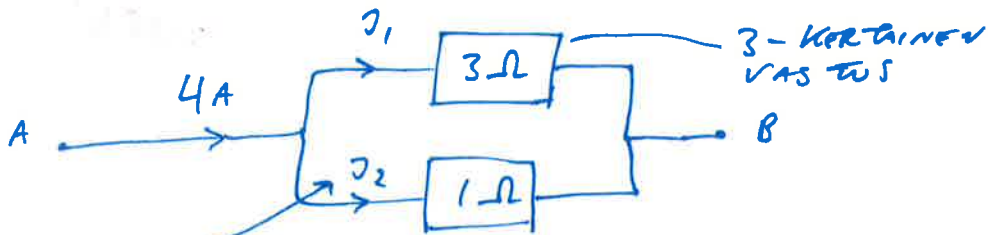
JÄNNITEKÄVIÖT VASTUKSISSA OVA T SAMAT

$$\Rightarrow U_{AB} = 2\Omega \cdot J_1 = 1\Omega \cdot J_2$$

SIIS  $J_1 = 1A$  JA  $J_2 = 2A$

$$\Rightarrow J_1 + J_2 = 1 + 2 = 3A \quad \text{OK}$$

VIRTA EI HÄVIÄ

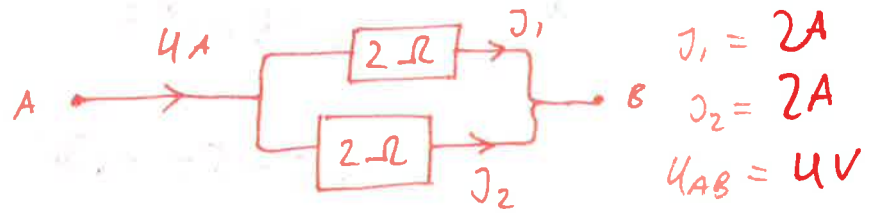


3-KERTAINEN VASTUS

SIIS 3-KERTAINEN VIRTA  $\Rightarrow J_1 = 1A$  &  $J_2 = 3A$

$$1 + 3 = 4 \quad \text{OK}$$

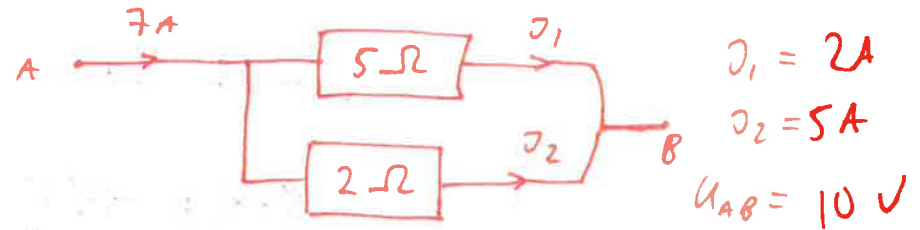
# LASKETA VIRRAT JA $U_{AB}$



$$J_1 = 2A$$

$$J_2 = 2A$$

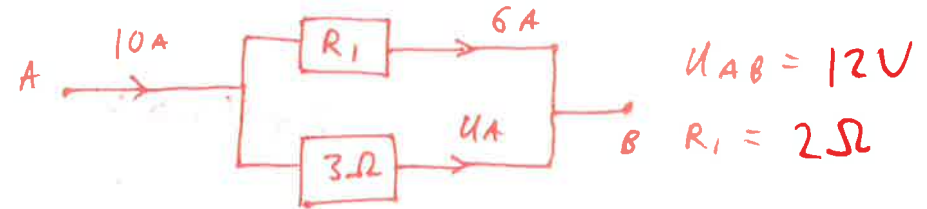
$$U_{AB} = 4V$$



$$J_1 = 2A$$

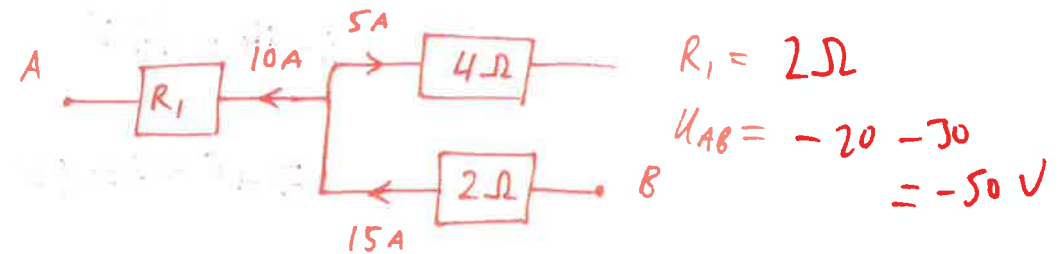
$$J_2 = 5A$$

$$U_{AB} = 10V$$



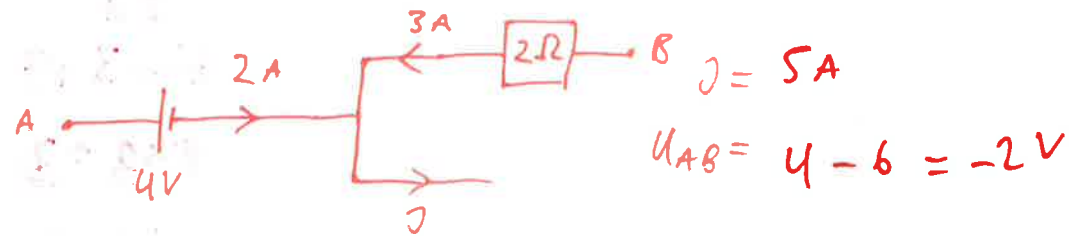
$$U_{AB} = 12V$$

$$R_1 = 2\Omega$$



$$R_1 = 2\Omega$$

$$U_{AB} = -20 - 30 = -50V$$



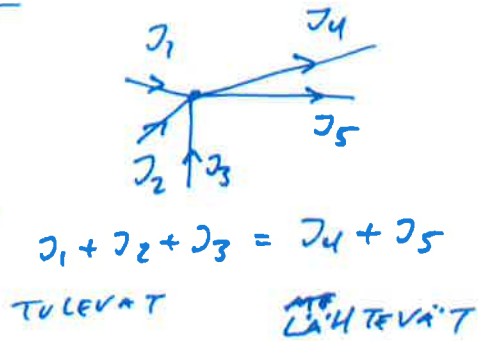
$$J = 5A$$

$$U_{AB} = 4 - 6 = -2V$$

# KIRCHOFFIN LAIT

K1

VIRTTA EI HÄVIÄ/  
SYNNY TYHJÄISTÄ

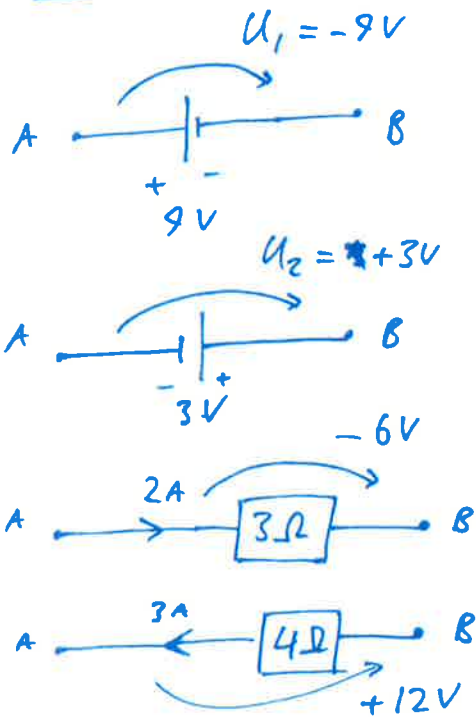


K2

SULJETUSSA  
SILMUKASSA

$$U_1 + U_2 + \dots + U_N = 0$$

## LASKUSÄÄNNÖT

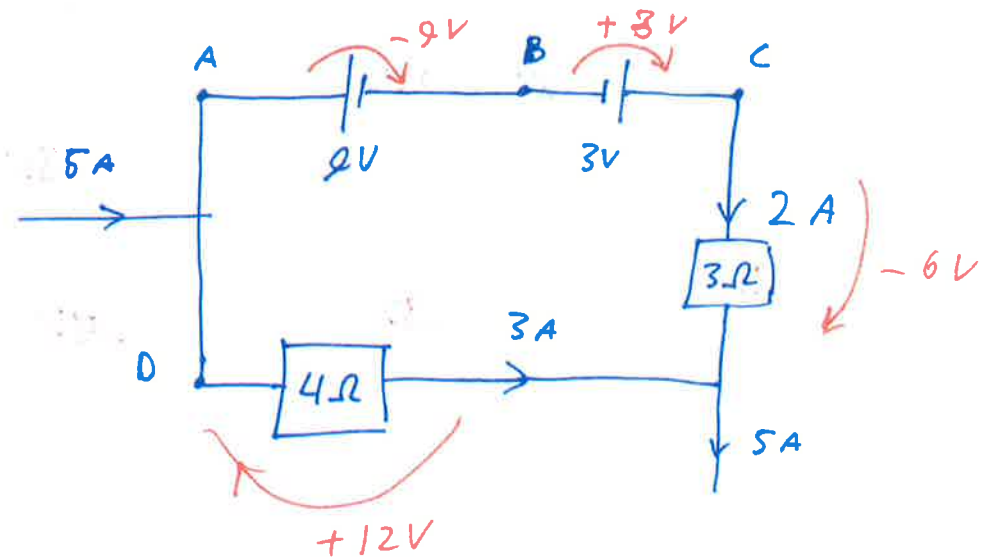


HYPÄTÄÄN 9V  
PIENEMPÄÄN  
POTENTIAALIIN

HYPÄTÄÄN 3V  
KORKEAMPAAN  
POTENTIAALIIN

POT. PIENENEÄ

POT. KASVAA



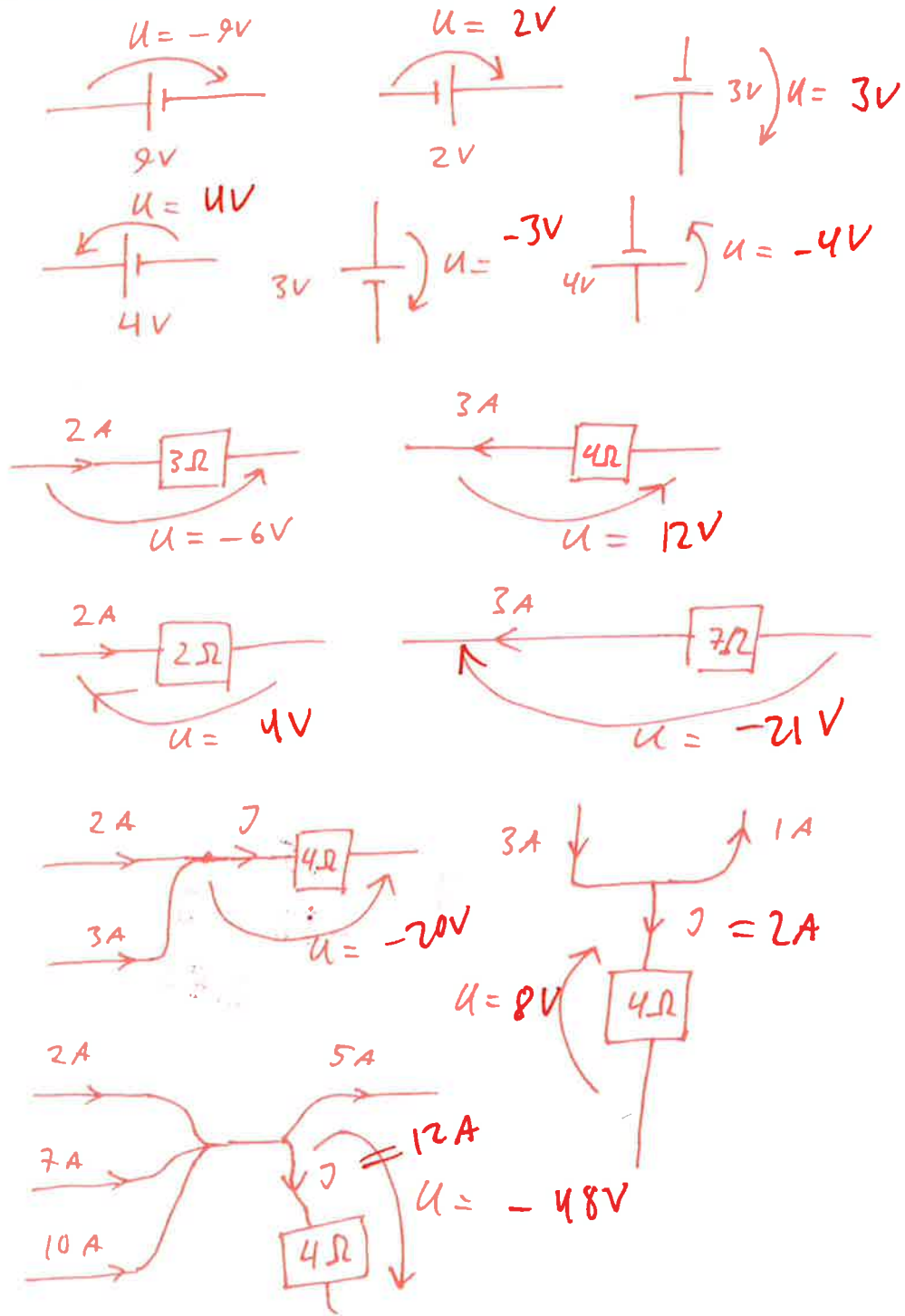
$$\underbrace{-9V + 3V}_{-6V} + \underbrace{-6V + 12V}_{+6V} = 0V$$

KIERROKSELLE ABCO

$$3 \cdot 15 - 12 = 3$$

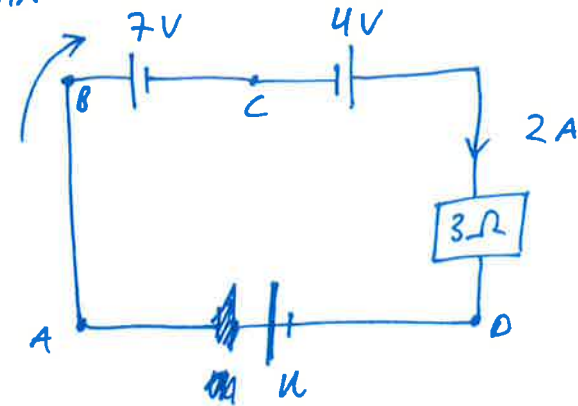
$$2.45$$

**MERKKA POTENTIAALI MUUTOKSET**



KOSKA  $U_1 + U_2 + \dots + U_N = 0$ , NIIN VOIDAAN LASKEA TUNTEMATTOMIA VIRTOJA JA JÄNNITTEITÄ JA VASTUKSIA

ESIM.

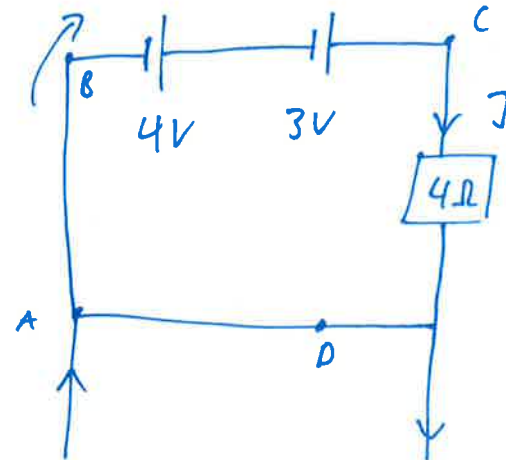


KIERRIS ABCD

$$\begin{aligned}
 0 &= -7V + 4V - 2 \cdot 3V + U \\
 &= -3V - 6V + U \\
 &= -9V + U
 \end{aligned}$$

$$\leadsto 0 = -9V + U \rightarrow \underline{\underline{U = 9V}}$$

ESIM.



$$\begin{aligned}
 0 &= +4 \\
 &+ 3 \\
 &- 4J \\
 &= 7 - 4J
 \end{aligned}$$

$$\leadsto J = \underline{\underline{\frac{7}{4} A}}$$



VIRTAPIIRI LASKUSSA TOLEE USETIN YHTÄLÖRYHMÄÄ, ESIM.

$$\begin{cases} I_1 + 2I_2 + I_3 = 4 \\ 2I_1 - I_2 + 3I_3 = 5 \\ 4I_1 - 2I_2 + 7I_3 = 0 \end{cases}$$

NÄITÄ VOI RATKOA NETISSIÄ, ESIM. GOOGLETA

"EQUATION GROUP SOLVER"

→ WOLFRAM ALPHA

→ SYÖTÄ YHTÄLÖIT

$$a + 2b + c = 4$$

$$2a - b + 3c = 5$$

$$4a - 2b + 7c = 0$$

→

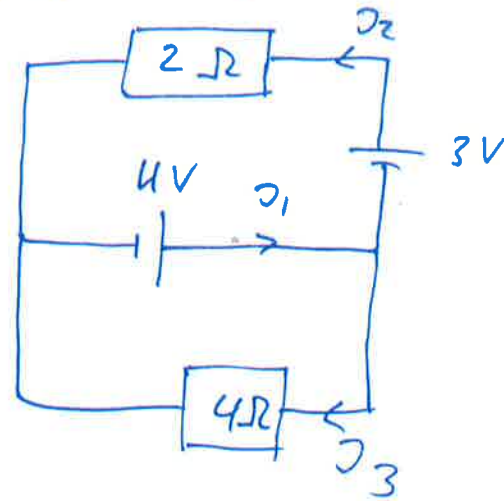
$$\begin{aligned} a &= \frac{84}{5} = I_1 \\ b &= -\frac{7}{5} = I_2 \\ c &= -10 = I_3 \end{aligned}$$

PAINA

VOI KÄYDÄ NIIN, ETÄ TULEE MIINUS MERKKEJÄ

(ÄLÄ ~~MIINUS~~ SEKOA KUVISSA)

ESIM. RATKAISTUAN VIRRAT



K1  $I_1 = I_2 + I_3$

① →  $4 + 3 - 2I_2 = 0$

② →  $4 - 4I_3 = 0$

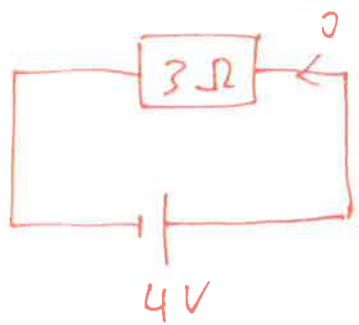
→ 
$$\begin{cases} I_1 - I_2 - I_3 = 0 \\ *2I_2 = 7 \\ 4I_3 = 4 \end{cases} \Rightarrow \begin{aligned} I_2 &= \frac{7}{2} \text{ A} \\ I_3 &= 1 \text{ A} \end{aligned}$$

⇒  $I_1 = I_2 + I_3 = 1 + \frac{7}{2} = \frac{9}{2} \text{ A}$





# RATKAISE VIRRAT

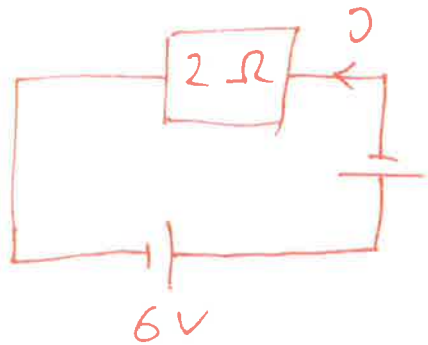


$$U = RI$$

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

$$\hookrightarrow 4 - 3I = 0$$

$$I = \frac{4}{3} \text{ A}$$

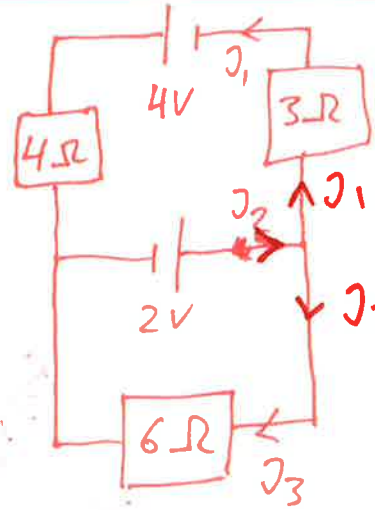


$$1V \text{ (3)}$$

$$6 - 1 - 2I = 0$$

$$I = \frac{5}{2} \text{ A}$$

# RATKAISE VIRRAT



(1)

(2)

$$\textcircled{1} \quad 2 - 3I_1 + 4 - 4I_1 = 0$$

$$6 - 7I_1 = 0$$

$$I_1 = \frac{6}{7} \text{ A}$$

$$\textcircled{2} \quad -2 + 6I_3 = 0$$

$$I_3 = \frac{1}{3} \text{ A}$$

$$I_2 = I_1 + I_3$$

$$= \frac{6}{7} + \frac{1}{3} = \frac{18}{21} + \frac{7}{21}$$

$$= \frac{25}{21} \text{ A}$$

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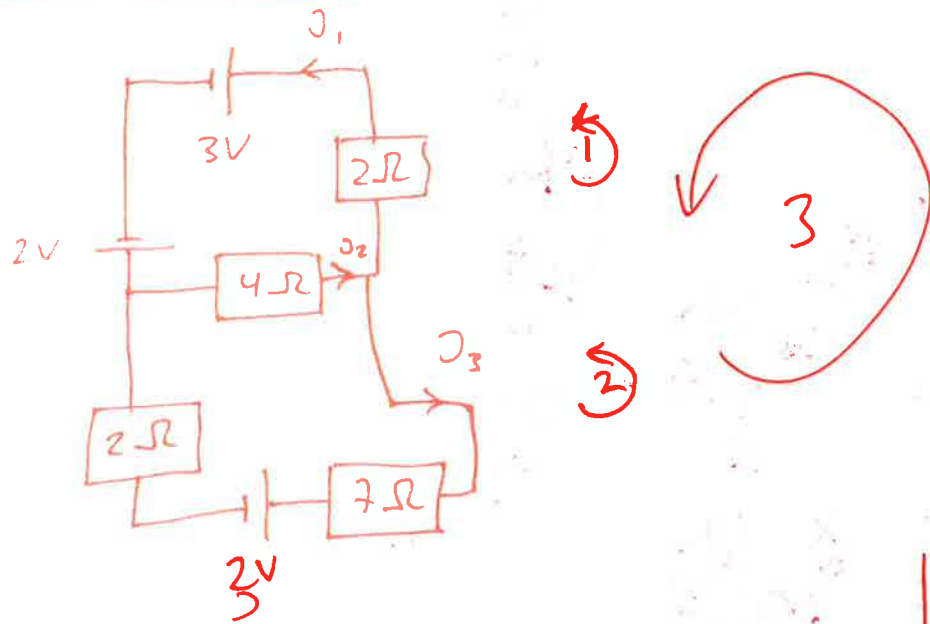
$$\lambda_1 = -\frac{5}{62} \approx -0.08$$

$$\lambda_2 = -\frac{4}{31} \approx -0.12$$

$$\lambda_3 = -\frac{13}{62} \approx -0.21$$

$$\lambda_2 = \lambda_1 + \lambda_3$$

RATNAISE VIRRAT

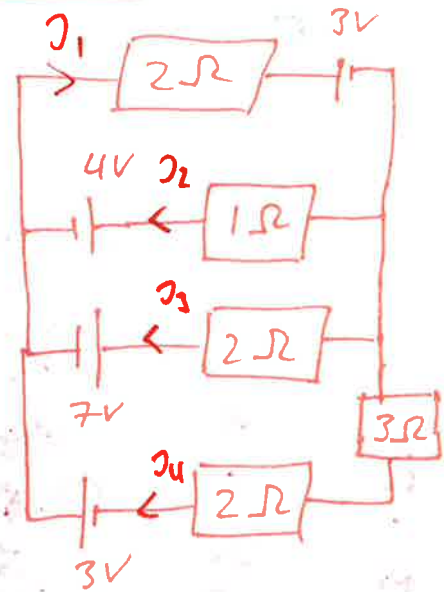


①  $2 - 4J_2 - 2J_1 - 3 = 0$   
 $-4J_2 - 2J_1 = 1$

②  $2 + 7J_3 + 4J_2 + 2J_1 = 0$   
 $4J_2 + 9J_3 = -2$

a)  $2J_1 + 4J_2 + 2J_3 = -1$  (2?)  
 b)  $4J_2 + 9J_3 = -2$  b + c 6J  
 c)  $2J_1 - 9J_3 = 1$

RATNAISE VIRRAT



$J_1 = J_2 + J_3 + J_4$

③  $2 - 3 + 7J_3 - 2J_1 + 2J_3 = 0$   
 $-2J_1 + 9J_3 = 0$   
 $2J_1 - 9J_3 = 1$

$J_1 = -\frac{5}{62} \approx -0,081 \text{ A}$

$J_2 = -\frac{13}{62} \approx -0,209 \text{ A}$

$J_3 = -\frac{4}{31} \approx -0,129 \text{ A}$

$$a^x = e^{x \ln a}$$

$$a^x = e^{x \ln a}$$

$$\int 3^{2x} dx$$

$$3^{2x} = e^{\ln 3 \cdot 2x}$$

$$= e^{\ln 3 \cdot 2x}$$

$$= e^{\ln 3^2 \cdot x} = e^{\ln 9 \cdot x}$$

$$\int 3^{2x} dx = \int e^{\ln 9 \cdot x} dx$$

$$= \frac{1}{\ln 9} e^{\ln 9 \cdot x} + C$$

$$= \frac{3^{2x}}{\ln 9} + C$$

$$\ln 9 = \ln 3^2 = 2 \ln 3$$

$$\textcircled{1} 3 + 2j_1 + 4 + j_2 = 0$$

$$\textcircled{2} -j_2 - 4 + 7 + 2j_3 = 0$$

$$\textcircled{3} -2j_3 - 7 - 3 + 5j_4 = 0$$

$$\begin{cases} 2j_1 + j_2 = -7 \\ -j_2 + 2j_3 = -3 \\ -2j_3 + 5j_4 = 10 \end{cases}$$
$$j_1 = j_2 + j_3 + j_4$$

$$\begin{cases} j_1 = -\frac{30}{11} \approx -2,7273 \\ j_2 = -\frac{17}{11} \approx -1,5455 \\ j_3 = -\frac{25}{11} \approx -2,2727 \\ j_4 = \frac{12}{11} \approx 1,0909 \text{ A} \end{cases}$$

$$3 = 1 + 2$$

