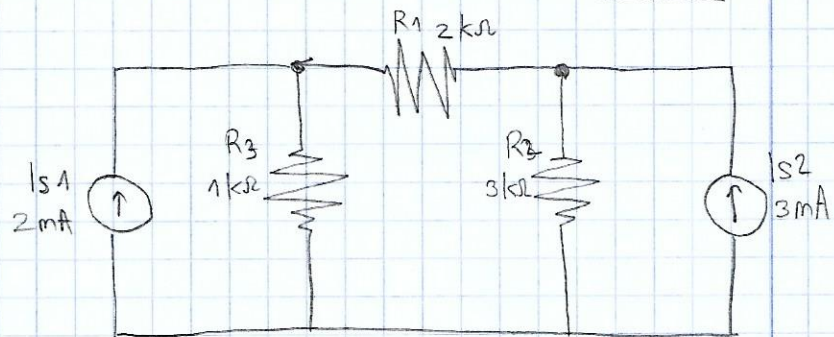
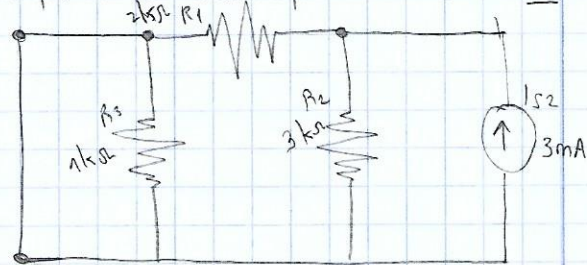


-1-

שאלה 2



א. נגד אחד מקור הזרם I_{S2} ונשאיר רק את מקור הזרם I_{S1} . מחלקי המתח נקרא:



$$R_{13} = R_1 + R_3 = 2 + 1 = 3 \text{ k}\Omega$$

$$I_{S2}^{(1)} = I_{S2} \cdot \frac{R_{13}}{R_2 + R_{13}} = 3 \cdot \frac{3}{3+3} = \frac{9}{3} = 1.5 \text{ mA}$$

$$I_{S2}^{(2)} = I_{S2} \cdot \frac{R_{13}}{R_2 + R_{13}} = 3 \cdot \frac{3}{3+3} = \frac{9}{3} = 1.5 \text{ mA}$$

נגד אחד מקור הזרם I_{S1} ונשאיר את מקור הזרם I_{S2} . מחלקי המתח נקרא:



$$R_{12} = R_1 + R_2 = 2 + 3 = 5 \text{ k}\Omega$$

$$I_{S1}^{(1)} = I_{S1} \cdot \frac{R_{12}}{R_3 + R_{12}} = 2 \cdot \frac{5}{5+1} = \frac{10}{6} = \frac{5}{3} \text{ mA}$$

$$I_{S1}^{(2)} = I_{S1} \cdot \frac{R_3}{R_{12} + R_3} = 2 \cdot \frac{1}{1+5} = \frac{2}{6} = \frac{1}{3} \text{ mA}$$

$$I_{R1} = I_{S2}^{(2)} - I_{S1}^{(2)} = 1.5 - \frac{1}{3} = 1.16667 \text{ mA}$$

$$I_{R2} = I_{S2}^{(1)} + I_{S1}^{(2)} = 1.5 + \frac{1}{3} = 1.8333 \text{ mA}$$

$$I_{R3} = I_{S2}^{(1)} + I_{S1}^{(1)} = 1.5 + \frac{5}{3} = 3.16667 \text{ mA}$$

$$P_{R1} = (1.16667)^2 \cdot 2 = 2.722 \text{ mW}$$

$$P_{R2} = (1.833)^2 \cdot 3 = 10.079 \text{ mW}$$

$$P_{R3} = (3.1666)^2 \cdot 1 = 10.027 \text{ mW}$$

$$P_E = P_{R1} + P_{R2} + P_{R3} = 2.722 + 10.079 + 10.027 = 22.82 \text{ mW}$$

$$\eta = \frac{P_{R2}}{P_E} = \frac{10.079}{22.82} = 0.4416 \cdot 100 = 44.16$$

העלות 44.16% עבור R2 ←

5 נדעו

$$E_1 = I_{33}R_1 + (I_{11} + I_{33})R_2 + (I_{33} - I_{22})R_3$$

$$E_2 = I_{22}R_4 + (I_{22} - I_{33})R_3 + (I_{11} + I_{22})R_5$$

$$E_3 = I_{11}R_6 + (I_{11} + I_{33})R_2 + (I_{11} + I_{22})R_5$$

$$10 = 5I_{33} + 4I_{11} + 4I_{33} + 3I_{33} - 3I_{22}$$

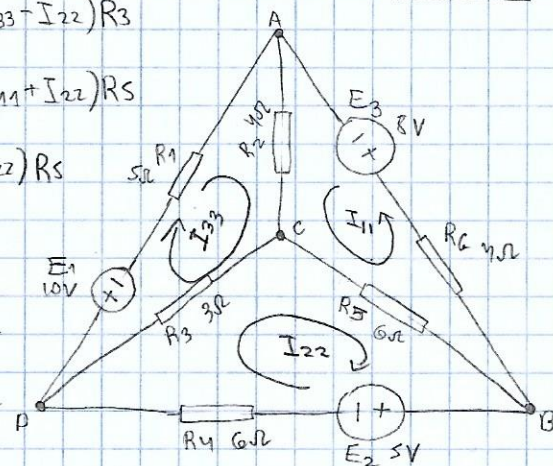
$$5 = 6I_{22} + 3I_{22} - 3I_{33} + 6I_{11} + 6I_{22}$$

$$8 = 4I_{11} + 4I_{11} + 4I_{33} + 6I_{11} + 6I_{22}$$

$$10 = 12I_{33} + 4I_{11} - 3I_{22}$$

$$5 = 6I_{11} + 15I_{22} - 3I_{33}$$

$$8 = 14I_{11} + 4I_{33} + 6I_{22}$$



$$I_{11} = 0.106 \text{ A}$$

$$I_{22} = 0.474 \text{ A}$$

$$I_{33} = 0.916 \text{ A}$$

$$I_{R1} = I_{33} = 0.916 \text{ A} \rightarrow \text{פדו}$$

$$I_{R2} = I_{11} + I_{33} = 0.106 + 0.916 = 1.022 \text{ A} \rightarrow \text{פדו}$$

$$I_{R3} = I_{33} - I_{22} = 0.916 - 0.474 = 0.442 \text{ A} \rightarrow \text{פדו}$$

$$I_{R4} = I_{22} = 0.474 \text{ A} \rightarrow \text{פדו}$$

$$I_{R5} = I_{11} + I_{22} = 0.106 + 0.474 = 0.58 \text{ A} \rightarrow \text{פדו}$$

$$I_{R6} = I_{11} = 0.106 \text{ A} \rightarrow \text{פדו}$$

! ספק ← כל המספרים חייבים - 5 המקור מזה (אם ספק)

$$\begin{cases} E_G = I_{11}R_G + (I_{11} + I_{33})R_2 + (I_{11} - I_{22})R_4 \\ E_3 = I_{22}R_5 + (I_{11} - I_{22})R_4 + (I_{22} + I_{33})R_3 \end{cases}$$

$$\begin{cases} 100 = 100I_{11} + 200I_{11} + 200I_{33} + 50I_{11} - 50I_{22} \\ 100 = 150I_{22} + 50I_{11} - 50I_{22} + 100I_{22} + 100I_{33} \end{cases}$$

$$\begin{cases} 100 = 35I_{11} - 50I_{22} + 200I_{33} \\ 100 = 200I_{22} + 50I_{11} + 100I_{33} \end{cases}$$

$$I_{33} = 2A \quad I_{11} = 0.926A \quad I_{22} = 0.487A$$

$$I_{R1} = \boxed{2A}$$

$$I_{R2} = I_{11} - I_{33} = 0.926 - 2 = \boxed{1.074A}$$

$$I_{R3} = I_{33} - I_{22} = 2 - 0.487 = \boxed{1.513A}$$

$$I_{R4} = I_{22} - I_{11} = 0.487 - 0.926 = \boxed{0.439A}$$

$$I_{R5} = I_{22} = \boxed{0.487A}$$

$$I_{RG} = I_{11} = \boxed{0.926A}$$

: find power in P

$$P_{R1} = 2^2 \cdot 100 = 400W$$

$$P_{R2} = (1.074)^2 \cdot 200 = 230.695W$$

$$P_{R3} = (1.513)^2 \cdot 100 = 228.916W$$

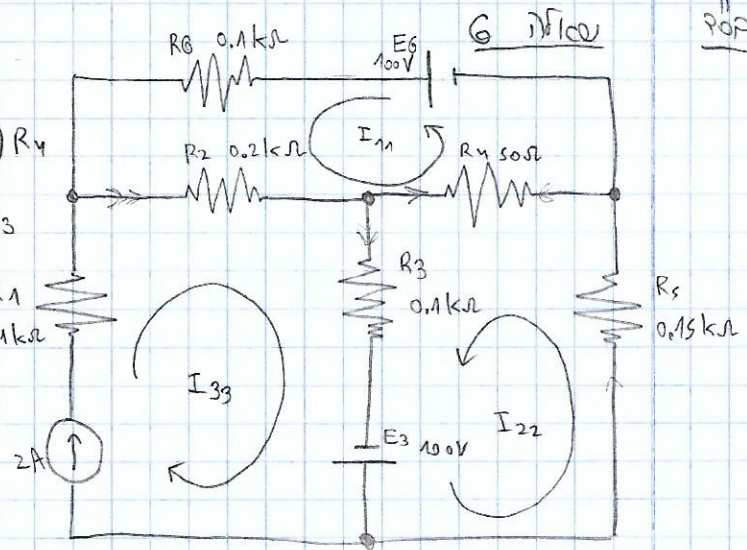
$$P_{R4} = (0.439)^2 \cdot 50 = 9.828W$$

$$P_{R5} = (0.487)^2 \cdot 150 = 11.858W$$

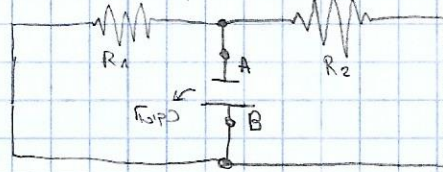
$$P_{RG} = (0.926)^2 \cdot 100 = 85.747W$$

$$P_{E3} = E_3 \cdot I_{R3} = 100 \cdot 1.513 = 151.3W$$

$$P_{EG} = E_G \cdot I_{RG} = 100 \cdot 0.926 = 92.6W$$

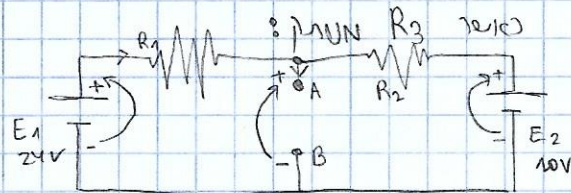


התנגדות R_{th} היא התנגדות הנראית מנקודה A ו-B כאשר R_3 מוסר.



$$R_{th} = \frac{R_1 \cdot R_2}{R_1 + R_2} = \frac{20 \cdot 30}{20 + 30} = \frac{600}{50} = 12 \Omega$$

המתח V_{th} הוא המתח הנמדד בין הנקודות A ו-B כאשר R_3 מוסר.



$$U_{AB} + U_{R1} - E_1 = 0 \quad \text{קירכוף:}$$

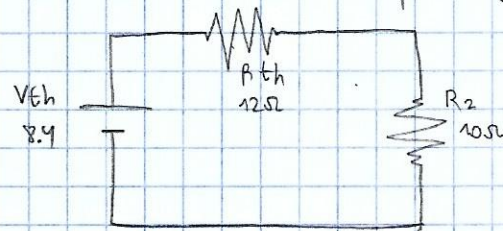
$$E = E_1 - E_2 = 24 - 10 = 14V$$

$$U_{R1} = E \cdot \frac{R_1}{R_1 + R_2} = 14 \cdot \frac{20}{20 + 30} = 5.6V$$

$$U_{AB} + 5.6 - 14 = 0$$

$$U_{AB} = 8.4 = V_{th}$$

התנגדות נכנסת:



$$R_N = R_{th} = 12 \Omega$$

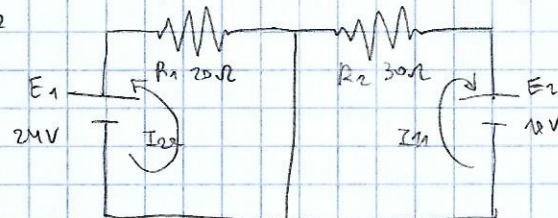
התנגדות נכנסת נוספת.

$$E_1 = I_{R2} \cdot R_1 \Rightarrow 24 = 20 I_{R2} \Rightarrow I_{R2} = 1.2$$

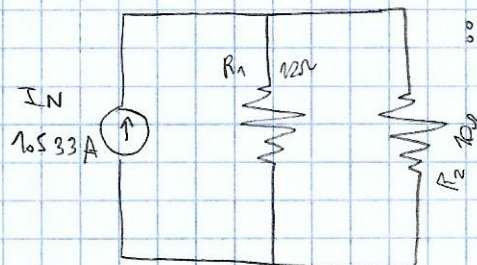
$$E_2 = I_{R1} \cdot R_2 \Rightarrow 10 = 30 I_{R1} \Rightarrow I_{R1} = \frac{1}{3}$$

$$I_N = I_{R1} + I_{R2} = \frac{1}{3} + 1.2 = 1.533A$$

התנגדות נכנסת I_N היא זרם ממוצע:



התנגדות נכנסת:



$$I_3 = I_N \cdot \frac{R_N}{R_N + R_2} =$$

302

$$1.533^\circ \frac{1^2}{12+10} = 0.836 \text{ A}$$

ע - $R_3 = R_N$ "תק"י של "תק"י והוספת ה"תק"י של R_3

הקצות R3-2 : (מחלקת הצוות)

$$I_3 = I_N \cdot \frac{R_N}{R_N + R_2}$$

$$I_3 = 1.533 \cdot \frac{12}{12+12} = 0.766 \text{ A}$$

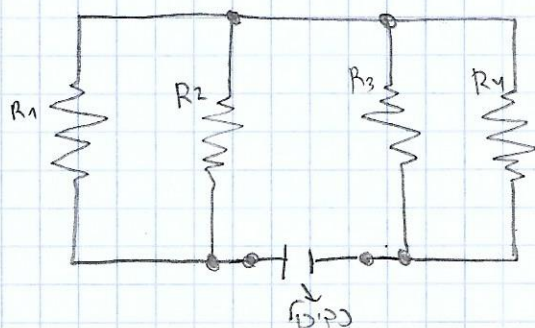
$$P_3 = 0.766^2 \cdot 12 = 7.05 \text{ W}$$

8. $\frac{1}{2}$ mile

∴ R_s-ից բայն հանա աղորակ ձգքը, R_{եդ}-ից բայն և

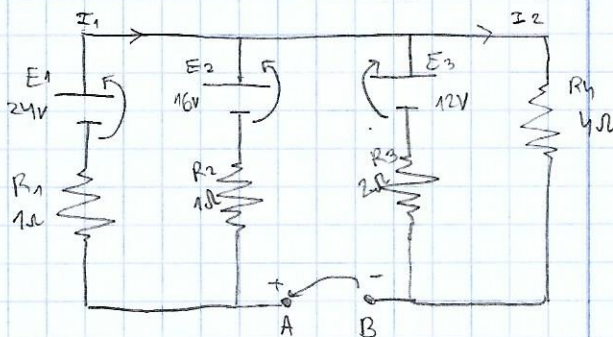
$$R_{th} = \frac{R_1 \cdot R_2}{R_1 + R_2} + \frac{R_3 \cdot R_4}{R_3 + R_4}$$

$$= \frac{1 \cdot 1}{1+1} + \frac{2 \cdot 4}{2+4} = 1.8333 \Omega$$



↓
צדקה

• Vth 2 min



קראט שט מ'זאגט ארייז, נעכט זענען וואוויס קאל אונז מוזן.

$$E = E_1 - E_2 = 24 - 16 = 8V$$

$$: \text{H} \text{C} \text{N} \text{O} \text{ } \text{F} \text{O} \text{N}$$

$$I = \frac{E}{R_1 + R_2} = \frac{8}{1+1} = 4A$$

$$U_{R2} = I \cdot R_2 = 4 \cdot 1 = 4V$$

$$I_{un} = \frac{E}{R_3 + R_4} = \frac{12}{2 + 4} = \boxed{2A}$$

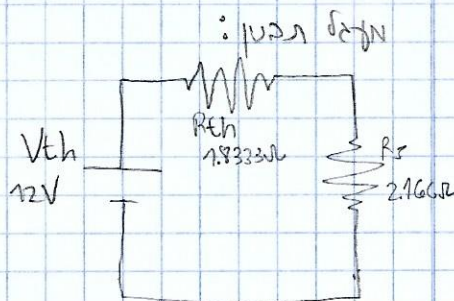
$$: \cup N' \cap \mathbb{Z} \setminus N$$

$$U_{R_3} = I_{UN'} \cdot R_3 = 2 \cdot 2 = \boxed{4 \text{ V}}$$

$$U_{AB} = -12V \leftarrow U_{AB} + \underset{\substack{\downarrow \\ 4}}{U_{R2}} + \underset{\substack{\downarrow \\ 16}}{E_2} - \underset{\substack{\downarrow \\ 12}}{E_3} + \underset{\substack{\downarrow \\ 4}}{U_{R3}} = 0 \quad : \text{ '3N10) } \text{C1AF } \text{P1007P}$$

-6-

$$I = \frac{V_{th}}{R_{th} + R_s} = \frac{12}{1.833 + 2.166} = 3 \text{ A}$$

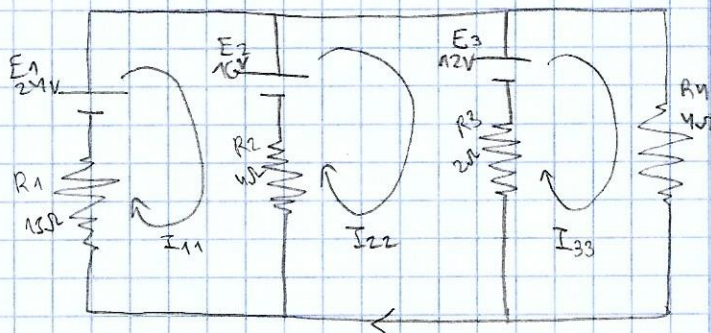


$I_N \rightarrow 10 \text{ A}$, $R_2 \rightarrow 10 \text{ } \Omega$, $R_N = R_{th} = 1.833\Omega$ μG $R_N \rightarrow 10 \text{ } \Omega$

μG $R_N \rightarrow 10 \text{ } \Omega$

$$\begin{cases} E_1 - E_2 = I_{11} \cdot R_1 + (I_{11} - I_{22}) R_2 \\ E_2 - E_3 = (I_{22} - I_{11}) R_2 + (I_{22} - I_{33}) R_3 \\ E_3 = I_{33} \cdot R_4 + (I_{33} - I_{22}) R_3 \end{cases}$$

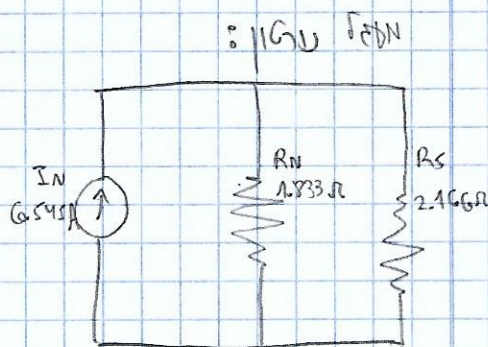
$$\begin{cases} 8 = 2 I_{11} - 1 I_{22} + 0 I_{33} \\ 4 = -1 I_{11} + 3 I_{22} - 2 I_{33} \\ 12 = 0 I_{11} - 2 I_{22} + 6 I_{33} \end{cases}$$



$$I_{22} = 0.545 \text{ A}$$

$$I_{RS} = I_N \cdot \frac{R_N}{R_N + R_s} = 0.545 \cdot \frac{1.833}{1.833 + 2.166}$$

$$= 3 \text{ A}$$

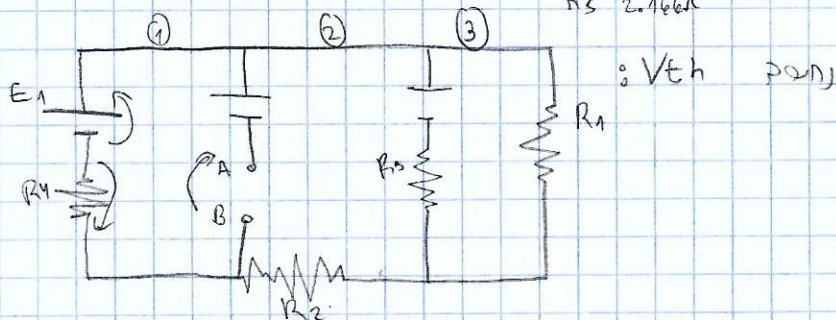
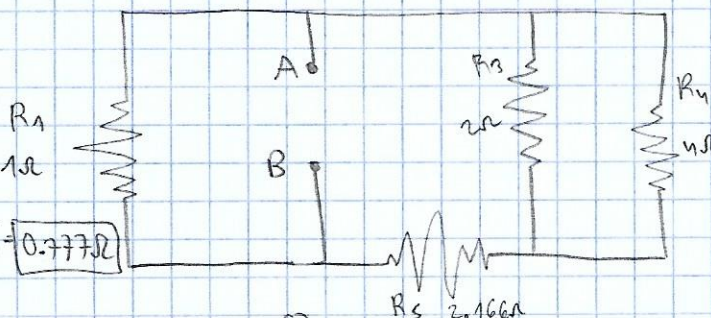


$R_2 \rightarrow 10 \text{ } \Omega$, $R_N \rightarrow 10 \text{ } \Omega$, $R_2 \rightarrow 10 \text{ } \Omega$, $R_N \rightarrow 10 \text{ } \Omega$, $R_2 \rightarrow 10 \text{ } \Omega$, $R_N \rightarrow 10 \text{ } \Omega$

$$R_{34} = \frac{R_3 \cdot R_4}{R_3 + R_4} = \frac{2 \cdot 4}{2 + 4} = \frac{8}{6} = \frac{4}{3} \Omega$$

$$R_{345} = R_{34} + R_5 = \frac{4}{3} + 2.166 = 3.499 \Omega$$

$$R_{th} = R_{1345} = \frac{R_1 \cdot R_{345}}{R_1 + R_{345}} = \frac{1 \cdot 3.499}{1 + 3.499} = 0.777 \Omega$$



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$$U_{R1} = \frac{R_1}{E_1 \cdot R_1 + R_4 + R_5} = \frac{1}{24 \cdot 1 + 4 + 2 \cdot 166}$$

רבי מחלקת המנהל

ר"ד

$$= 3.349 V$$

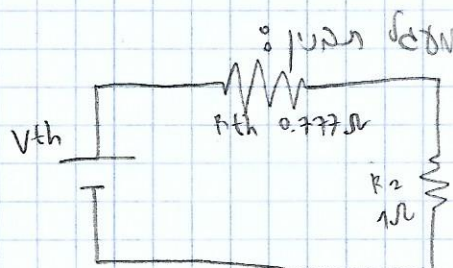
∴ V_{AB} למחלקת ① של קורבנות

$$U_{AB} + E_2 - E_1 + U_{R1} = 0$$

$$U_{AB} + 16 - 24 + 3.349 = 0$$

$$U_{AB} = 4.651 V$$

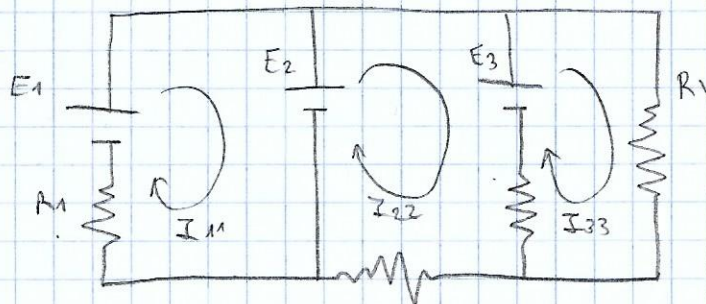
$$I = \frac{V_{th}}{R_{th} + R_2} = \frac{4.651}{0.777 + 1} = 2.5 A$$



$R_N = R_{th} = 0.777 \Omega$ - סכום ההתנגדות

נקודת אי-זרם I_N - נקודת אי-זרם

$$\begin{cases} E_1 - E_2 = I_{11} \cdot R_1 \\ E_2 - E_3 = (I_{22} - I_{33}) R_3 + I_{22} \cdot R_5 \\ E_3 = I_{33} \cdot R_4 + (I_{33} - I_{22}) \cdot R_3 \\ I_{11} = 8 \\ 4 = 166 I_{22} - 2 I_{33} \\ 12 = -2 I_{22} + 6 I_{33} \end{cases}$$



$$I_{22} = 2.286 A$$

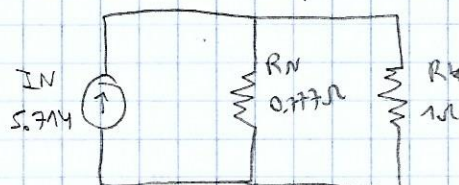
$$I_{33} = 2.762 A$$

$$I_N = I_{11} - I_{22} = 8 - 2.286 = 5.714 A \leftarrow$$

$$I_1 = I_N \cdot \frac{R_N}{R_N + R_2} = 5.714 \cdot \frac{0.777}{0.777 + 1} = 2.5 A$$

∴ פתרון המערכת

∴ סכום ההתנגדות



$$I = \frac{V_{th}}{R_{th} + R_5} = \frac{12}{1.833 + 1.166} = 4 A$$

$$R_5 = 1.166 \Omega$$

∴

$$I = 6.545 \cdot \frac{1.833}{1.833 + 1.166} = 4 A$$

R_5 - נקודת אי-זרם