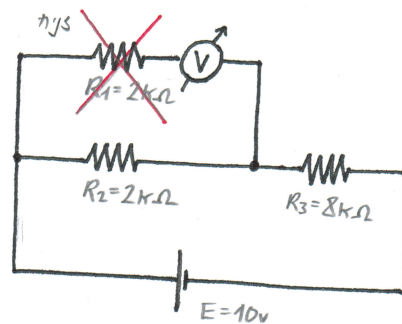


עבודה - תורת החשמל - מעגלי זרם ישיר - חלק 1

- 1 * מושתטת אידיאלי הינו בעל התנגדות אינסופית
 (R₀) = ∞Ω ולכן קרק הנקד R₁, המחובר בטור
 למושתטת לא זורם כלל זרם.
 מה שיותר אומתן עם מעגל אחר בסוג.

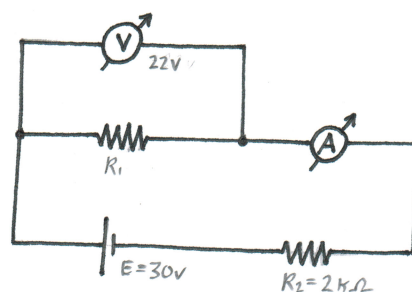
$$V = E \frac{R_2}{R_2 + R_3} = 10 \cdot \frac{2 \cdot 10^3}{(2+8) \cdot 10^3} = \boxed{2V}$$



2 $E = U_{R1} + U_{R2}$
 $30 = 22 + U_{R2}$
 $U_{R2} = \boxed{8V}$

$$I_{R2} = \frac{U_{R2}}{R_2} = \frac{8}{2 \cdot 10^3} = 0.004$$

$$I = \boxed{4mA}$$



3 $U_{R1} = 20V$
 $U_{R2} = 5V$
 $R_1 = 32k\Omega$
 $I_{R1} = I_{R2}$ (חייב)

$$I_{R1} = \frac{U_{R1}}{R_1} = \frac{20}{32 \cdot 10^3} = \boxed{625\mu A}$$

$$R_2 = \frac{U_{R2}}{I_{R1}} = \frac{5}{625 \cdot 10^{-6}} = \boxed{8k\Omega}$$

4 $U_3 = \frac{P_3}{I_3} = \frac{17.6}{0.8} = \boxed{22V}$

$$U_2 = U_3 = \boxed{22V}$$

$$I_2 = \frac{U_2}{R_2} = \frac{22}{8.8} = \boxed{2.5A}$$

$$I_1 = I_2 + I_3 = 0.8 + 2.5 = \boxed{3.3A}$$

$$I_1 = \boxed{3.3A}$$

$$U_{R1} = I_1 \cdot R_1 = 3.3 \cdot 4$$

$$U_{R1} = \boxed{13.2V}$$

24 $E = U_1 + U_{2,3} = 22 + 13.2$

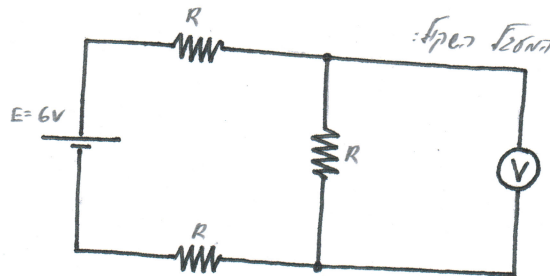
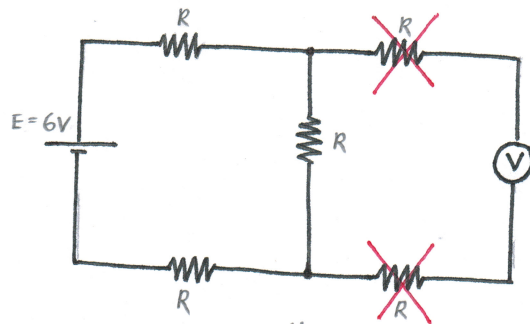
$$E = \boxed{35.2V}$$

34 $R_T = \frac{E}{I_T} = \frac{35.2}{3.3}$

$$R_T = \boxed{10.666\Omega}$$

13

* מאחר ופוטנציאל איקואלי קיימת בתנאים
אנטיסימטריים, 2 הנגדים החתומים באות
למסלול המסלול הנגדים (00+2R=00).



$$U_R = \frac{E}{3} = \frac{6}{3}$$

$$U_R = 2V$$

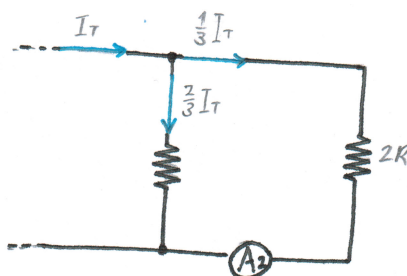
14

$$(A_1) = I_T = 3A$$

נקודה נכונה של חוק מחלקת הזרם:

$$(A_2) = I_T \cdot \frac{R}{R + (2R)} = 3 \cdot \frac{R}{3R}$$

$$(A_2) = 1A$$



עם KVL במסלול העליון מתקבל:

15

$$I_{1max} = \sqrt{\frac{P_1}{R_1}} = \sqrt{\frac{8}{2}} = 2A$$

$$I_{2max} = \sqrt{\frac{P_2}{R_2}} = \sqrt{\frac{3}{6}} = 0.707A$$

$$I_{3max} = \sqrt{\frac{P_3}{R_3}} = \sqrt{\frac{3}{3}} = 1A$$

$$I_{3max} = I_T = 1A$$

* נבדוק תחילה את הזרם המקסימלי
שניתן להעביר דרך כל נגד.
מאחר ו- R_3 מהווה זרואר בקבוק
והזרם המקסימלי דרכו הוא 1A
נבדוק אם זרם זה מתאים
לשא המצומת ואינו עולה על הזרם
המקסימלי ב- R_1 או ב- R_2 .

$$I_1 = I_T \cdot \frac{R_2}{R_1 + R_2} = 1 \cdot \frac{6}{2+6} = \frac{3}{4} = 0.75A$$

$$I_2 = I_T \cdot \frac{R_1}{R_1 + R_2} = 1 \cdot \frac{2}{2+6} = \frac{1}{4} = 0.25A$$

מתקבל שזרם $I_T = I_{3max}$ הזרם באשר
המצומת לא עובר את הערך המותר.
 $I_1 < I_{1max}$ וכן $I_2 < I_{2max}$

1A]

$$U_{AB} = (U_{1,2} + U_3) = (I_T \cdot R_{1,2} + I_T \cdot R_3) = (1 \cdot 1.5 + 1 \cdot 3)$$

$$U_{ABmax} = 4.5V$$

$$R_{1,2} = R_1 \parallel R_2 = 2 \parallel 6$$

$$R_{1,2} = 1.5\Omega$$

22 $I_T = \frac{U_{R_1}}{R_1} = \frac{3}{3}$ $U_{R_1} = 3V$ $R_1 = 3\Omega$

$I_T = 1A$

$R_T = R_1 + (R_2 \parallel R_3) + R_4 + (R_5 \parallel R_6) + R_7$

$R_T = 3 + (4 \parallel 6) + 5 + (2 \parallel 8) + 3$

$R_T = 3 + 2.4 + 5 + 1.6 + 3$

$R_T = 15\Omega$

$E = I_T \cdot R_T = 1 \cdot 15$

$E = 15V$

$I_{R_6} = I_T \cdot \frac{R_5}{R_5 + R_6}$

$I_{R_6} = 1 \cdot \frac{2}{2+8} = \frac{1}{5}$

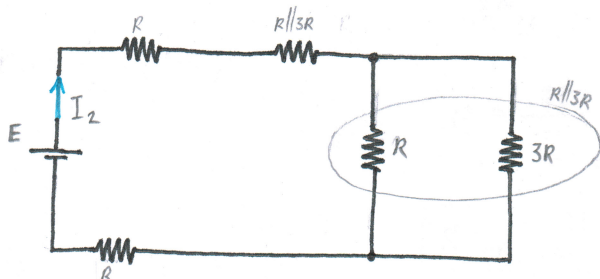
$I_{R_6} = 0.2A$

$P_{R_6} = I_{R_6}^2 \cdot R_6 = 0.2^2 \cdot 8$

$P_{R_6} = 0.32W$

23

(S) $2 \parallel 3N$ $2 \parallel 3N$



$R_{T_2} = R + R \parallel 3R + R \parallel 3R + R$

$R_{T_2} = 2R + 2 \cdot (R \parallel 3R)$

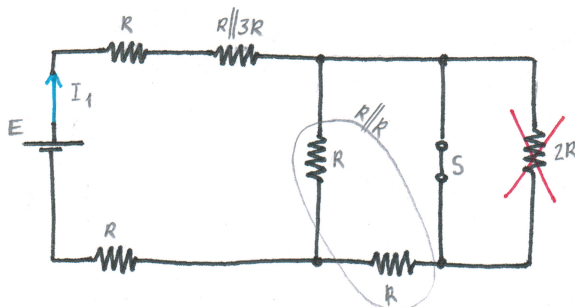
$R_{T_2} = 2R + 2 \left(\frac{R \cdot 3R}{R+3R} \right)$

$R_{T_2} = 2R + 2 \cdot \frac{3}{4}R$

$R_{T_2} = 3.5R$

$I_2 = \frac{E}{R_{T_2}} = \frac{E}{3.5R}$ $\frac{1}{8} \quad 4A$

(S) $1 \parallel 2N$ $1 \parallel 2N$



$R_{T_1} = R + R \parallel 3R + R \parallel R + R$

$R_{T_1} = 2R + \left(\frac{R \cdot 3R}{R+3R} \right) + \frac{R}{2}$

$R_{T_1} = 2.5R + \frac{3}{4}R$

$R_{T_1} = 3.25R$

$I_1 = \frac{E}{R_{T_1}} = \frac{E}{3.25R}$

$\frac{I_1}{I_2} = \frac{\frac{E}{3.25R}}{\frac{E}{3.5R}} = \frac{3.5R}{3.25R} = \frac{3.5}{3.25} = 1.0769$

$(1 - 1.0769) \cdot 100\% = 7.69\%$

* הז'רת המסך S - הסר
7.69% - 7.69%

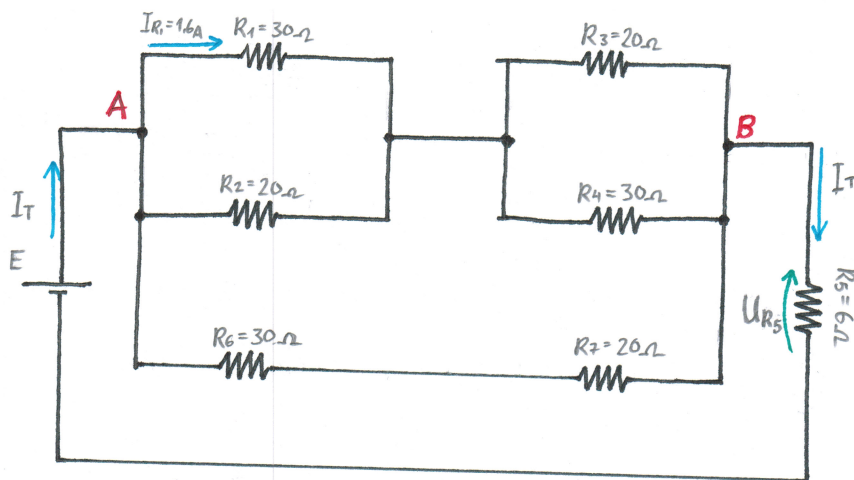
26

$$I_{R1} = 1.6A$$

$$R_1 = R_4 = 30\Omega$$

$$R_2 = R_3 = 20\Omega$$

$$R_1 \parallel R_2 = R_3 \parallel R_4$$

$$1/12$$


$$- R_{1,2} = R_1 \parallel R_2 = (30^{-1} + 20^{-1})^{-1}$$

$$R_{1,2} = 12\Omega$$

$$R_{3,4} = R_{1,2} = 12\Omega$$

$$- R_{1,2,3,4} = R_{1,2} + R_{3,4} = 12 + 12$$

$$R_{1,2,3,4} = 24\Omega$$

$$R_{6,7} = R_6 + R_7 = 30 + 20$$

$$R_{6,7} = 50\Omega$$

$$R_{1-7} = R_{1,2,3,4} \parallel R_{6,7} = (24^{-1} + 50^{-1})^{-1}$$

$$R_{1-7} = 16.216\Omega$$

$$U_{R1} = I_{R1} \cdot R_1 = 1.6 \cdot 30 = 48V$$

$$R_{1,2} = R_{3,4}$$

התחבורה
ב- Γ A / Ω

$$U_{1,2} = U_{3,4} = 48V$$

$$U_{AB} = U_{6,7} = U_{1,2,3,4} = (U_{1,2} + U_{3,4}) = (48 + 48)$$

$$U_{AB} = 96V$$

$$I_T = \frac{U_{AB}}{R_{1-7}} = \frac{96}{16.216} = 5.92A$$

$$U_{R5} = I_T \cdot R_5 = 5.92 \cdot 6 = 35.52V$$

$$E = U_{AB} + U_{R5} = 96 + 35.52$$

$$E = 131.52V$$

27

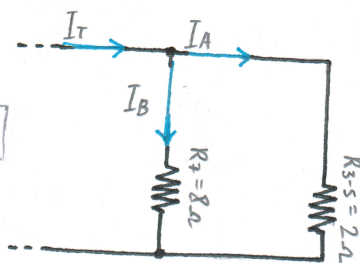
$$R_{3,4,5} = R_3 + R_4 + R_5 = 0.7 + 1 + 0.3 = 2\Omega$$

$$R_{3-5,7} = R_{3-5} \parallel R_7 = (2^{-1} \cdot 8^{-1})^{-1} = 1.6\Omega$$

$$R_T = R_1 + R_2 + R_6 + R_{3-5,7} = 1 + 0.1 + 0.3 + 1.6$$

$$R_T = 3\Omega$$

$$I_T = \frac{E}{R_T} = \frac{12}{3} = 4A$$



$$I_A = I_T \cdot \frac{R_7}{R_7 + R_{3-5}} = 4 \cdot \frac{8}{8+2} = 3.2A$$

$$I_B = I_T - I_A = 4 - 3.2 = 0.8A$$

$$U_{R4} = I_A \cdot R_4 = 3.2 \cdot 1 =$$

$$U_{R4} = 3.2V$$

$$P_{R7} = I_B^2 \cdot R_7 = 0.8^2 \cdot 8$$

$$P_{R7} = 5.12W$$

28

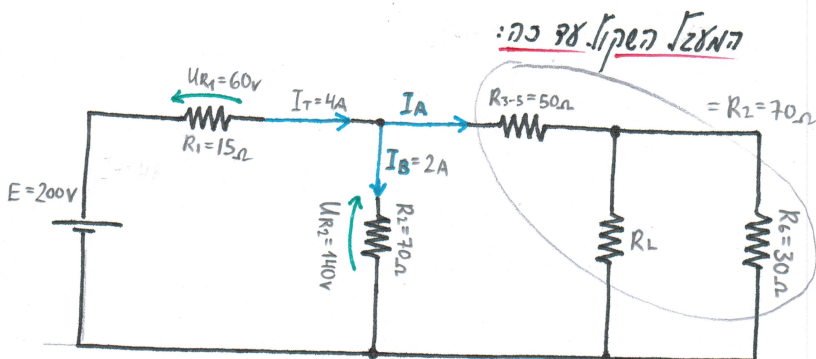
$$\underline{U_{R_2}} = I_{R_2} \cdot R_2 = 2 \cdot 70 = \boxed{140V}$$

$$\underline{U_{R_1}} = E - U_{R_2} = 200 - 140 = \boxed{60V}$$

$$\underline{I_T} = \frac{U_{R_1}}{R_1} = \frac{60}{15} = \boxed{4A}$$

$$R_{3,4,5} = R_3 + R_4 \parallel R_5 = 20 + (40^{-1} + 120^{-1})^{-1}$$

$$\boxed{R_{3,4,5} = 50\Omega}$$



$$I_A = I_T - I_B$$

$$I_A = 4 - 2 \Rightarrow$$

$$\boxed{I_A = 2A}$$

לפיכך התפלגות סטנדרטית

:כך (IA = IB = 2A) נקבע

$$R_{3-6,L} = R_2 = 70\Omega$$

$$R_{3-5} + R_6 \parallel R_L = 70$$

$$50 + \frac{30 \cdot R_L}{30 + R_L} = 70$$

$$30R_L = 20(30 + R_L)$$

$$30R_L - 20R_L = 600$$

$$R_L = \frac{600}{10}$$

$$\boxed{R_L = 60\Omega}$$

$$I_{R_L} = I_A \cdot \frac{R_6}{R_L + R_6} =$$

$$I_{R_L} = 2 \cdot \frac{30}{60 + 30} = \frac{2}{3}$$

$$\boxed{I_{R_L} = 0.666A}$$

$$P_{R_L} = I_{R_L}^2 \cdot R_L = 0.666^2 \cdot 60 = \frac{80}{3}$$

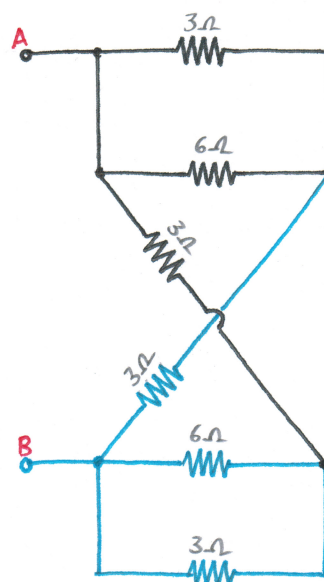
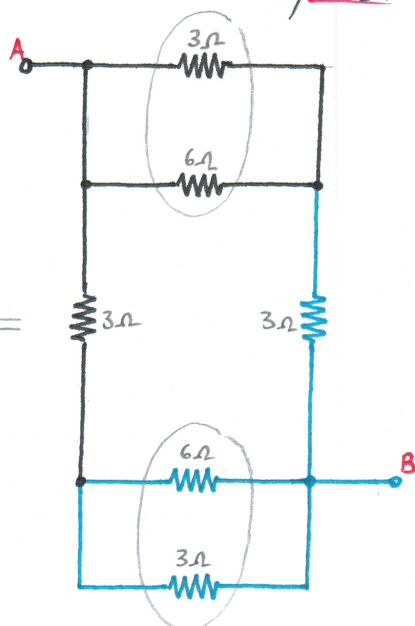
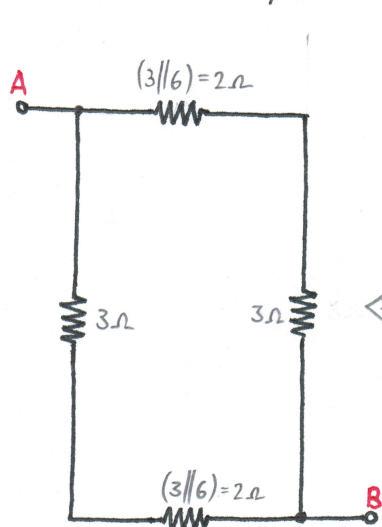
$$\boxed{P_{R_L} = 26.666W}$$

29

הקבוצה 1: 3Ω

הקבוצה 2: 6Ω

הקבוצה 3: 3Ω



$$3 \parallel 6 = (3^{-1} + 6^{-1})^{-1} = 2 \Omega$$

$$R_{AB} = (2+3) \parallel (2+3) = 5 \parallel 5 = \frac{5}{2}$$

$$R_{AB} = 2.5 \Omega$$

30

$$R_{1,2} = R_1 \parallel R_2 = (3^{-1} + 6^{-1})^{-1} = 2 \Omega$$

$$R_{1,2,3} = R_{1,2} + R_3 = 2 + 4 = 6 \Omega$$

$$R_{1-4} = R_{1,2,3} \parallel R_4 = 6 \parallel 6 = \frac{6}{2} = 3 \Omega$$

$$R_T = R_{1-4} + R_5 = 3 + 3 = 6 \Omega$$

$$R_{1-4} = R_5 \quad : [KVL] \text{ ד"ר}$$

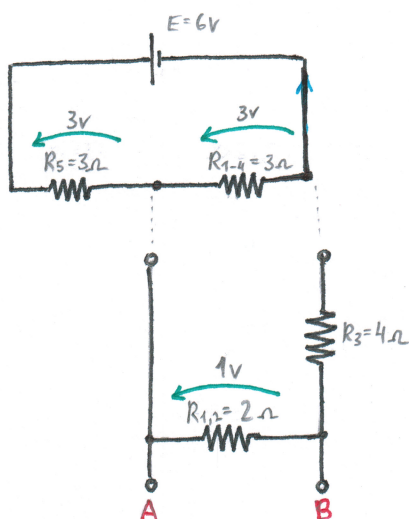
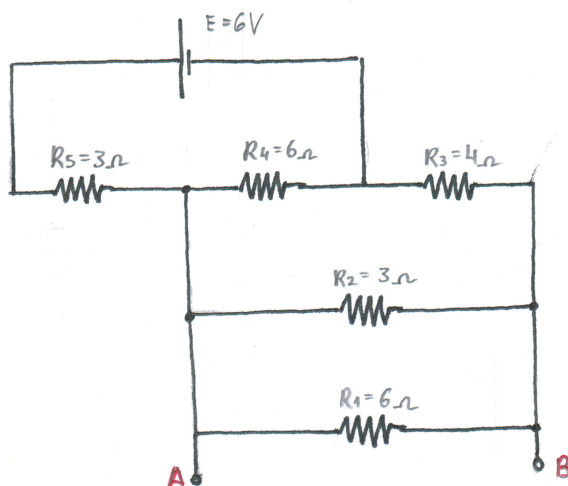
$$U_{1-4} = U_5 = \frac{E}{2} = \frac{6}{2}$$

$$U_{1-4} = 3V$$

$$U_{1,2} = U_{1-4} \frac{R_{1,2}}{R_{1,2} + R_3}$$

$$U_{1,2} = 3 \cdot \frac{2}{2+4} = 1V$$

$$U_{AB} = U_{1,2} = 1V$$

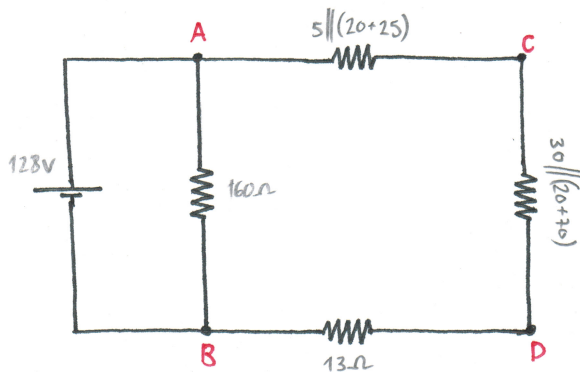
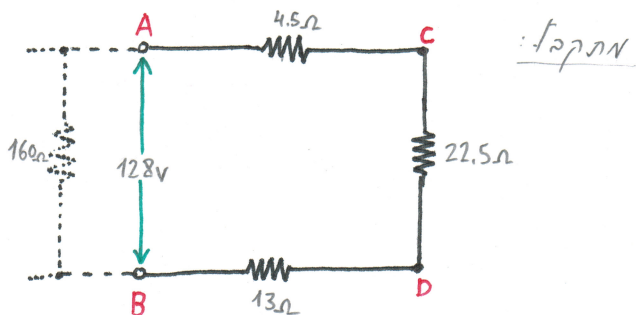


31

נחשב תחילה את הנקודות השקולות:

$$5 \parallel (20+25) = (5^{-1} + 45^{-1})^{-1} = 4.5 \Omega$$

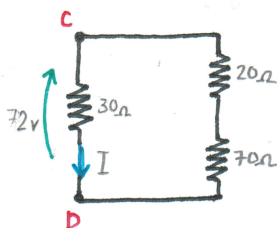
$$30 \parallel (20+70) = (30^{-1} + 90^{-1})^{-1} = 22.5 \Omega$$



נחשב את הנקודה CD - במקרה המקורי:

$$U_{AB} = 128V$$

$$U_{CD} = U_{AB} \cdot \frac{22.5}{13 + 22.5 + 4.5} = 72V$$



$$I = \frac{U_{CD}}{30} = \frac{72}{30}$$

$$I = 2.4A$$

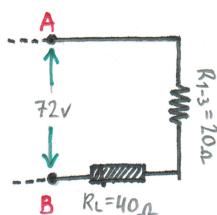
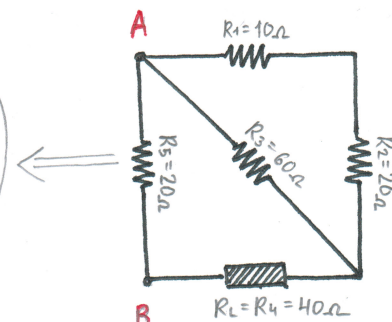
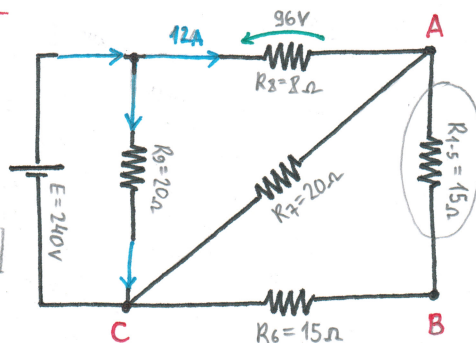
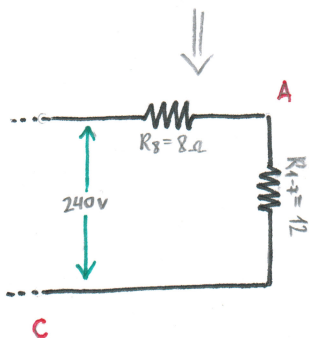
32

נחשב תחילה את הנקודות במקרה:

$$R_{1,2,3} = (R_1 + R_2) \parallel R_3 = (10 + 20) \parallel 60 = 20 \Omega$$

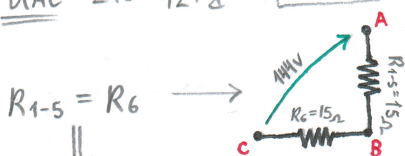
$$R_{1-5} = (R_{1-3} + R_4) \parallel R_5 = (20 + 40) \parallel 20 = 15 \Omega$$

$$R_{1-7} = (R_{1-5} + R_6) \parallel R_7 = (15 + 15) \parallel 20 = 12 \Omega$$



$$U_{AC} = E \cdot \frac{R_{1-7}}{R_{1-7} + R_8}$$

$$U_{AC} = 240 \cdot \frac{12}{12 + 8} = 144V$$



$$U_{R_{1-5}} = \frac{U_{AC}}{2} = \frac{144}{2} = 72V$$

$$U_{AB} = U_{R_{1-5}} = 72V$$

$$U_{RL} = U_{AB} \cdot \frac{R_L}{R_L + R_{1-3}}$$

$$U_{RL} = 72 \cdot \frac{40}{40 + 20}$$

$$U_{RL} = 48V$$

$$P_{RL} = \frac{U_{RL}^2}{R_L} = \frac{48^2}{40}$$

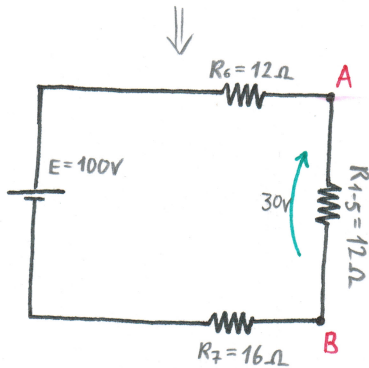
$$P_{RL} = 57.6W$$

12

33 $V_0 = U_{R_5}$: נקודה 17

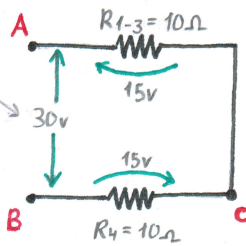
$$R_{1,2,3} = (R_1 + R_2) \parallel R_3 = (15 + 5) \parallel 20 = \frac{20}{2} = 10 \Omega$$

$$R_{1-5} = (R_{1,2,3} + R_4) \parallel R_5 = (10 + 10) \parallel 30 = 12 \Omega$$



$$U_{R_{1-5}} = E \cdot \frac{R_{1-5}}{R_{1-5} + R_6 + R_7} = 100 \cdot \frac{12}{12 + 12 + 16} = 30 \text{ V}$$

$$U_{AB} = U_{R_{1-5}} = 30 \text{ V}$$

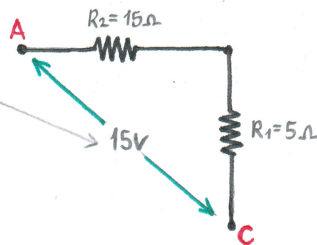


$$R_{1-5} = R_4$$



$$U_{R_{1-3}} = \frac{U_{AB}}{2} = \frac{30}{2} = 15 \text{ V}$$

$$U_{AC} = U_{R_{1-3}} = 15 \text{ V}$$



$$U_{R_1} = U_{AC} \cdot \frac{R_1}{R_1 + R_2} = 15 \cdot \frac{5}{5 + 15} = 3.75 \text{ V}$$

$$V_0 = U_{R_1} = 3.75 \text{ V}$$

ס'מין / נקודות חיוניים במעגל:

