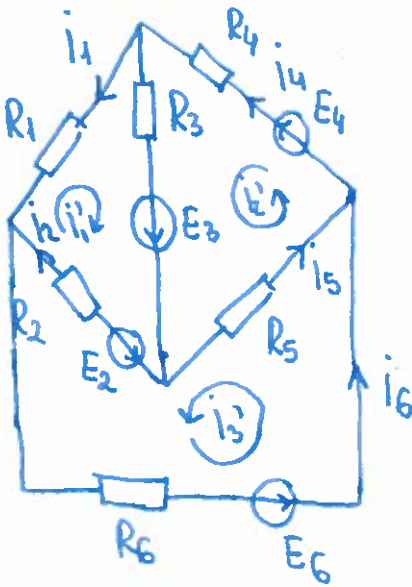


①



R (Ω)	i (A)	E (V)
R ₁ = 2	1	
R ₂ = 10	2	E ₂ = 11
R ₃ = 4	4	E ₃ = 23
R ₄ = 3	5	E ₄ = 10
R ₅ = 1	2	
R ₆ = 3	3	E ₆ = 10

N=4
B=6
L=3

l₁: b₁, b₂, b₃
 l₂: b₃, b₅, b₄
 l₃: b₂, b₆, b₅

$$\begin{cases} R_{11}i_1' + R_{12}i_2' + R_{13}i_3' = E_1' \\ R_{21}i_1' + R_{22}i_2' + R_{23}i_3' = E_2' \\ R_{31}i_1' + R_{32}i_2' + R_{33}i_3' = E_3' \end{cases}$$

$$\begin{bmatrix} R_{11} & R_{12} & R_{13} \\ R_{21} & R_{22} & R_{23} \\ R_{31} & R_{32} & R_{33} \end{bmatrix} \begin{bmatrix} i_1' \\ i_2' \\ i_3' \end{bmatrix} = \begin{bmatrix} E_1' \\ E_2' \\ E_3' \end{bmatrix}$$

R₁₁ = R₁ + R₂ + R₃ = 2 + 10 + 4 = 16 Ω

R₂₂ = R₃ + R₄ + R₅ = 8 Ω

R₃₃ = R₂ + R₆ + R₅ = 14 Ω

E₁' = E₂ + E₃ = 34 V

E₂' = E₃ + E₄ = 33 V

E₃' = E₂ + E₆ = 27 V

R₁₂ = R₂₁ = +R₃ = 4 Ω

R₂₃ = R₃₂ = -R₅ = -1 Ω

R₁₃ = R₃₁ = +R₂ = 10 Ω

$$\begin{cases} 16i_1' + 4i_2' + 10i_3' = 34 \\ 4i_1' + 8i_2' - 1i_3' = 33 \quad | \cdot 5 \quad | \cdot 14 \\ 10i_1' - i_2' + 14i_3' = 27 \end{cases}$$

$$\begin{cases} 8i_1' + 2i_2' + 5i_3' = 17 \\ 28i_1' + 42i_2' = 182 \\ 66i_1' + 111i_2' = 489 \end{cases} \quad \begin{cases} 14i_1' + 21i_2' = 91 \quad | \cdot 11 \\ 22i_1' + 37i_2' = 163 \quad | \cdot 7 \end{cases}$$

$$i_2' (21 \cdot 11 - 37 \cdot 7) = -163 \cdot 7 + 91 \cdot 11$$

$$-28i_2' = -140 \quad i_2' = 5 \text{ A}$$

$$14i_1' + 105 = 91 \Rightarrow 14i_1' = -14 \Rightarrow i_1' = -1 \text{ A}$$

$$-4 + 40 - i_3' = 33 \Rightarrow i_3' = 3 \text{ A}$$

$$J_1 = -i_1' = 1 \text{ A}$$

$$J_2 = +i_1' + i_3' = 2 \text{ A}$$

$$J_3 = +i_1' + i_2' = 4 \text{ A}$$

$$J_4 = +i_2' = 5 \text{ A}$$

$$J_5 = +i_2' - i_3' = 2 \text{ A}$$

$$J_6 = +i_3' = 3 \text{ A}$$

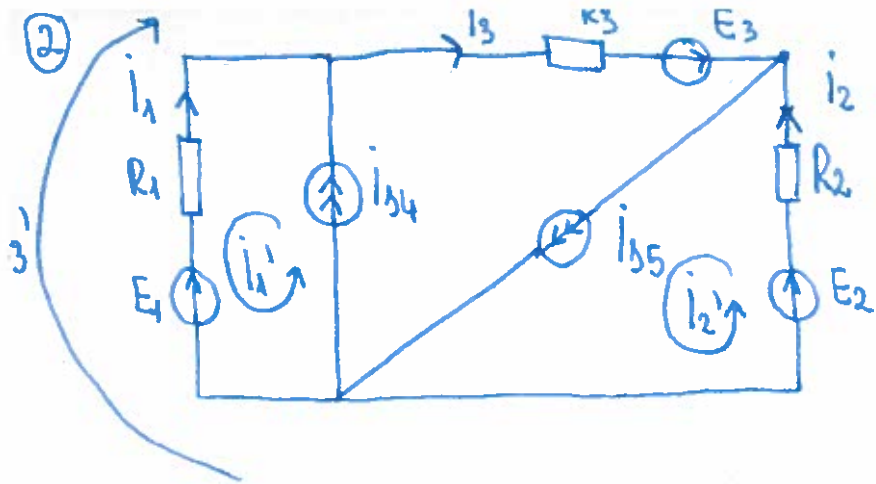
Power Balance

$$P_{\text{gen.}} = P_{\text{rec.}}$$

$$P_{\text{gen.}} = E_2 i_2 + E_3 i_3 + E_4 i_4 + E_6 i_6 = 22 + 92 + 50 + 48 = 212 \text{ W}$$

$$P_{\text{rec.}} = R_1 i_1^2 + R_2 i_2^2 + \dots + R_6 i_6^2 = 2 + 40 + 64 + 75 + 4 + 27 = 212 \text{ W}$$

Homework: Kirchhoff on this circuit



$R(\Omega)$	$i(A)$	$E(V)$
$R_1 = 2$	3	$E_1 = 12$
$R_2 = 1$	6	$E_2 = 24$
$R_3 = 2$	9	$E_3 = 3$
	$i_{14} = 6$	$U_{14} = 6$
	$i_{15} = 15$	$U_{15} = -18$

- $l_1 : \underline{b_1}, b_4$
- $l_2 : \underline{b_2}, b_5$
- $l_3 : \underline{b_1}, \underline{b_2}, b_3$

$$\left\{ \begin{array}{l} l_1 : i_1' = I_{14} = 6A \\ l_2 : I_2' = I_{15} = 15A \\ R_{31} i_1' + R_{32} i_2' + R_{33} i_3' = E_3' \end{array} \right.$$

$$R_{31} = -R_1 = -2 \Omega$$

$$R_{32} = -R_2 = -1 \Omega$$

$$R_{33} = R_1 + R_2 + R_3 = 5 \Omega$$

$$E_3' = E_1 + E_3 - E_2 = 18V$$

$$\rightarrow -12 - 15 + 5I_3' = 18 \Rightarrow 5I_3' = 45 \Rightarrow I_3' = 9A$$

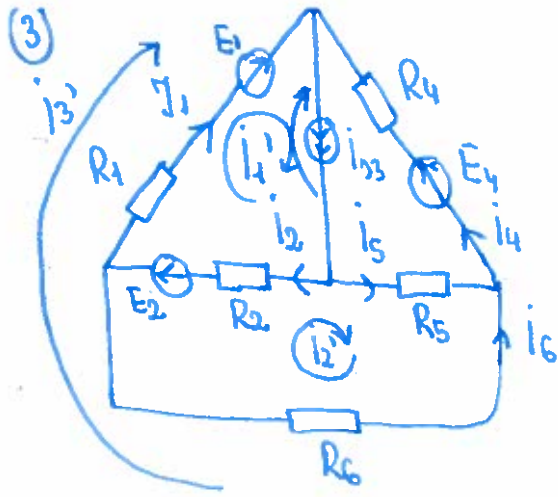
$$i_1 = I_3' - i_1' = 9 - 6 = 3A$$

$$i_2 = I_2' - I_3' = 15 - 9 = 6A$$

$$i_3 = I_3' = 9A$$

$$U_{14} = E_1 - R_1 i_1 = 6V$$

$$U_{15} = i_2 R_2 - E_2 = -18V$$



$R(\Omega)$	$i(A)$	$E(V)$
$R_1 = 3$		$E_1 = 3$
$R_2 = 3$		$E_2 = 49$
	$i_{n3} = 3$	$U_{n3} = -10$
$R_4 = 1$		$E_4 = 2$
$R_5 = 1$		
$R_6 = 10$		

$$l_1: \underline{b_1}, \underline{b_2}, b_3$$

$$l_2: \underline{b_2}, b_5, \underline{b_6}$$

$$l_3: \underline{b_1}, b_4, \underline{b_6}$$

$$i_1' = i_{n3} = 3A$$

$$\begin{cases} R_{21} i_1' + R_{22} i_2' + R_{23} i_3' = E_2' \\ R_{31} i_1' + R_{32} i_2' + R_{33} i_3' = E_3' \end{cases}$$

$$R_{21} = R_{12} = -R_2 = -3\Omega$$

$$R_{22} = +R_2 + R_5 + R_6 = 14\Omega$$

$$R_{23} = R_6 = 10\Omega$$

$$R_{31} = +R_1 = 3\Omega$$

$$R_{32} = R_6 = 10\Omega$$

$$R_{33} = R_1 + R_4 + R_6 = 3 + 1 + 10 = 14\Omega$$

$$E_2' = -E_2 = -49V$$

$$E_3' = E_1 - E_4 = 1V$$

$$\begin{cases} -3 \cdot 3 + 14i_2' + 10i_3' = -49 \\ 9 + 10i_2' + 14i_3' = 1 \end{cases}$$

$$i_2' = -5A$$

$$i_3' = \frac{-40 + 70}{10} = 3A$$

$$I_1 = +i_1' + i_3' = 6A$$

$$I_2 = +i_1' - i_2' = 8A$$

$$i_4 = -i_3' = -3A$$

$$i_5 = i_2' = -5A$$

$$i_6 = -i_2' - i_3' = +2A$$

$$U_{s3} - R_4 i_4 - R_5 i_5 = -E_4 \Rightarrow U_{s3} = -10V$$

$$\begin{aligned} P_{\text{gen}} &= E_1 i_1 + E_2 i_2 + U_{s3} i_3 + E_4 i_4 \\ &= 18 + 392 - 30 \cdot 6 = 374 \text{ W} \end{aligned}$$

$$\begin{aligned} P_{\text{res}} &= R_1 i_1^2 + R_2 i_2'^2 + R_4 i_4^2 + R_5 i_5^2 + R_6 i_6^2 \\ &= 108 + 192 + 9 + 25 + 40 \\ &= 374 \text{ W} \end{aligned}$$

Homework: Kirchhoff:

