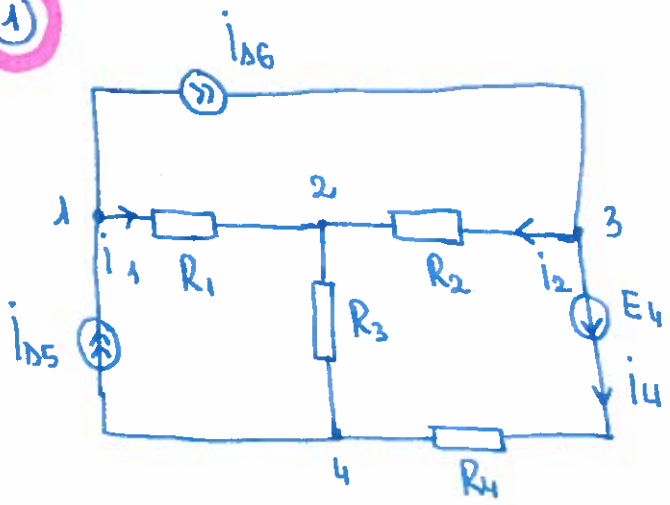
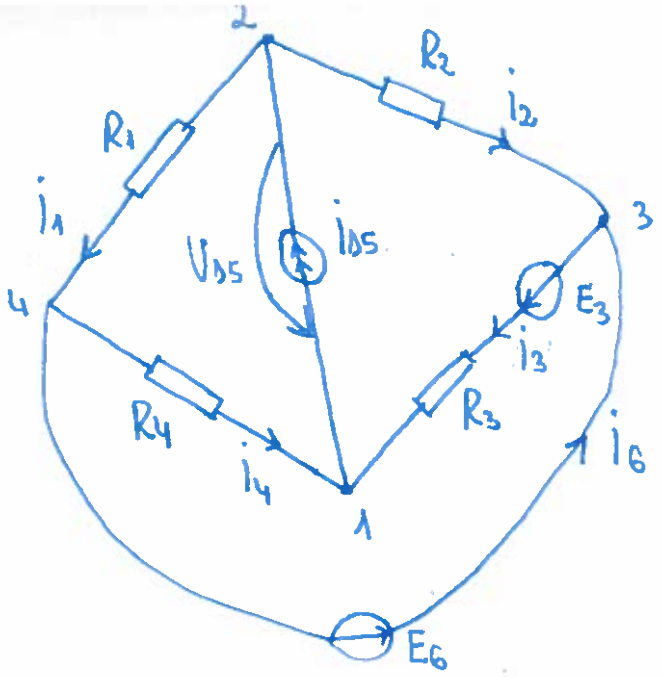
① 

$R_1 = 1$		
$R_2 = 1$		
$R_3 = 1$		
$R_4 = 1/2$		E_4
	$i_{ns5} = 3$	
	$i_{ns6} = 8$	

$V_4 = 0$

$$\begin{cases} G_{11}V_1 + G_{12}V_2 + G_{13}V_3 = J_{sc1} \\ G_{21}V_1 + G_{22}V_2 + G_{23}V_3 = J_{sc2} \\ G_{31}V_1 + G_{32}V_2 + G_{33}V_3 = J_{sc3} \end{cases}$$

②



R(Ω)	i(A)	E(V)
$R_1 = 1$	2	
$R_2 = 1$	1	
$R_3 = +2$	2	$E_3 = 2$
$R_4 = 1$	1	
	$i_{J5} = 3$	$V_{J5} = 3$
	1	$E_6 = 1$

$V_4 = 0$

$V_3 - V_4 = E_6$

$V_3 = E_6 = 1$

$$\begin{cases} G_{11}V_1 + G_{12}V_2 + G_{13}V_3 = J_{ic1} \\ G_{21}V_1 + G_{22}V_2 + G_{23}V_3 = J_{ic2} \end{cases}$$

$$G_{11} = \frac{1}{R_4} + \frac{1}{R_3} = \frac{3}{2}$$

$$G_{22} = \frac{1}{R_1} + \frac{1}{R_2} = 2$$

$G_{12} = G_{21} = 0$

$$G_{13} = -\frac{1}{R_3} = -\frac{1}{2}$$

$$G_{23} = -\frac{1}{R_2} = -1$$

$$J_{ic1} = \frac{E_3}{R_3} - J_{J5} = 1 - 3 = -2$$

$$J_{ic2} = J_{J5} = 3$$

$$\begin{cases} \frac{3}{2}V_1 - \frac{1}{2}\cdot 1 = -2 \\ 2V_2 - 1 = 3 \end{cases}$$

$3V_1 = -3 \Rightarrow V_1 = -1$

$V_2 = 2$

$V_2 - V_4 = R_1 J_1 \Rightarrow J_1 = \frac{2}{1} = 2A$

$V_2 - V_3 = R_2 J_2 \Rightarrow J_2 = \frac{2-1}{1} = 1A$

$V_3 - V_1 = R_3 i_3 - E_3 \Rightarrow i_3 = \frac{1+1+2}{2} = 2A$

$V_1 - V_4 = -R_4 i_4 \Rightarrow i_4 = \frac{-1}{-1} = 1A$

$V_2 - V_1 = U_{J5}$

$U_{J5} = 3V$

$i_6 + i_2 = i_3 \Rightarrow i_6 = 1A$

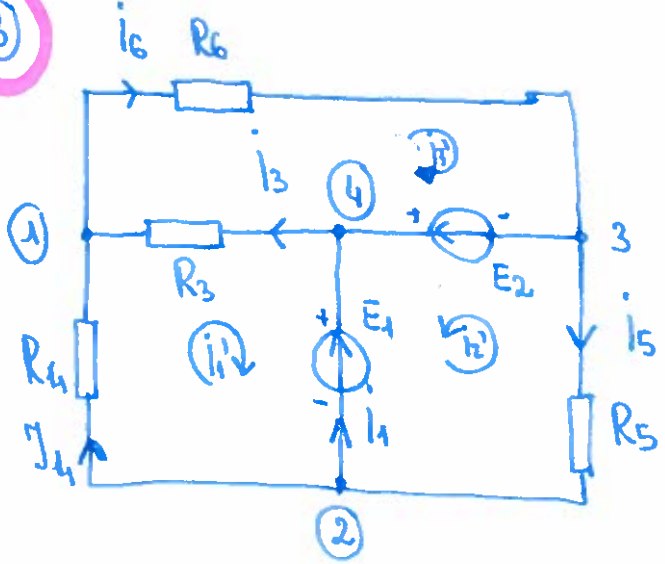
POWER BALANCE

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

$P_{rec} = R_1 J_1^2 + R_2 i_2^2 + R_3 i_3^2 + R_4 i_4^2 = 4 + 1 + 8 + 1 = 14\ W$

$P_{gen} = J_3 E_3 + U_{J5} \cdot i_{J5} + i_6 E_6 = 4 + 9 + 1 = 14\ W$

③



R(Ω)	i(A)	E(V)
R_1 =	4	$E_1 = 4$
	-2	$E_2 = 2$
$R_3 = 1$	2	
$R_4 = 1$	-2	
$R_5 = 1$	2	
$R_6 = 1$	0	

$V_4 = 0$

$G_{11} V_1 + G_{12} V_2 + G_{13} V_3 = J_{sc1}$

$G_{11} = \frac{1}{R_4} + \frac{1}{R_3} + \frac{1}{R_6} = 3$

$G_{12} = -\frac{1}{R_4} = -1$ $\qquad J_{sc1} = 0$

$G_{13} = -\frac{1}{R_6} = -1$

$V_3 - V_4 = -E_2 \Rightarrow V_3 = -2$

$V_2 - V_4 = -E_1 \Rightarrow V_2 = -4$

$3V_1 + 4 + 2 = 0$

$V_1 = -2$

$V_2 - V_1 = J_4 R_4 \Rightarrow i_4 = \frac{-4+2}{1} = -2A$

$V_3 - V_2 = J_5 R_5 \Rightarrow J_5 = \frac{-2+4}{R_5} = 2A$

$V_1 - V_3 = i_6 R_6 \Rightarrow i_6 = \frac{-2+2}{1} = 0A$

$V_4 - V_1 = i_3 R_3 \Rightarrow i_3 = 2A$

$i_6 = J_2 + J_5 \Rightarrow i_2 = J_6 - i_5 = -2A$

$i_5 = i_1 + i_4 \Rightarrow i_1 = 4$

Power Balance: $P_{rec} = P_{gen}$

$P_{rec} = R_3 i_3^2 + R_4 i_4^2 + R_5 i_5^2 + R_6 i_6^2$

$= 4 + 4 + 4 = 12\ W$

$P_{gen} = E_2 i_2 + E_1 i_1 = 16 - 4 = 12W$

Kirchoff , Loop Current

Kirchoff:

$$\begin{cases} i_1 R_1 - i_3 R_3 = -E_1 \\ -R_5 i_5 = E_2 - E_1 \\ i_3 R_3 + i_6 R_6 = E_2 \end{cases}$$

Loop Current:

l_1 : b_4, b_3

l_2 : b_5

l_3 : b_3, b_6

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

$R_{11} = R_1 - R_3 = 0$ $\quad R_{13} = R_{31} = -R_3 = -1$

$R_{12} = R_{21} = 0$ $\quad R_{33} = R_6 = 1$

$R_{22} = -R_5 = -1$

$$\begin{cases} E_1' = -E_1 = -4 \\ E_2' = E_2 - E_1 = -2 \\ E_3' = E_2 = 2 \end{cases}$$