EE209 First Midterm Exam 16 Nov 2023

First name:_____

Last name: Solh

Student ID:_____

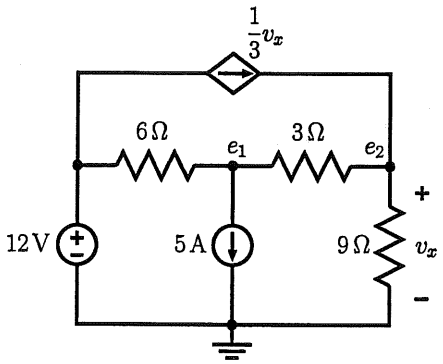
Signature:_____

Read before you start:

- There are four questions.
- The examination is closed-book.
- No computer/calculator is allowed.
- The duration of the examination is 100 minutes.
- Besides correctness, the CLARITY of your presentation will also be graded.

Q1	Q2	Q3	Q4	Total

Q1.



Find the node voltages e_1 and e_2.

Node ①: $\frac{e_1 - 12}{6} + 5 + \frac{e_1 - e_2}{3} = 0$

$\Rightarrow \frac{1}{2}e_1 - \frac{1}{3}e_2 = -3 \quad (1)$

Node ②: $\frac{e_2 - e_1}{3} + \frac{e_2}{9} - \frac{1}{3}v_x = 0$

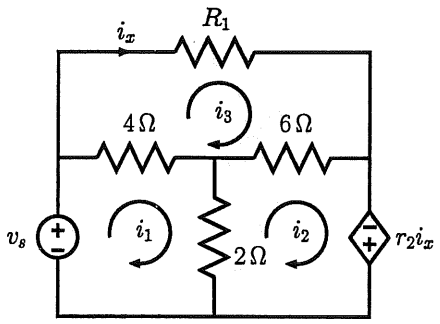
$v_x = e_2$

$\Rightarrow \frac{e_2 - e_1}{3} + \frac{e_2}{9} - \frac{e_2}{3} = 0$

$\Rightarrow -\frac{1}{3}e_1 + \frac{1}{9}e_2 = 0 \quad (2)$

(1) & (2) $\Rightarrow$ $\boxed{e_1 = 6V}$ & $\boxed{e_2 = 18V}$

Q2.



(a) Write the mesh equations in matrix form.

(b) Suppose the mesh currents are measured as $i_1 = 4\,\text{A}$, $i_2 = 3\,\text{A}$, and $i_3 = 2\,\text{A}$.

(i) Find R_1, r_2, and v_s.

(ii) Find the power supplied/absorbed by the dependent source.

a)

Mesh ①: $-v_s + 4(i_1 - i_3) + 2(i_1 - i_2) = 0$

$\Rightarrow \quad 6i_1 - 2i_2 - 4i_3 = v_s \qquad (1)$

Mesh ②: $2(i_2 - i_1) + 6(i_2 - i_3) - r_2 i_x = 0$

$i_x = i_3$

$\Rightarrow \quad 2(i_2 - i_1) + 6(i_2 - i_3) - r_2 i_3 = 0$

$\Rightarrow \quad -2i_1 + 8i_2 - (r_2 + 6) i_3 = 0 \qquad (2)$

Mesh ③: $4(i_3 - i_1) + R_1 i_3 + 6(i_3 - i_2) = 0$

$\Rightarrow \quad -4i_1 - 6i_2 + (R_1 + 10) i_3 = 0 \qquad (3)$

(1), (2), (3) implies

$$\begin{bmatrix} 6 & -2 & -4 \\ -2 & 8 & -(r_2+6) \\ -4 & -6 & R_1+10 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ i_3 \end{bmatrix} = \begin{bmatrix} v_s \\ 0 \\ 0 \end{bmatrix}$$

b) i)

(1) $\Rightarrow 6 \cdot 4 - 2 \cdot 3 - 4 \cdot 2 = v_s$

$\Rightarrow$ **$v_s = 10\,\text{V}$**

(2) $\Rightarrow -2 \cdot 4 + 8 \cdot 3 - (r_2 + 6) \cdot 2 = 0$

$\Rightarrow$ **$r_2 = 2\,\Omega$**

(3) $\Rightarrow -4 \cdot 4 - 6 \cdot 3 + (R_1 + 10) \cdot 2 = 0$

$\Rightarrow$ **$R_1 = 7\,\Omega$**

ii) Let P be the power of dep. source

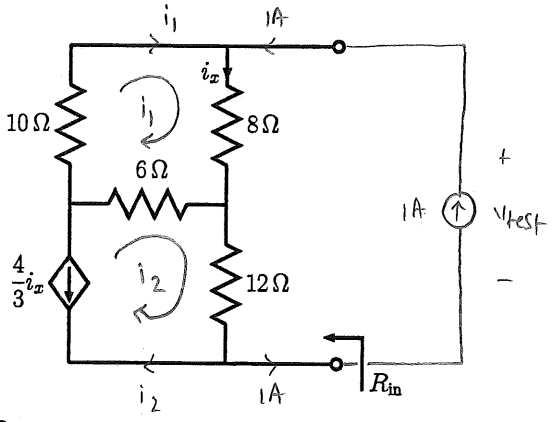
$P = (r_2 i_x) \cdot (-i_2) = -r_2 i_3 i_2$

$= -2 \cdot 2 \cdot 3$

$= -12\,\text{W}$

Hence the dep. source **supplies 12 W** power.

Q3.



Compute the input resistance R_{in}.

Mesh ①: $10i_1 + 8(i_1+1) + 6(i_1 - i_2) = 0$

$\Rightarrow 24i_1 - 6i_2 = -8 \quad (1)$

constraint: $\frac{4}{3}i_x = -i_2$, $i_x = i_1 + 1$ $\Big\}$ $\frac{4}{3}(i_1+1) = -i_2$

$\Rightarrow \frac{4}{3}i_1 + i_2 = -\frac{4}{3} \quad (2)$

(1) & (2) $\Rightarrow$ $i_1 = -\frac{1}{2}A$ & $i_2 = -\frac{2}{3}A$

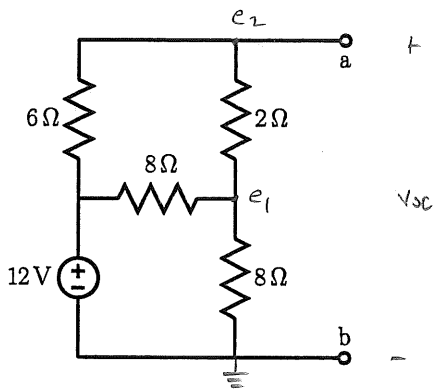
$V_{test} = V_{8\Omega} + V_{12\Omega} = 8(i_1+1) + 12(i_2+1)$

$= 8\left(\frac{1}{2}\right) + 12\left(\frac{1}{3}\right)$

$= 4 + 4 = 8V$

$R_{in} = \frac{V_{test}}{1A} = \frac{8V}{1A} \Rightarrow \boxed{R_{in} = 8\Omega}$

Q4.



Find and draw the Thevenin equivalent of the above one-port circuit.

Find the open-circuit voltage V_{oc}.

Node ①: $\frac{e_1 - 12}{8} + \frac{e_1}{8} + \frac{e_1 - e_2}{2} = 0$

$\Rightarrow \quad \frac{3}{4}e_1 - \frac{1}{2}e_2 = \frac{3}{2} \qquad (1)$

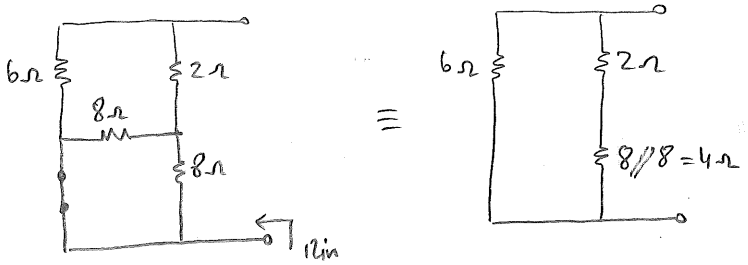
Node ②: $\frac{e_2 - 12}{6} + \frac{e_2 - e_1}{2} = 0$

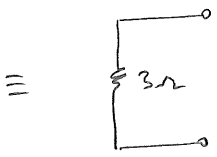
$\Rightarrow \quad -\frac{1}{2}e_1 + \frac{2}{3}e_2 = 2 \qquad (2)$

(1)&(2) $\Rightarrow \quad e_1 = 8V \;,\; e_2 = 9V$

$V_{oc} = e_2 \quad \Rightarrow \quad \boxed{V_{th} = 9V}$

Find the input resistance R_{in}.





$\Rightarrow \quad \boxed{R_{th} = 3\Omega}$

Hence the Thevenin equiv. is