Name ______________________

By writing or printing my name in the space above, I hereby affirm that I have neither given nor received assistance in preparing solutions for this exam.

EE 2240

Exam #1

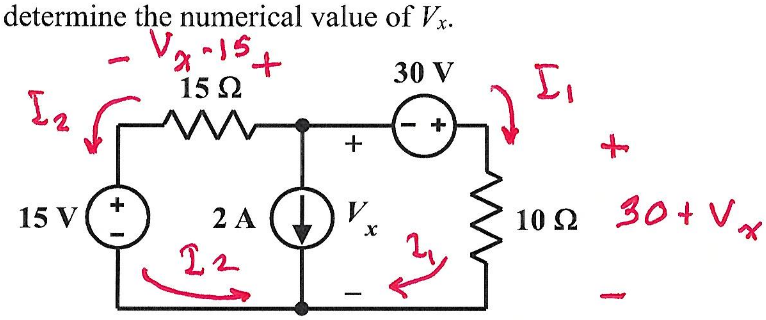
Due by 9:15AM, Tuesday, September 28, 2021

[open book, open notes, calculator and computer allowed – no internet access]

Work must be neat, orderly, and complete in order to receive partial credit.

***PLEASE* submit your solutions as a single PDF file.**

1. Use any method to determine the numerical value of V_x.



$$I_1 = \frac{30 + V_x}{10} \qquad I_2 = \frac{V_x - 15}{15}$$

$$I_1 + I_2 + 2 = 0$$

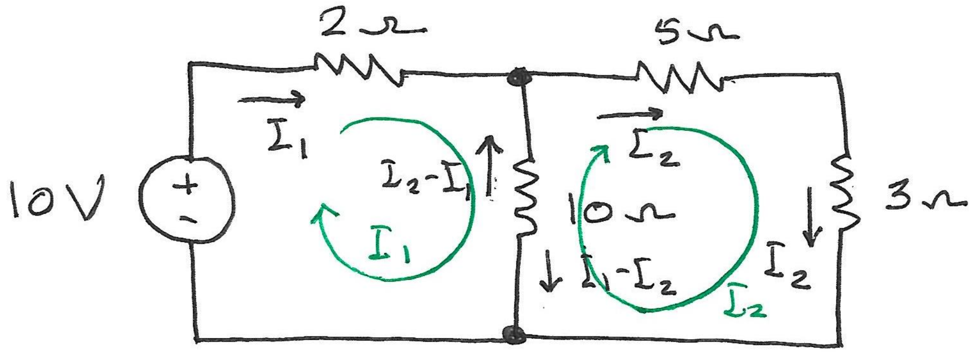
$$3 + \frac{V_x}{10} + \frac{V_x}{15} - 1 + 2 = 0$$

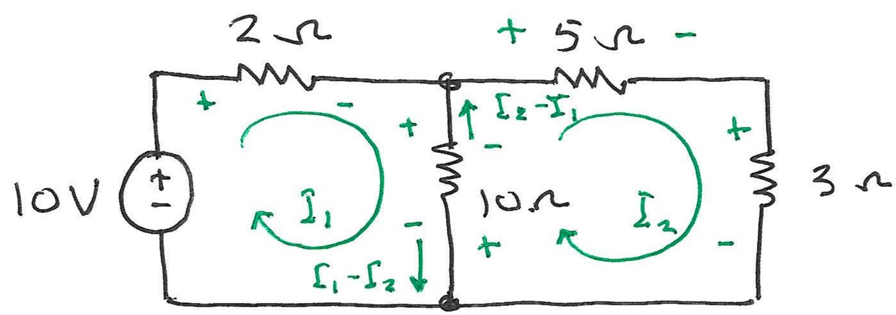
$$\frac{V_x}{6} = -4$$

$$V_x = -24\ V$$

Mesh Analysis

Systematic application of KVL.





For mesh #1: $2 I_1 + 10(I_1 - I_2) - 10 = 0$

For mesh #2: $5(I_2) + 3 I_2 + 10(I_2 - I_1) = 0$

$$\begin{bmatrix} 12 & -10 \\ -10 & 18 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} 10 \\ 0 \end{bmatrix}$$

Cramer's Rule:

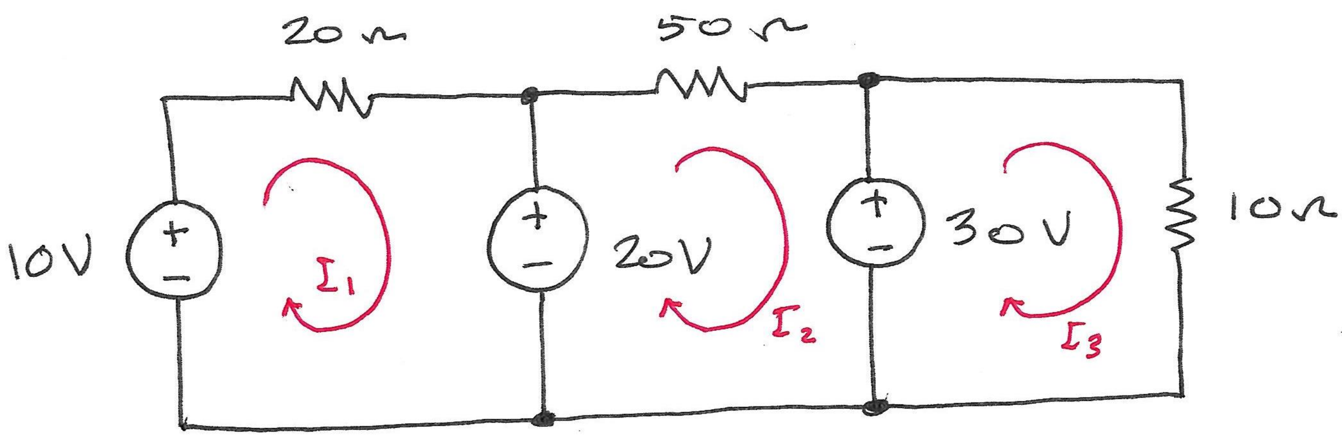
$$I_1 = \frac{\begin{vmatrix} 10 & -10 \\ 0 & 18 \end{vmatrix}}{\begin{vmatrix} 12 & -10 \\ -10 & 18 \end{vmatrix}} = \frac{(10 \times 18) - (-10 \times 0)}{(12 \times 18) - (-10)(-10)}$$

$$= \frac{180}{216 - 100} = \frac{180}{116}$$

$$= \frac{45}{29} \text{ A}$$

$$I_2 = \frac{\begin{vmatrix} 12 & 10 \\ -10 & 0 \end{vmatrix}}{116} = \frac{0 - (-100)}{116}$$

$$= \frac{100}{116} = \frac{25}{29} \text{ A}$$

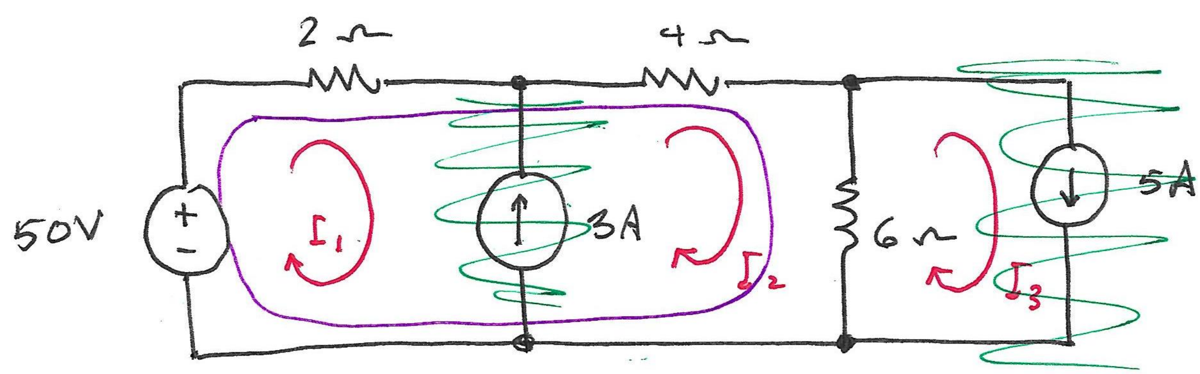


Mesh 1: $-10 + 20 I_1 + 20 = 0$

Mesh 2: $-20 + 50 I_2 + 30 = 0$

Mesh 3: $-30 + 10 I_3 = 0$

$$\begin{bmatrix} 20 & 0 & 0 \\ 0 & 50 & 0 \\ 0 & 0 & 10 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} 10-20 \\ 20-30 \\ 30 \end{bmatrix}$$

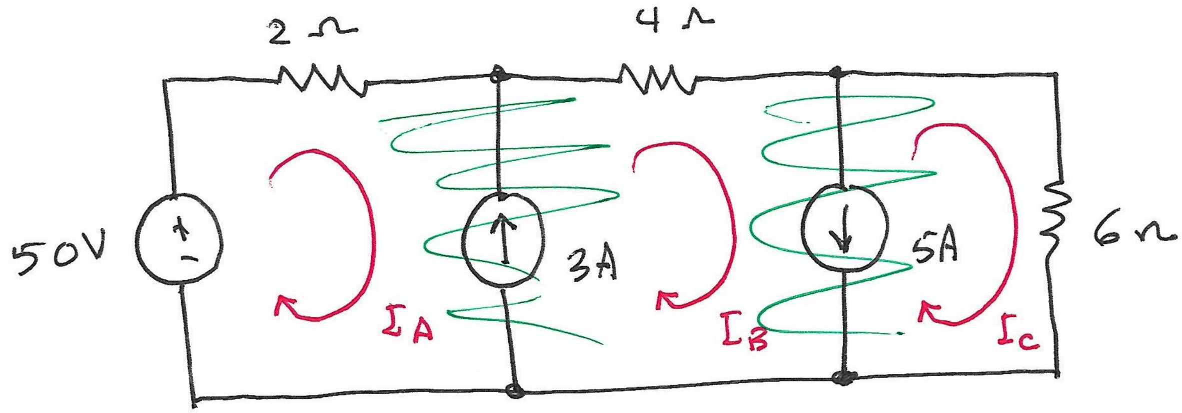


$I_3 = 5A$ (constraint equation)

$I_2 - I_1 = 3A$ (constraint equation)

$-50 + 2I_1 + 4I_2 + 6(I_2 - I_3) = 0$ (KVL for supermesh)

$$\begin{bmatrix} 0 & 0 & 1 \\ -1 & 1 & 0 \\ 2 & 10 & -6 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} 5 \\ 3 \\ 50 \end{bmatrix}$$



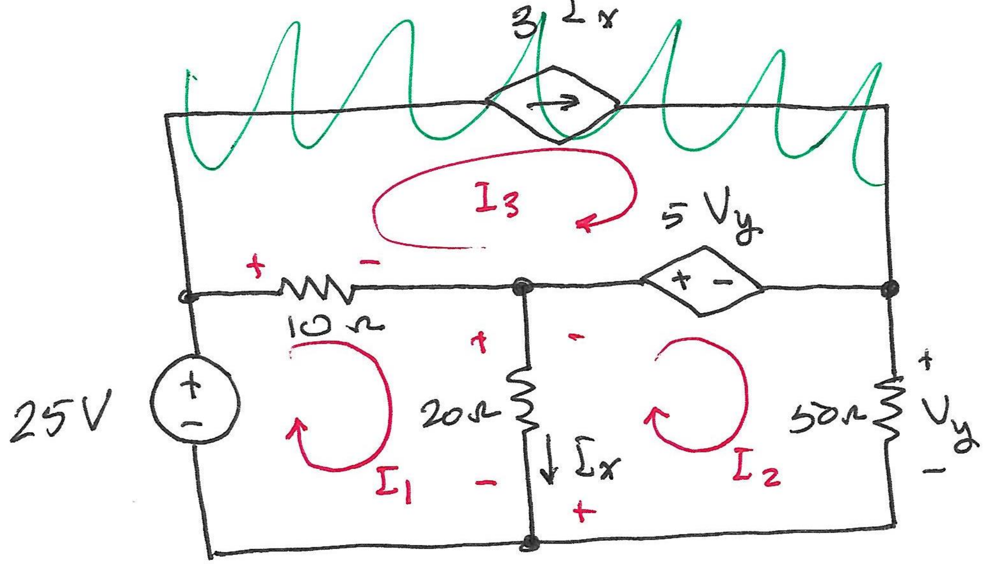
Super Mesh ~~AB~~:

$$-50 + 2I_A + 4I_B + 6I_C = 0$$

$$I_B - I_A = 3A$$

$$I_B - I_C = 5A$$

$$\begin{bmatrix} 2 & 4 & 6 \\ -1 & 1 & 0 \\ 0 & 1 & -1 \end{bmatrix} \begin{bmatrix} I_A \\ I_B \\ I_C \end{bmatrix} = \begin{bmatrix} 50 \\ 3 \\ 5 \end{bmatrix}$$



$I_3 = 3 I_x$ (constraint equation)

$-25 + 10(I_1 - I_3) + 20(I_1 - I_2) = 0$ (KVL for mesh 1)

$20(I_2 - I_1) + 5 V_y + 50 I_2 = 0$ (KVL for mesh 2)

$I_x = I_1 - I_2$

$V_y = 50 I_2$

In matrix form:

$$\begin{bmatrix} 0 & 0 & 1 & -3 & 0 \\ 30 & -20 & -10 & 0 & 0 \\ -20 & 70 & 0 & 0 & 5 \\ -1 & 1 & 0 & 1 & 0 \\ 0 & -50 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \\ I_x \\ V_y \end{bmatrix} = \begin{bmatrix} 0 \\ 25 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$