ECE 20001 Spring 2020

Midterm Exam 1

Last Name: _____ **First Name:** _____

Student ID: _____ **Section:**

- ◯ 2:30 Mayer
- ◯ 12:30 Kildishev
- ◯ 12:30 Irazoqui
- ◯ 7:30 Cui
- ◯ 1:30 Michelusi

I have neither given nor received unauthorized assistance on this exam.

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Instructions:

1. Adhere to the Purdue Honor Pledge. Sign the statement above before turning in your exam.
2. This is a closed-book, closed-note exam. No study materials should be visible or accessible during the exam. Use of a TI-30X IIS calculator is allowed.
3. For each question, determine the answer and then select the closest choice. Mark the choice by filling in the bubble completely: ●. Only the marked choice will be scored. Your work to determine an answer may be reviewed as part of an academic integrity assurance process.
4. All questions are equally weighted but are not equally difficult – manage your time wisely.
5. If you need extra space for a question, raise your hand and a proctor will provide an extra sheet of paper.
6. You have 60 minutes to complete the exam.
7. You must turn in (a) all pages of this exam and (b) any extra sheet(s) provided by a proctor.

Learning Outcomes

i. An ability to analyze linear resistive circuits.
ii. An ability to analyze first-order linear circuits with sources and/or passive elements.
iii. An ability to analyze electronic circuits with diodes and transistors.

Question	LO	Points	Score
1	i	6.67	
2	i	6.67	
3	i	6.67	
4	i	6.67	
5	i	6.67	
6	i	6.67	
7	i	6.67	
8	i	6.67	
9	i	6.67	
10	i	6.67	
11	i	6.67	
12	i	6.67	
13	i	6.67	
14	i	6.67	
15	i	6.67	

1. The cumulative charge through a cross section of a particular conductor is expressed as

$$q(t) = \begin{cases} 3 & t < 0 \\ 3e^{-2t}\ \text{C} & t \geq 0 \end{cases}$$

What is the value of current $i(t)$ in amperes at $t = 0.5$ s? Assume that $q(t)$ and $i(t)$ share the same reference direction.

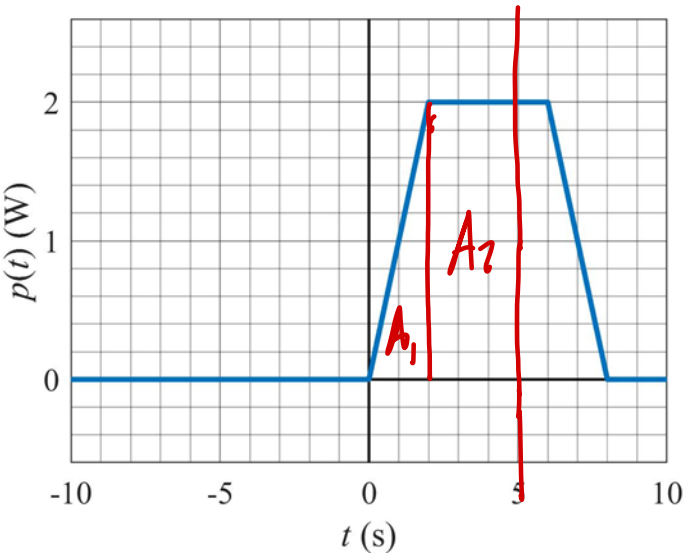
- ○ -3
- ● -2.207
- ○ -1.104
- ○ -0.552
- ○ 0
- ○ 0.552
- ○ 1.104
- ○ 2.207
- ○ 3
- ○ 3.552

$$i(t) = \frac{dq(t)}{dt} = \begin{cases} 0 & t<0 \\ -6e^{-2t}, & t \geq 0 \end{cases}$$

$$\Rightarrow i(0.5) = -6e^{-1} \simeq -2.2\,\text{A}$$

2. What is the energy in joules absorbed by a resistor between the beginning of time and $t = 5$ s if the graph shows the instantaneous power absorbed by the resistor? Assume that $p(t) = 0$ for $t < -10$ s.

- ○ 0
- ○ 0.4
- ○ 1
- ○ 2
- ○ 2.5
- ○ 4
- ○ 5
- ○ 6
- ● 8
- ○ 10

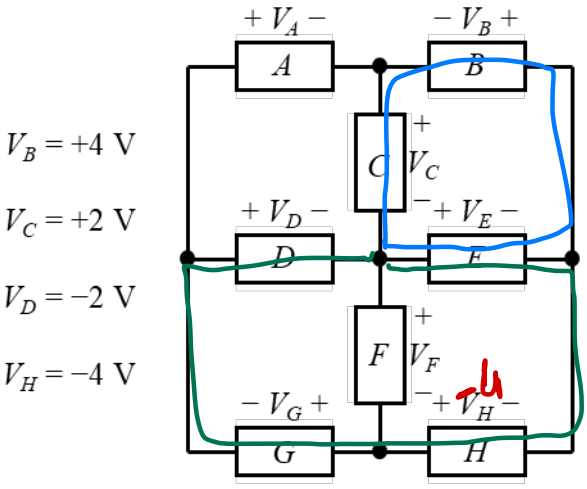


$$e([-\infty, 5]) = \int_{-\infty}^{5} p(\tau)\,d\tau = A_1 + A_2 = 8\,\text{J}$$

$$A_1 = \frac{2\,\text{s} \cdot 2\,\text{W}}{2} = 2\,\text{J}$$

$$A_2 = 3\,\text{s} \cdot 2\,\text{W} = 6\,\text{J}$$

For Questions 3 and 4 consider the voltages indicated on the schematic diagram.



3. What is the value of V_E in volts?

- ○ −8
- ○ −6
- ○ −4
- ○ −2
- ○ 0
- ○ 2
- ○ 4
- ○ 6
- ○ 8
- ○ 12

$V_E + V_C + V_B = 0 \Rightarrow V_E = -6V$

4. What is the value of V_G in volts?

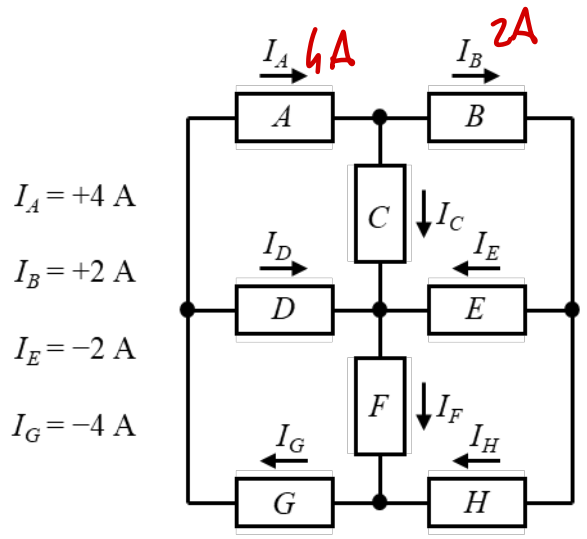
- ○ −8
- ○ −6
- ○ −4
- ○ −2
- ○ 0
- ○ 2
- ○ 4
- ○ 6
- ○ 8
- ○ 12

$V_D + V_E - V_H + V_G = 0$

$\Rightarrow V_G = 4V$

5. What is the value of I_C in amperes?

- ○ −8
- ○ −6
- ○ −4
- ○ −2
- ○ 0
- ○ 2
- ○ 4
- ○ 6
- ○ 8
- ○ 12

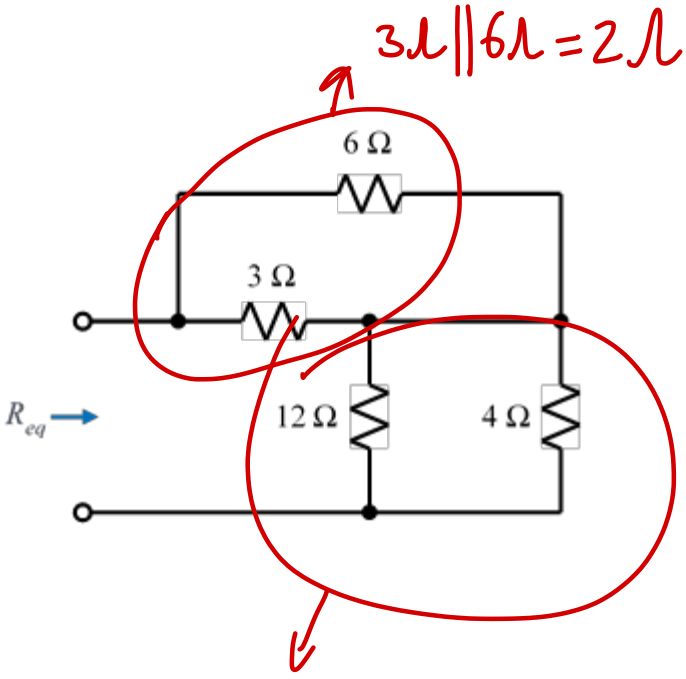


$I_A = I_C + I_B$

$\Rightarrow I_C = 2A$

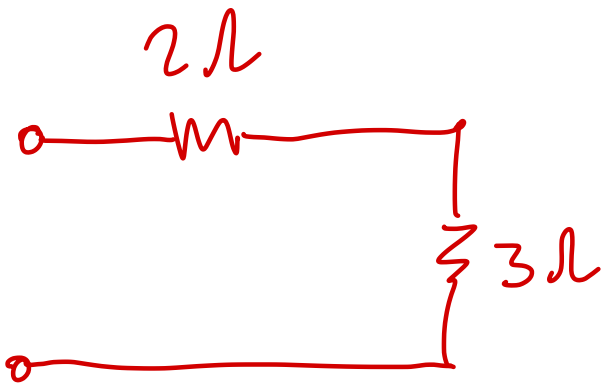
6. What is the value of R_{eq} in ohms?

○ 1	○ 6
○ 2	○ 9
○ 3	○ 12
○ 4	○ 18
● 5	○ 25



$3\Omega \| 6\Omega = 2\Omega$

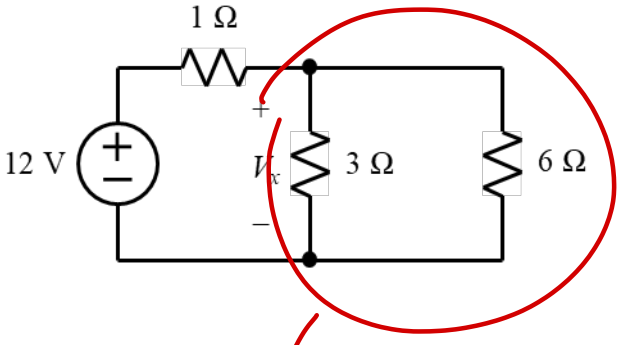
$12\Omega \| 4\Omega = 3\Omega$



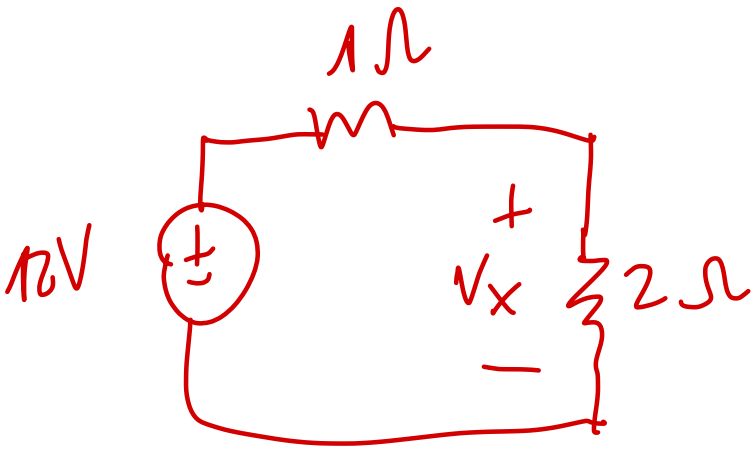
$\Rightarrow R_{eq} = 5\Omega$

7. What is the value of V_x in volts?

- ○ 0
- ○ 1
- ○ 2
- ○ 3
- ○ 4
- ○ 6
- ● 8
- ○ 9
- ○ 10
- ○ 12



$3 \| 6 = 2\,\Omega$

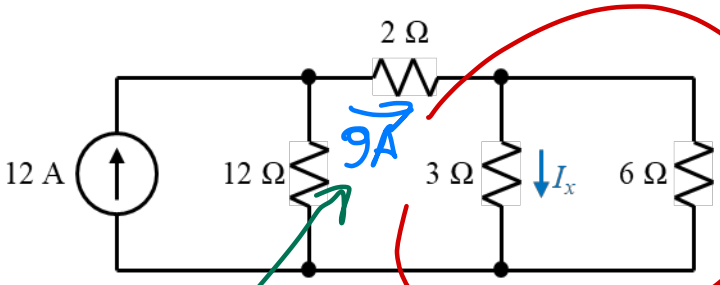


$$V_x = \frac{2}{2+1} \cdot 12V$$

$$= 8V$$

8. What is the value of I_x in amperes?

○ 0	● 6
○ 1	○ 8
○ 2	○ 9
○ 3	○ 10
○ 4	○ 12



$3 \| 6 = 2\Omega$

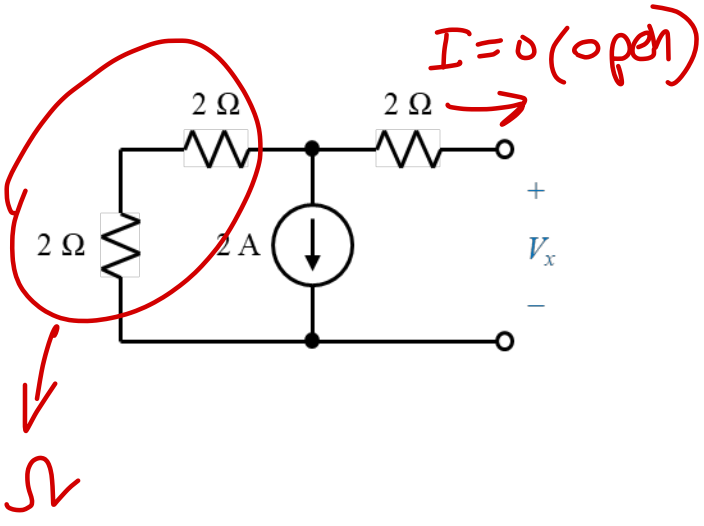
$2\Omega + 2\Omega \rightarrow 4\Omega$

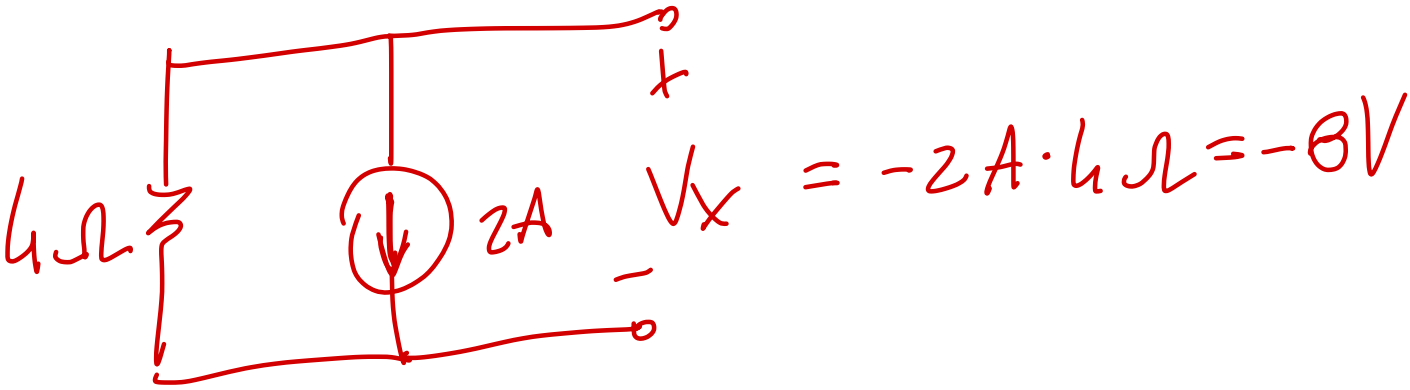
$I_1 = \frac{1/4}{1/12 + 1/4} \cdot 12A$

$\Rightarrow I_x = \frac{1/3}{1/3 + 1/6} \cdot 9A = 6A$

9. What is the value of V_x in volts?

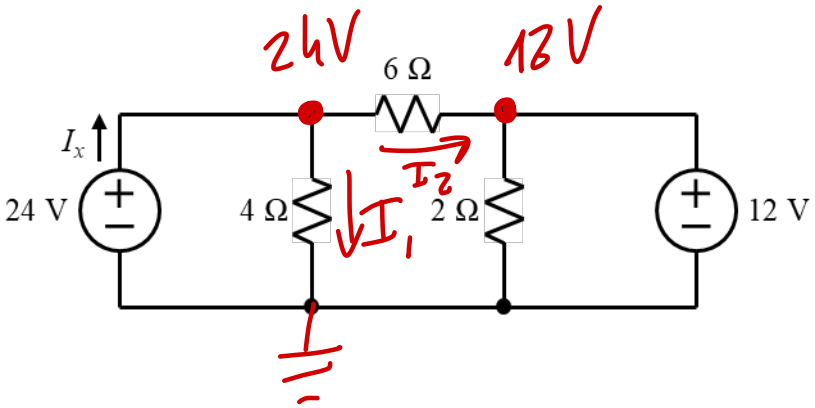
○ −12	○ 2
● −8	○ 4
○ −4	○ 8
○ −2	○ 12
○ 0	○ 16





10. What is the value of I_x in amperes?

- ○ 0
- ○ 1
- ○ 2
- ○ 3
- ○ 4
- ○ 6
- ● 8
- ○ 9
- ○ 10
- ○ 12

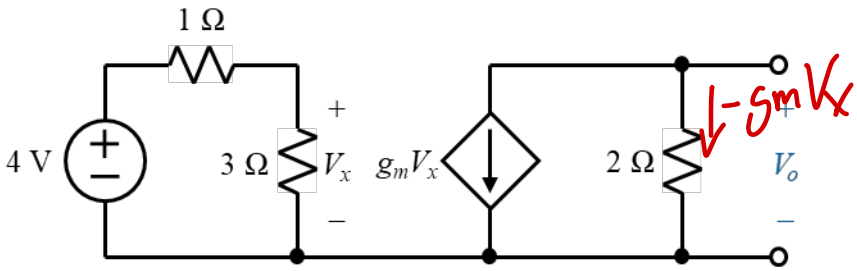


$$I_1 = \frac{24V}{4\Omega} = 6A \quad ; \quad I_2 = \frac{(24-12)V}{6\Omega} = 2A$$

$$\Rightarrow I_x = I_1 + I_2 = 8A$$

11. What is the value of V_o in volts if $g_m = 2$ S?

- ○ -16
- ● -12
- ○ -8
- ○ -3
- ○ 0
- ○ 2
- ○ 3
- ○ 8
- ○ 12
- ○ 16



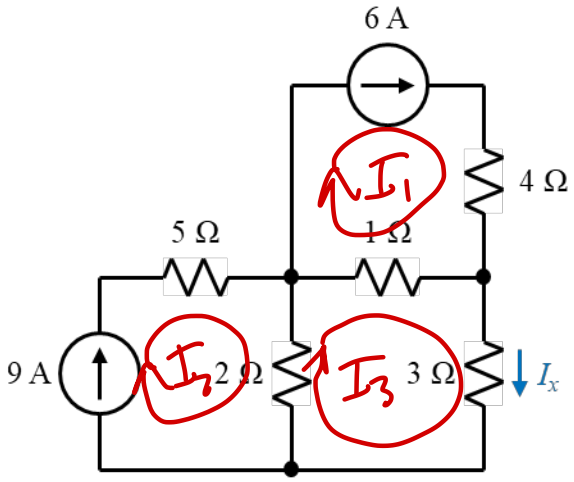
$V_o = -2 \cdot g_m \cdot V_x = -4 V_x$

$V_x = \frac{3}{3+1} \cdot 4V = 3V$

$\Rightarrow V_o = -12V$

12. What is the value of I_x in amperes?

○ −9	○ −1.5
○ −6	○ 1.5
○ −4	○ 2
○ −3	● 4
○ −2	○ 6



Mesh

$I_1 = 6A$

$I_2 = 9A$

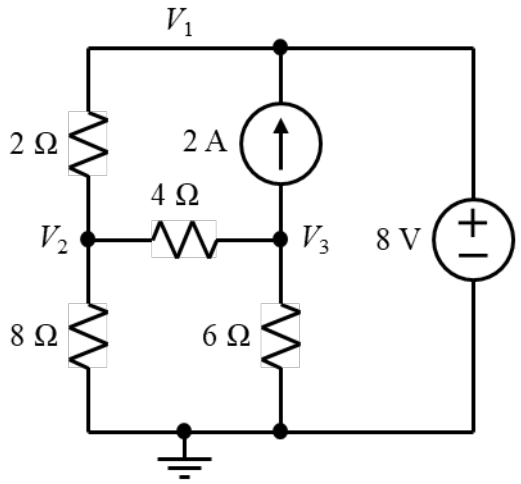
Loop 3: $1(I_3 - 6) + 3 \cdot I_3 + 2(I_3 - 9) = 0$

$\Rightarrow I_3 = 4A$

$I_x = I_3 = 4A$

For Questions 13 and 14 consider the following network model obtained via nodal analysis:

$$\begin{bmatrix} \frac{7}{8} & -\frac{1}{4} \\ -\frac{1}{4} & \text{B} \end{bmatrix} \begin{bmatrix} V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} \text{A} \\ -2 \end{bmatrix}$$



13. What is the value redacted by Box A?

- ○ -8
- ○ -6
- ○ -4
- ○ -2
- ○ 0
- ○ 1
- ○ 2
- ● 4
- ○ 6
- ○ 8

14. What is the value redacted by Box B?

- ○ 1/10
- ○ 1/8
- ○ 1/6
- ○ 1/4
- ○ 3/8
- ● 5/12
- ○ 1/2
- ○ 7/8
- ○ 12/5
- ○ 10

$V_1 = 8\,V$

Node V_2 :

$$\frac{8 - V_2}{2} + \frac{0 - V_2}{8} + \frac{V_3 - V_2}{4} = 0$$

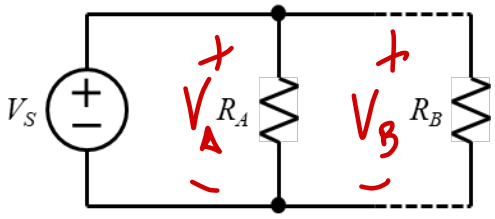
$$\Rightarrow \boxed{\frac{7}{8}V_2 - \frac{1}{4}V_3 = 4} \Rightarrow A = 4$$

Node V_3 :

$$-2 + \frac{V_2 - V_3}{4} + \frac{0 - V_3}{6} = 0$$

$$\Rightarrow \boxed{-\frac{1}{4}V_2 + \frac{5}{12}V_3 = -2} \Rightarrow B = \frac{5}{12}$$

15. What will happen to the power supplied by the source, P_S, and the power absorbed by resistor R_A, P_A, if resistor R_B is connected in parallel with resistor R_A? Assume that R_B and R_A have similar but not identical resistance values. In addition to marking an answer choice, explain your reasoning as clearly, concisely, and completely as possible in the box below.



- ○ P_S decreases and P_A decreases.
- ○ P_S decreases and P_A stays the same.
- ○ P_S decreases and P_A increases.
- ○ P_S stays the same and P_A decreases.
- ○ P_S stays the same and P_A stays the same.
- ○ P_S stays the same and P_A increases.
- ○ P_S increases and P_A decreases.
- ● P_S increases and P_A stays the same.
- ○ P_S increases and P_A increases.

$P_S = P_A + P_B$

Powers absorbed by R_A and R_B

Since they are in parallel, $V_A = V_B = V_S$

$\Rightarrow P_A = \frac{V_S^2}{R_A}$; $P_B = \frac{V_S^2}{R_B}$

$\Rightarrow P_S = \left(\frac{1}{R_A} + \frac{1}{R_B}\right) V_S^2$

$\Rightarrow P_S$ increases ; P_A stays the same