



ENGG 225 - Fundamentals of Electrical Circuits and Machines **Midterm Examination**

Start: Wednesday, February 24, 2021, 5:00 PM MST

End: Thursday, February 25, 2021, 5:00 PM MST

L01 - *Pouyan (Yani) Jazayeri*

L02 - *Norm Bartley*

L03 - *Anis Haque*

Instructions

- **Due Date and Time:** The completed exam is due on Thursday, February 25 at 5:00 PM.
- **Open-book exam:** You may refer to any books, notes, or websites you choose while writing the exam, except that you may not use websites to communicate with other people about the exam.
- **Use of electronics:** All desktop and laptop computers, tablets, smartphones and calculators are allowed, and all software applications are allowed, except that none of these devices may be used to communicate with other people about the exam.
- **Individual effort and academic integrity:** Each student is expected to hand in work that is entirely their own. If there is strong evidence that a student has received help from another person (other than a clarification from one of the course lecture instructors) during the course of the exam, that student will be reported for suspected academic misconduct.

Continued on Page 2 ...

- **Submission of PDF files to D2L Dropboxes.**
 - In order to facilitate marking, this exam has been split into Component One, Component Two and Component Three. You must upload three PDF files: one for each component.
 - It is your responsibility to ensure that the PDF files are easy to read and complete. For convenience, you may print out the question paper and write your answers directly in blank spaces provided. You may add extra paper if you need it.
 - The dropboxes are configured to allow you to **replace** a submission as many times as you like before the deadline. Please keep in mind that this implies that you must resubmit **all answers for a component** to the dropbox even if you are only changing the answer to one problem.
- Be sure to write your name, lecture section, and ID number on all three components of your exam.
- The maximum number of marks is 40. The midterm exam counts 25% toward your final grade.

Component One

Name: _____

Lecture Section: _____

UCID: _____

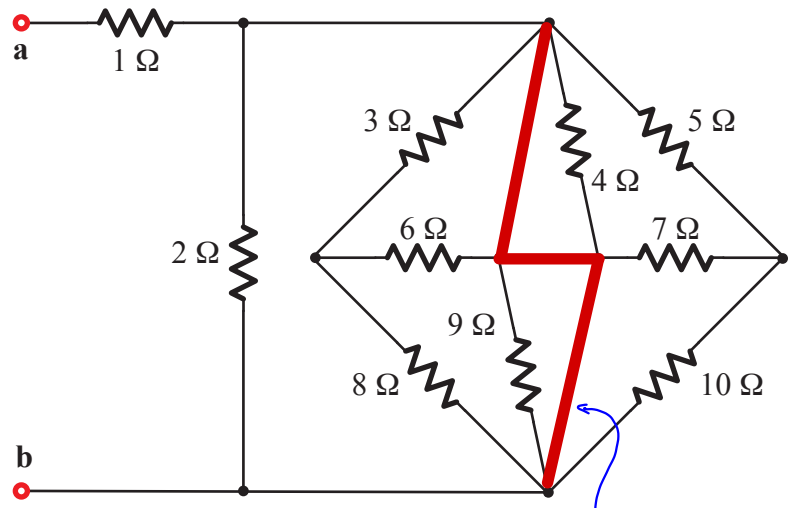
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1. [15 marks.] Parts (a)-(e) below each have an identical weighting of three marks. Please answer the questions in the boxes provided.

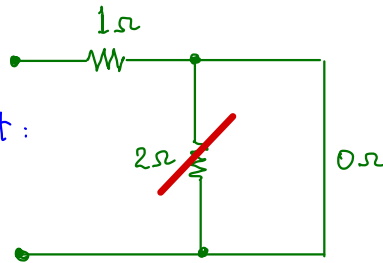
- (a) [3] In the circuit at right, find the total equivalent resistance R_{ab} between the terminals a and b.



Notice the short circuit from top to bottom!

Equivalent circuit:

$R_{ab} = 1\Omega$

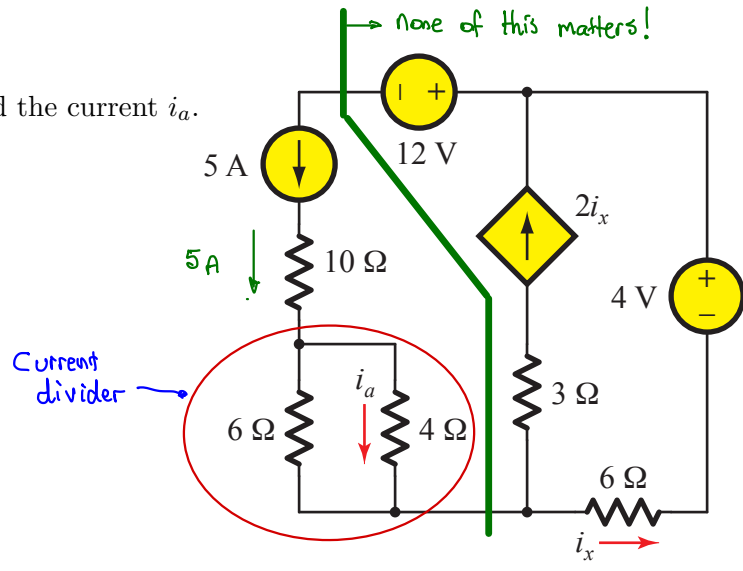


Answer: $R_{ab} = 1\Omega$

(b) [3] In the circuit at right, find the current i_a .

$$i_a = \frac{6\Omega}{6\Omega + 4\Omega} \times 5A$$

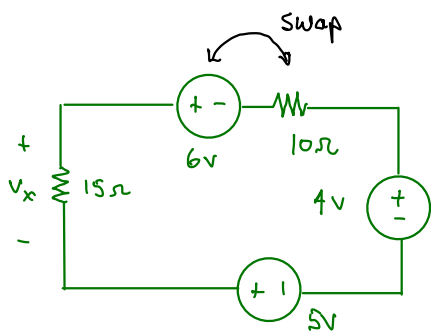
$$i_a = 3A$$



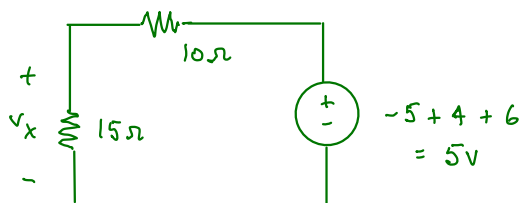
Answer: $i_a = 3A$

(c) [3] Calculate the voltage v_x in the circuit at right.

Equivalent circuit:

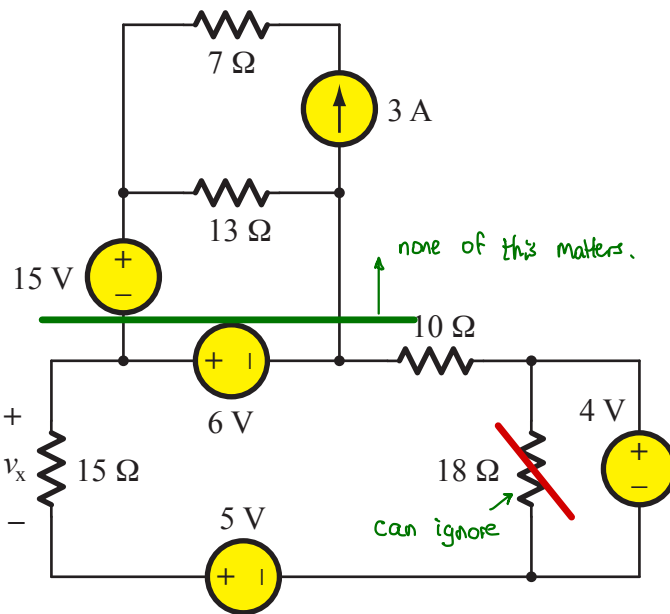


After swapping and combining sources



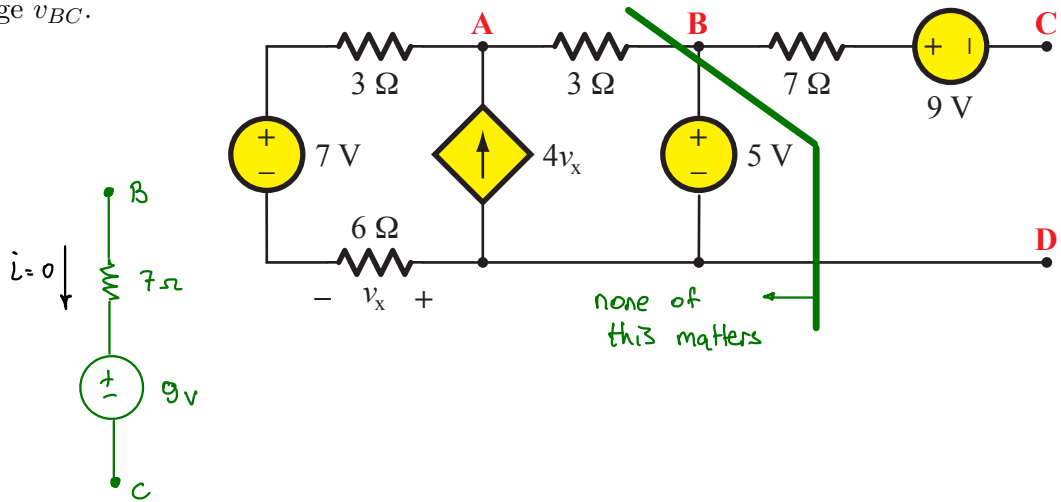
Voltage divider: $V_x = \frac{15\Omega}{10\Omega + 15\Omega} \times 5V$

$$V_x = 3V$$



Answer: $v_x = 3V$

(d) [3] In the circuit at right, calculate the voltage v_{BC} .



$$V_{BC} = 9V$$

$$\text{Answer: } v_{BC} = 9V$$

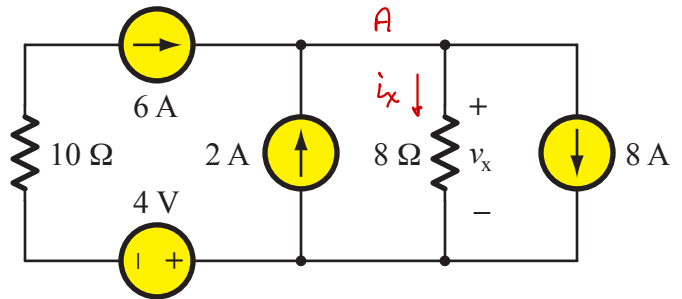
(e) [3] In the circuit at right, determine the voltage v_x .

KCL at node A:

$$6 + 2 - 8 - i_x = 0$$

so $i_x = 0$

$$V_x = 8\Omega \times i_x = 0$$



$$V_x = 0$$

$$\text{Answer: } v_x = 0V$$

Component Two

Name: _____

Lecture Section: _____

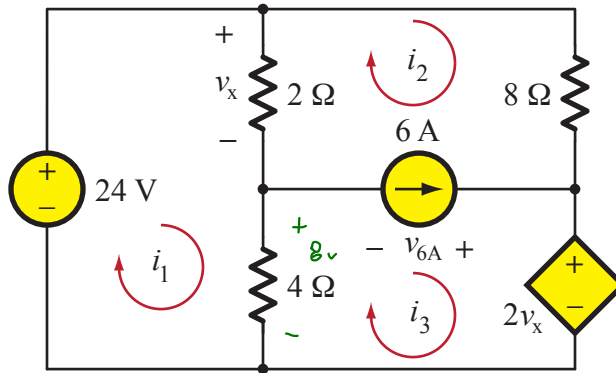
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2. [12 marks.] Consider the circuit below.



(a) [9] Determine the mesh currents i_1, i_2, i_3 .

(b) [3] Using your answers to part (a), calculate the voltage v_{6A} .

Mesh currents (Amperes)

Parameter	Value
i_1	7
i_2	-1
i_3	5

Voltage (Volts)

Parameter	Value
v_{6A}	24

(a) Mesh i_1 : $-24 + 2(i_1 - i_2) + 4(i_1 - i_3) = 0$
 $6i_1 - 2i_2 - 4i_3 = 24$ — (1)

Supermesh:

$$4(i_3 - i_1) + 2(i_2 - i_1) + 8i_2 + 2v_x = 0$$

where $v_x = 2(i_1 - i_2)$

so $4(i_3 - i_1) + 2(i_2 - i_1) + 8i_2 + 4(i_1 - i_2) = 0$
 $-2i_1 + 6i_2 + 4i_3 = 0$ — (2)

Supermesh dependence: $i_3 - i_2 = 6$
 $i_3 = i_2 + 6$ — (3)

Substitute (3) into (1): $6i_1 - 2i_2 - 4(i_2 + 6) = 24$
 $6i_1 - 6i_2 - 24 = 24$
 $i_1 - i_2 = 8$
 $i_1 = i_2 + 8$ — (4)

(Question 2, additional workspace ...)

Substitute (3) into (2): $-2i_1 + 6i_2 + 4(i_2 + 6) = 0$
 $-2i_1 + 10i_2 + 24 = 0$ ————— (5)

Substitute (4) into (5): $-2(i_2 + 8) + 10i_2 + 24 = 0$
 $8i_2 + 8 = 0$, $i_2 = -1A$

And from (4), $i_1 = 7A$

And from (3), $i_3 = 5A$

(b) Kvl around mesh i_3 : $4(i_3 - i_1) - V_{6A} + 2V_x = 0$
 where $V_x = 2(i_1 - i_2) = 2(7 - (-1)) = 16V$
 so $4(5 - 7) - V_{6A} + 32 = 0$
 $-8 + 32 = V_{6A}$

$V_{6A} = 24V$

Component Three

Name: _____

Lecture Section: _____

UCID: _____

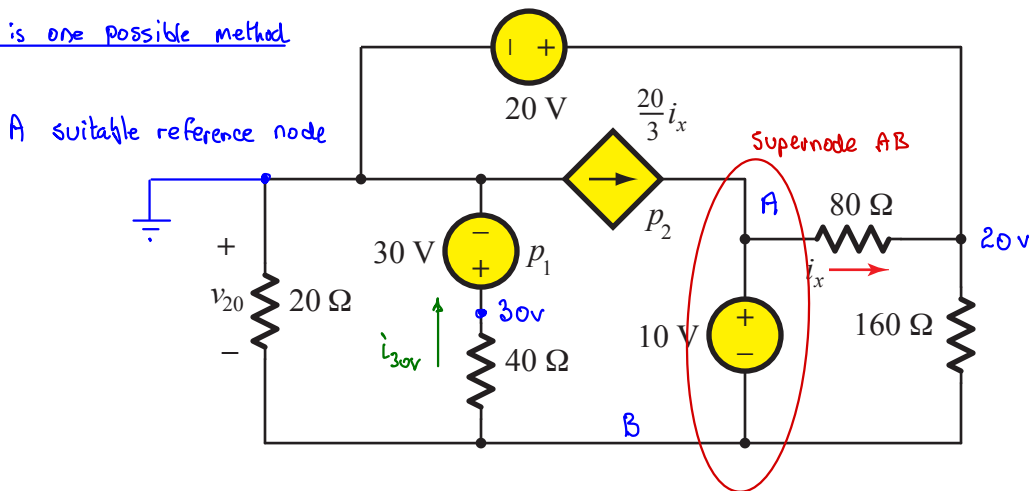
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3. [13 marks.] Consider the circuit below.

This is one possible method



- (a) [8] Use the node-voltage method to solve for the current i_x and voltage v_{20} .
- (b) [5] Using your answers to part (a), calculate the power p_1 and p_2 .

Voltage and Current

Parameter	Value
i_x (Amps)	0.075
v_{20} (Volts)	-16

Power (Watts)

Parameter	Value
p_1	-10.5W
p_2	-13W

(a) Supernode equation:

$$\frac{V_B}{20} + \frac{V_B - 30}{40} + \frac{V_B - 20}{160} + \frac{V_A - 20}{80} - \frac{20}{3} i_x = 0$$

this is i_x

$$8V_B + 4V_B - 120 + V_B - 20 + 2V_A - 40 - \frac{3200}{3} i_x = 0$$

$$2V_A + 13V_B - 180 - \frac{3200}{3} i_x = 0$$

$$2V_A + 13V_B - 180 - \frac{3200}{3} \left(\frac{V_A - 20}{80} \right) = 0$$

$$2V_A + 13V_B - 180 - \frac{40}{3} V_A + \frac{800}{3} = 0$$

$$-\frac{34}{3} V_A + 13V_B = -86.667$$

$$\text{or } -34 V_A + 39 V_B = -260 \quad \text{--- (1)}$$

Supernode dependence:

$$\begin{aligned} V_A - V_B &= 10 \\ V_A &= V_B + 10 \quad \text{--- (2)} \end{aligned}$$

Substitute (2) into (1)

$$\begin{aligned} -34(V_B + 10) + 39V_B &= -260 \\ 5V_B &= 80 \end{aligned}$$

Node voltages:

$$\begin{aligned} V_B &= 16V \\ V_A &= 26V \end{aligned}$$

Therefore, $i_x = \frac{V_A - 20}{80} = \frac{6}{80} \text{ A}$

(Question 3, additional workspace ...)

$$i_x = 75 \text{ mA}$$

And $V_{20} = -V_B$

$$V_{20} = -16 \text{ V}$$

(b) Current i_{30V} : $i_{30V} = \frac{V_B - 30}{40} = \frac{16 - 30}{40} = \frac{-14}{40} \text{ A}$

and $P_1 = 30 \times i_{30V} = 30 \left(-\frac{14}{40} \right)$ $P_1 = -10.5 \text{ A}$

Current i_x : $i_x = \frac{V_A - 20}{80} = \frac{26 - 20}{80} = \frac{6}{80} \text{ A}$.

and $P_2 = -V_A \left(\frac{20}{3} i_x \right) = -26 \times \frac{20}{3} \left(\frac{6}{80} \right)$ $P_2 = -13 \text{ W}$