ECE 20100 – Spring 2016
Exam #1
February 10, 2016

Section (include on scantron)

Li (12:30) – 0001 Cui (1:30) – 0004 Tan (9:30) – 0005
Mohammadi (2:30) – 0006 Peroulis (12:00 TR) – 0007
Liu (10:30) – 0008 Michelusi (3:00 TR) – 0009

Solutions

Instructions

1. DO NOT START UNTIL TOLD TO DO SO.
2. Write your name, section, professor, and student ID# on your Scantron sheet. We may check PUIDs.
3. This is a CLOSED BOOKS and CLOSED NOTES exam.
4. The use of a TI-30X IIS calculator is allowed, but not necessary.
5. If extra paper is needed, use the back of test pages.
6. Cheating will not be tolerated. Cheating in this exam will result in, at the minimum, an F grade for the course. In particular, continuing to write after the exam time is up is regarded as cheating.
7. If you cannot solve a question, be sure to look at the other ones, and come back to it if time permits.
8. All of the problems on Exam #1 provide evidence for satisfaction of this ECE 20100 Learning Objective:
   i) An ability to analyze linear resistive circuits.

The minimum score needed to satisfy this objective will be posted on Blackboard after the exam has been graded. Remediation options will be posted in Blackboard if you fail to satisfy any of the course outcomes.
Question 1

A charge rate of $-10 \text{C/s}$ passes through the device shown from point (2) to point (1). If the device absorbs $200 \text{W}$ of power, find the voltage $V_{12}$ across it.

\[ V_{12} \]

- $10 \text{C/s}$ from $2 \rightarrow 1$ means $10 \text{C/s}$ from $1 \rightarrow 2$, or $I = 10 \text{A}$ from $1 \rightarrow 2$

\[ \text{Hence } P = V_{12} \cdot I \]

\[ \Rightarrow V_{12} = \frac{P}{I} = \frac{200}{10} = 20 \text{ V} \]

(1) $-20 \text{ V}$
(2) $-10 \text{ V}$
(3) $-1 \text{ V}$
(4) $0 \text{ V}$
(5) $1 \text{ V}$
(6) $10 \text{ V}$
(7) $20 \text{ V}$
(8) none of the above
Question 2

In the circuit shown below, find the transfer conductance $g_m$.

\begin{align*}
\text{(1)} & \quad 1 \Omega \\
\text{(2)} & \quad 0.1 \Omega \\
\text{(3)} & \quad 0.2 \text{ S} \\
\text{(4)} & \quad 0.1 \text{ S} \\
\text{(5)} & \quad 0.2 \Omega \\
\text{(6)} & \quad 1 \text{ S} \\
\text{(7)} & \quad 0.5 \text{ S} \\
\text{(8)} & \quad \text{none of the above}
\end{align*}

\[ I_1 = \frac{10V}{10\Omega} = 1A \]

\[ V_2 = r_m I_1 = 5 \cdot 1 = 5V \]

\[ g_m V_2 = 1A \Rightarrow g_m = \frac{1A}{5V} = 0.2 \text{ S} \]
Question 3

In the circuit shown below, find the current $I_x$.

\[ \text{Due to symmetry: } V_A = V_B \]

Thus: $I_x = 0$

(1) 1 A
(2) 0 A
(3) 0.5 A
(4) 2 A
(5) -1 A
(6) -0.5 A
(7) -2 A
(8) none of the above
Question 4

In the circuit below, the power dissipated by the 10 Ω resistor is 40W. Find the resistance $R_x$.

![Circuit diagram]

1. $2 \Omega$
2. $5 \Omega$
3. $6 \Omega$
4. $10 \Omega$
5. $15 \Omega$
6. $20 \Omega$
7. $25 \Omega$
8. $40 \Omega$

- \[ P_{\text{Lo}} = I^2 R \Rightarrow I = \sqrt{\frac{40\text{W}}{10 \Omega}} = 2 \text{A} \]

- From loop analysis:

  \[-60 + I(10 + R_x + 5) = 0 \Rightarrow \]

  \[ R_x + 15 = \frac{60}{2} = 30 \Rightarrow R_x = 15 \Omega \]
Question 5

In the circuit below, find the current $i_x$.

![Circuit Diagram]

(1) 5 A  (2) 4 A  (3) 3 A  (4) 2 A
(5) 1.5 A  (6) 1 A  (7) 0.4 A  (8) none of above

- $\frac{4}{12} = \frac{4 \cdot 12}{4 + 12} = 3 \Omega$
- $\frac{5}{20} = \frac{5 \cdot 20}{5 + 20} = 4 \Omega$

The circuit becomes:

![Modified Circuit Diagram]

$V_1 = 4 \cdot 3 = 12 \text{V}$
$V_2 = 4 \cdot 4 = 16 \text{V}$

Hence $i_x = \frac{V_1}{4 \cdot 3} = 3 \text{A}$
Question 6

In the circuit shown below, find the current $i_x$.

![Circuit Diagram]

(1) $-6\,A$  (2) $-4\,A$  (3) $-2\,A$  (4) $0\,A$
(5) $2\,A$  (6) $4\,A$  (7) $6\,A$  (8) none of the above

Applying KCL for the big circle gives:

$1 + i_x + 5 = 0 \Rightarrow i_x = -6\,A$
Question 7

In the circuit shown below, find the voltage \( V_x \).

\[
\begin{array}{c}
\begin{array}{c}
20V \\
\downarrow
\end{array}
\end{array}
\begin{array}{c}
\begin{array}{c}
15\Omega \\
\downarrow
\end{array}
\end{array}
\begin{array}{c}
\begin{array}{c}
5\Omega \\
\downarrow
\end{array}
\end{array}
\begin{array}{c}
\begin{array}{c}
8\Omega \\
\downarrow
\end{array}
\end{array}
\begin{array}{c}
\begin{array}{c}
4\Omega \\
\downarrow
\end{array}
\end{array}
\begin{array}{c}
\begin{array}{c}
4\Omega \\
\downarrow
\end{array}
\end{array}
\begin{array}{c}
\begin{array}{c}
20\Omega \\
\downarrow
\end{array}
\end{array}
\begin{array}{c}
\begin{array}{c}
10\Omega \\
\downarrow
\end{array}
\end{array}
\begin{array}{c}
\begin{array}{c}
24\Omega \\
\downarrow
\end{array}
\end{array}
\end{array}
\]

(1) 1 V  (2) 2 V  (3) 3 V  (4) 4 V
(5) 5 V  (6) 6 V  (7) 7 V  (8) 8 V

\[
\begin{align*}
4 + 20 \Omega &= 24 \Omega \\
8 \parallel 24 \Omega &= \frac{8 \cdot 24}{8 + 24} = 6 \Omega \\
4 + 6 \Omega &= 10 \Omega \\
(15 + 5) \parallel 10 &= \frac{20 \cdot 10}{20 + 10} = \frac{200}{30} = \frac{20}{3} \Omega
\end{align*}
\]

Not needed.
Just in case you are wondering.

From voltage division: \( V_x = \frac{20 \cdot 5}{15 + 5} = 5V \)
Question 8

In the figure below, find the voltage $V_{BG}$ between nodes B and G. Note that the lines do not represent short circuits, they represent generic devices (branches) in this circuit.

\[ V_{BG} = V_{BA} + V_{AE} + V_{EC} + V_{CF} + V_{FH} + V_{HG} \]

\[ = 1 - 7 + 2 + 2 + 3 - 4 = \]

\[ = -3 \text{V} \]
Question 9

In the circuit shown, find the current $i_x$.

From Loop Analysis:

- $I_2 = -1$ A
- $I_3 = -2$ A
- $-5 + 3 \cdot (I_1 - I_2) + 1 \cdot (I_1 - I_3) = 0$ \Rightarrow \[3 \cdot (I_1 + 1) + I_1 + 2 = 5 \Rightarrow 4 \cdot I_1 = 5 - 5 \Rightarrow I_1 = 0\]

Hence $i_x = I_1 - I_3 = 2$ A
Question 10

The circuit below contains a variable voltage source \(v_x\). Select the value of \(v_x\) such that the current \(i_x\) is 1 A.

(1) \(-1\) V
(2) \(-0.5\) V
(3) \(-0.25\) V
(4) 0 V
(5) 0.25 V
(6) \(0.5\) V
(7) 1 V

From Loop Analysis:

- \(I_1 = 1\) A
- \(1 \cdot I_2 - v_x + 1 \cdot (I_1 + I_2) - 0.5 = 0 \Rightarrow I_2 - v_x + 1 + I_2 - 0.5 = 0 \Rightarrow I_2 = \frac{v_x - 0.5}{2}

Since \(i_x = 1\) A \(\Rightarrow I_1 + I_2 = 1 \Rightarrow 1 + \frac{v_x - 0.5}{2} = 1 \Rightarrow v_x = 0.5\) V

\(v_x = 0.5\) V
Question 11

In the circuit below, find the power absorbed by the 0.5 Ω resistor (Hint: You may want to use source transformations).

(1) – 1 W
(2) – 0.5 W
(3) 0 W
(4) 0.5 W
(5) 1 W
(6) 2 W

Applying source transformation:

Hence the power consumed by the 0.5 Ω resistor is:

\[ P = I^2 \cdot 0.5 \]

\[ = \left( \frac{3}{2.5 + 0.5} \right)^2 \cdot 0.5 \]

\[ = 0.5 \text{ W} \]