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 and will be dealt with according to the policy in your section. 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.

By signing the scantron sheet, you affirm you have not received or provided assistance on this exam.
Question 1

Find the case where the element shown must be a source.

\[ V_{AB} = 5 \, \text{V} \quad V_{AB} = -4 \, \text{V} \quad V_{AB} = 3 \, \text{V} \quad V_{AB} = -2 \, \text{V} \]
\[ I = 0.5 \, \text{A} \quad I = -0.1 \, \text{A} \quad I = 0.2 \, \text{A} \quad I = 0.4 \, \text{A} \]

(1) 1  
(2) 2  
(3) 3  
(4) 4  
(5) None of the above

SOLUTION: To be a source the element must \textit{generate} the current flow from a lower voltage node (A) to a higher voltage node (B), then \( V_{AB} \) must be negative for a positive I. The only possible choice is (4).
Question 2

Find the value for node voltage $V_D$ (in V).

\[ R_{eq} = [(3 + 9)\Omega \parallel 6\Omega] + 2\Omega = 4\Omega + 2\Omega = 6\Omega \]

\[ V_B = \frac{4\Omega}{R_{eq}} \times 24V = \frac{4}{6} \times 24V = 16V; \]

Then, using voltage division again we get,

\[ V_{CB} = V_B = \frac{-3\Omega}{(3 + 9)\Omega} \times V_B = -\frac{3}{12} \times 16V = -4V; \]

The current in VCCS is equal to $I_{VCCS} = 1S \times V_{CB} = -4A$;

So that, $V_D = I_{VCCS} \times (3 + 1)\Omega = -4A \times 4\Omega = -16V$. 

(1) 6
(2) 9
(3) 12
(4) 16
(5) 18
(6) –8
(7) –12
(8) –16
(9) None of the above
Question 3

In the circuit shown, determine the power delivered by the voltage source (in W).

1) 110
2) 120
3) 130
4) 140
5) 150
6) 160
7) 180
8) 200
9) None of the above

SOLUTION: Find the power absorbed in resistors as $P = \frac{U^2}{R}$ and sum up the powers. Both branches share the same voltage, so we write, $P_{1\,\Omega} = \frac{(100\,V)^2}{1000\,\Omega} = 10\,W$; $P_{100\,\Omega} = \frac{(100\,V)^2}{100\,\Omega} = 100\,W$, and the total is $P_{1\,\Omega} + P_{100\,\Omega} = 110\,W$. The power delivered is equal to the power absorbed.

Alternative: the total load is $R_{eq} = R_{1\,\Omega} \parallel R_{100\,\Omega} = \frac{(10^2 \times 10^3/11 \times 10^2)}{\Omega}$, $G_{eq} = (11 \times 10^{-3})S$; and the result is $P = U^2 \times G = 10^4 \times 11 \times 10^{-3} \, W = 110W$. 
Question 4

In the circuit shown below, find the current $I$ (in A).

![Circuit Diagram]

1) 3
2) 4
3) 5
4) 6
5) 8
6) 9
7) 12
8) 15
9) None of the above

**SOLUTION:** Use current division, $G_{12\Omega} = (1/12)S$; $G_{24\Omega} = (1/24)S$;

$$I = \left[\frac{G_{12\Omega}}{G_{12\Omega} + G_{24\Omega}}\right] \times I_{\text{eq}},$$ or $I = (2/3) \times I_{\text{eq}}.$

Use current division again. Conductance of the entire branch is, $G_{\text{eq}} = 1/[12\Omega + 1/(G_{12\Omega} + G_{24\Omega})] = (1/20)S$, and, $I_{\text{eq}} = G_{\text{eq}} / (G_{\text{eq}} + G_{12\Omega}) \times 24\text{A} = [(1/20)/(1/20 + 1/12)] \times 24\text{A}$, or

$$I_{\text{eq}} = (3/8) \times 24\text{A} = 9\text{A}.$$  

$$I = (2/3) \times I_{\text{eq}} = (2/3) \times 9\text{A} = 6\text{A}.$$
Question 5

Find the equivalent resistance, $R_{eq}$, as shown in the figure (in $\Omega$).

\[ R_{eq} = 10 \Omega \parallel (2.5 \Omega + 6 \Omega) \parallel (2 \Omega + [8 \Omega \parallel (6 \Omega + 2 \Omega)]) = 2 \Omega + 3 \Omega = 5 \Omega \]
Question 6
In the circuit shown, find the short circuit current, \( I_{SC} \) (in A). [Hint: superposition and source transformations are NOT recommended approaches.]

SOLUTION: 40V source is directly connected to node B and to the ground, i.e., \( V_B = -40V \). From KCL at node B, \( I_{10\Omega} + I_{40\Omega} = I_{sc} + 6A \), while from KCL at A, \( I_{10\Omega} = (6+2) \) A, and on the other hand, \( I_{40\Omega} = -V_B/40\Omega = 1A \); \( I_{sc} = (I_{10\Omega} - 6A) + I_{40\Omega} \); \( I_{sc} = 2A + 1A = 3A \);
Question 7

For the circuit below, find the power delivered by the dependent source (in W).

\[
\begin{align*}
\text{SOLUTION: The power delivered by the CCCS is } P &= V \times I_{\text{CCCS}}; \\
\text{Transforming the independent source from } 6V \text{ to } 6A, \text{ and using KCL @ A we get, } & \\
6A + I_{\text{CCCS}} = I + I; \text{ as } V = 1\Omega \times I \text{ and } I_{\text{CCCS}} = -I, \text{ then } I = 2A. \\
P &= V \times I_{\text{CCCS}} = (1\Omega \times I) \times (-I) = (1\Omega \times 1) \times (-1) = (1 \times 2) \times (-2) W = -4W.
\end{align*}
\]
Question 8

The loop equations for the circuit shown below are,

\[
\begin{bmatrix}
21 & 10 \\
0 & 1
\end{bmatrix}
\begin{bmatrix}
I_1 \\
I_2
\end{bmatrix}
= 
\begin{bmatrix}
V_s \\
I_s
\end{bmatrix}
\]

Find the value of \( R_1 \) (in \( \Omega \)).

(1) 1
(2) 2
(3) 4
(4) 5
(5) 6
(6) 9
(7) 10
(8) 11
(9) None of the above

SOULUTION: rewrite the first equation as \( V_s = 21\Omega \times I_1 + 10\Omega \times I_2 \), and then compare it with the mesh equation for mesh current \( I_1 \).

KVL @ M1: \( V_s = R_1 \times I_1 + R_2 \times (I_1 + I_2) \); or \( V_s = (R_1 + R_2) \times I_1 + R_2 \times I_2 \); Comparing with the above, \( R_1 + R_2 = 21\Omega \), and \( R_2 = 10\Omega \). So that, \( R_1 = 21\Omega - R_2 = 11\Omega \).
Question 9

Find the coefficients \( \alpha \) and \( \beta \) for the circuit shown below.

\[ V_o = \alpha V_S + \beta I_S \]

(1) \( \alpha = -\frac{1}{5}, \beta = 1 \)

(2) \( \alpha = -\frac{1}{5}, \beta = 3 \)

(3) \( \alpha = -\frac{1}{15}, \beta = 2 \)

(4) \( \alpha = \frac{1}{5}, \beta = 1 \)

(5) \( \alpha = \frac{1}{5}, \beta = -1 \)

(6) \( \alpha = \frac{1}{15}, \beta = 3 \)

(7) \( \alpha = \frac{1}{30}, \beta = -2 \)

(8) None of the above
Question 10

Using superposition, find the value for $I_x$ in the circuit below (in A).

(1) 1
(2) 2
(3) 3
(4) 4
(5) 5
(6) 6
(7) 7
(8) None of the above

Solution

\[ I_x = \frac{40V}{4\Omega + 6\Omega} + 5A \frac{4\Omega}{10\Omega} \quad \text{current due with} \quad 40V \text{ source turned off} \]

\[ = 4V + 2V = 6V \]

Ohm's Law with
5A source turned off
Question 11

For the circuit shown below, $V_O = 24$ V. The contribution to $V_O$ from the current source, $I_S$, is only 20% of the contribution from the voltage source, $V_S$. Find the factor that $I_S$ must be increased by for the contributions to be equal, and the new output voltage, $V_O$ (in V).

1. $2.5x, 30$ V
2. $2.5x, 36$ V
3. $4x, 36$ V
4. $4x, 40$ V
5. $4x, 48$ V
6. $5x, 36$ V
7. $5x, 40$ V
8. $5x, 48$ V
9. None of the above

Solution:

\[ V_O = 24\text{V} = \alpha V_S + \beta I_S \]

\[ \beta I_S = (0.2) \times V_S \]

\[ V_S = 24\text{V} = 1.2 V_S \]

\[ \Rightarrow \alpha V_S = 20\text{V}, \quad \beta I_S = 4\text{V} \]

For $\beta I_S' = \alpha V_S = 20\text{V}$,

$\beta I_S$ must be increased by a factor $\times 5$

and $V_O = \alpha V_S + \beta I_S' = 20\text{V} + 20\text{V} = 40\text{V}$
Question 12

Find the voltage $V_A$ in the circuit below (in V). [Hint: source transformations would be helpful.]

(1) 1
(2) 1.5
(3) 3
(4) 4.5
(5) 6
(6) 7.5
(7) 9
(8) 16.5
(9) None of the above

$V_A = (3A) \times 1.5\Omega = 4.5V$